AFRICAN JOURNAL OF SPECIAL EDUCATIONAL NEEDS

VOLUME V NO.1
DECEMBER, 2010

unicef
UNICEF

ISSN-0855-7713

UNIVERSITY *of*
EDUCATION, WINNEBA, GHANA

AFRICAN JOURNAL OF SPECIAL EDUCATIONAL NEEDS

VOLUME 5 NO. 1

DECEMBER, 2010

AFRICAN JOURNAL QF SPECIAL EDUCATIONAL NEEDS

African Journal of Special Education Needs is a peer
Reviewed journal published twice a year.

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ISSN 0855-7713

AFRICAN JOURNAL OF SPECIAL EDUCATIONAL NEEDS

Subscription Rates (For each volume)

Individuals	$50
Institutions	$150

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ISSN 0855 7713

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INCREASING JSS FEMALE STUDENTS' ACHIEVEMENT IN SCIENCE THROUGH FORMATIVE TESTING, FEEDBACK AND REMEDIATION: A STUDY IN SCHOOL EFFECTIVENESS

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Abstract: *The federal government of Nigeria emphasized the importance of science and technology and had decided to have a ratio of science to liberal arts in schools as 60:40. However, students' achievement (particularly females) in JSS Integrated science is poor. Previous effort to increase students' performance has not yielded the desired results; therefore, this study finds the effect of formative testing with feedback and remediation on students' achievement in Integrated science with the view of increasing female students' achievement in the subject. This is a quasi-experimental design with a non-randomized pre-test and post-test control group (4 x 2) factorial design. Eight schools out of 25 in Ibadan North Local Government Area were randomly selected and a total of 128 students participated in the study. Two instruments (Integrated Science Achievement Test and treatment package) were used in the study. Analysis of covariance (ANCOVA) and post hoc test (Scheffe) were employed to analyse the data. The study showed that a combination of formative testing, feedback and remediation used alongside teaching was an effective instructional strategy that could be used in reversing the trend of poor performance in Junior Secondary Certificate Examination in Integrated Science by all students in general and female students in particular. It is therefore recommended that teaching + testing + feedback + remediation should be used in Integrated science classes as this will improve all students' achievement in general and female students in particular.*

Keywords:

Formative testing, Female students' achievement in integrated Science, Remediation, Feedback, Student gender

Introduction

Integrated science is prescribed as a basic introductory course to Biology, Physics and Chemistry (although, this is the era of transiting from Integrated science to Basic Science). It is also a course which is expected to lay a foundation for specialized science study as well as increased understanding of the environment. At this level, integrated science will give the students (who are youths) general education and emphasizes the importance of observation for explaining things in their environment. It also introduces the students to logical thinking and scientific method. Integrated Science arouses in the students, curiosity and develop in them, scientific attitudes. The importance of science was attested to in the National Policy on Education (FRN, 2004 revised) and states thus:

> *A greater proportion of education expenditure will be devoted to science and technology. Universities and other levels of the education system will be required to pay greater attention to the development of scientific orientation... More colleges of Technology and Polytechnics will be opened in a bid to improve technology and science education. The ratio of science to liberal arts in our universities have been fixed for 60:40. (p.25).*

Consequently, attempts have been made in the country to emphasize the process of science and not just factual knowledge. Science educators, through the agencies of National bodies and associations have always been disseminating relevant information which could improve teaching and learning activities of science in secondary schools. Bodies like the Science Teachers Association of Nigeria (STAN), Nigeria Educational Research and Development Council (NERDC), the Comparative Education Studies and Adaptation Centers (CESAC) have been custodians of relevant information which is expected to have raised the status of teaching and learning of science in schools. One would expect that in the situation of a country like Nigeria,

which is in a dire need of trained scientists to form the basis of and boost the much needed technology; achievement in science at the secondary school level should be very encouraging. The contrary is the case; with science studies being characterized by low enrolment and poor performance at the senior secondary school level (particularly in Chemistry and Physics). The situation is worsened with low performance of female students in science. Although, the findings on gender differences in science are controversial and inconclusive, amount of researches pointing to achievement of males over the female is overwhelming.

In a review of sex differences conducted by Maccoby and Jacklin (1974), they discussed six cognitive areas in which such differences between the sexes can be linked to any of the measured traits. There is a large overlap between the distribution of scores for the two sexes. The first area for which differences have been documented is general intelligence (IQ). Females perform better on general IQ tests during the pre-school years but males perform better in high school. After age ten, gender differences in verbal ability are not large, but females perform better in grammar, spellings and word fluency.

According to Haertel, Moss, Pullin, and Gee. (2008), gender differences have been noted in numerical ability, males do better at arithmetic reasoning by high school age (approximately fourteen), though in the early years, no differences were obtained. Males also outperform females in special ability and it was also discovered that men's average scores on mathematical and Scholastic Aptitude Test (SAT) were above women's average scores. Reap and Cavello (1992) use mental modeling to ascertain the nature of students' understanding of concepts. The results showed significant gender differences – with the male scoring higher than female students.

Recent studies point to the fact that males perform at higher rates with regard to science achievement, particularly in high school than females. Analysis of the NAEP 2005 results reveals that males continue to outperform females in science achievement at all three grade levels (grades 4, 8, and 12). Females at all levels have made relatively little gains in their average science achievement scores since 1996. Males studied physics, engineering, and engineering/science technologies at higher rates (National Science Foundation, 2008). Males' propensity to enroll in physics has been attributed to their higher performance on science achievement tests (Hazari, Tai, & Saddler, 2007). Among eighth-graders, males scored

significantly higher overall than females in science (Mullis, Martin, & Foy, 2008). In 2007, male high school students took science advanced placement subject tests in larger percentages than female students and tended to score higher. Males surpassed females in the number of undergraduate degrees awarded in science and engineering fields – in particular, computer science, physical science, and engineering (National Science Foundation, 2005). Okeke (1992) carried out an extensive study of gender related issues in science participation and achievement; the observation was that physics, technology and mathematics are viewed as being masculine while languages are for females. Finley (1982) finds that male students perform better than female students in sciences. However, other researchers found that females are better in science under certain conditions, for example, Balogun and Olanrewaju (1985) and Deboer (1986) conclude that females outperformed males in certain concepts in physics. These results seem explicable considering the study result of Adeoye (2000) that females would achieve better than males when test items are based on physics contents that require learners of low numerical ability while the reverse would be the case when the test is based on physics concepts/contents that require learners of high numerical ability.

There are some studies that found no significant differences between boys and girls in their academic achievement. These include the Monitoring of Learning Achievement (MLA) study in Nigeria which showed that there was no significant difference between boys and girls in their average scores on tests for literacy, numeracy and life skills (Makoju, Falayajo, Ayodele, Obaitan, Akinsola, Falaye, Adewale & Onugha, 2003). Dalton, Ingels, Downing, and Bozick, (2007) show that the mean number of credits earned in science increased for both males and females thereby shows no significant differences. Smullin (1983), Inomiesa (1989) and Jimoh (2004) who conclude that gender difference do not influence students' academic achievement in sciences.

Since there is a gap between what is expected in female's participation and achievement in science, the specialists in the field of Special Education would suggest an inclusive education to solve the problem. Many people believe that inclusive education means integration and mainstreaming of students with disabilities into the normal school system. These tended to be concerned principally with disability and special educational needs and implied learners changing or becoming ready for accommodation by spending most or all of their time with non-

disabled students. In modern days, inclusive education can be defined as a process of removing barriers and enabling all students, including previously excluded groups, to learn, participate effectively within general school systems and achieve the same way. UNESCO (2009) summarily defines inclusive education as the transformation of schools and other centres of learning to cater for all children and recognizes that many currently marginalized groups (such as religious, racial, ethnic, and linguistic minorities, immigrants, girls, the poor, students with disabilities, HIV/AIDS patients, remote populations, and more) are not actively included in education and learning processes.

For Nigeria to achieve the desired goal of 60:40 of Science to Arts, girls should not be left behind, therefore, this study is to increase female students' knowledge of science through formative testing, feedback and remediation. Although, the mastery learning strategy is found to be effective in facilitating learning, the implementation of the entire package in the Nigerian secondary school system is likely to face many obstacles (Erinosho, 1988; Ezewu, 1981). Therefore, a formative evaluation strategy which involves feedback with remediation is being proposed. Formative testing which uses feedback and remedial instruction can be seen as an attempt to diagnose learning difficulties in individuals and to identify strengths and weaknesses in group performance for the purposes of improving instruction as a panacea for a better educational achievement (Ibeagha, 2002). This study will seek to investigate the effects of formative testing with feedback and remediation on learning outcomes in Integrated science.

Bloom (1971) opined that formative tests have diagnosis functions and capacity of providing corrective feedback to both teachers and students. Formative tests are criterion-referenced, that is the curriculum is used to determine what to test. For formative tests to be effective in ascertaining the degree to which students learn the supposed learning, instruction must be relevant to what is being tested. This necessitates that there must be a table of specification which must be followed duly. That is, the teacher must know the principles of test construction which ensures proper relationship between intended objectives and the curriculum (Capper, 1996). Formative testing is effective in promoting students' learning across a wide range of educational settings (Yorke, 2003). Without informative feedback on what they do, students will have relatively little by which to chart their development (Black & William, 1998).

A feedback is information from a teacher to students about their performance in a test. There is general acceptance that feedback is an important component of learning which might lead to a change in learner's subsequent behaviour (Chauhan, 1985; Ekeruo, Ikedeashi, Ekwe and Nwamuo, 1989). Feedback to students provides reinforcement of successful learning and identifies the specific learning errors that need correction. It is also useful to the teacher by providing information for modifying instruction and for prescribing group and individual remedial work. Previous researches show that students change as a result of receiving feedback. Afemikhe (1985) reports that formative tests with remediation are more effective in improving students' cognitive achievement. It is believed that formative testing with feedback and remediation is potent to increase girls' participation and achievement in Integrated science. Therefore, this study examined the effect of formative testing with feedback and remediation on students' achievement in Integrated science with the view of increasing female students' achievement in the subject.

Research Question

What are the performances of male and female students in integrated science before and after the treatment?

Research Hypotheses

Three research hypotheses were raised and answered in order to guide this study:

1. There is no significant main effect of treatment on students' achievement in Integrated Science?
2. There is no significant main effect of gender on students' achievement in Integrated Science?
3. There is no significant interaction effect of treatment and gender on students' achievement in Integrated Science?

This study uses a quasi-experimental design with a non-randomized pre-test and post-test control group design (4 x 2) factorial design.

Outline of design

The outline of design is as follows:

Experimental group 1	O_1	X_1	O_2
Experimental group 2	O_1	X_2	O_2
Experimental group 3	O_1	X_3	O_2
Control group	O_1	X_4	O_2

Where

0_1 represents pre-test measures

0_3 represents post test measures

X_1 – teaching with formative testing, feedback and remediation of selected concept within the unit.

X_2 - teaching with testing with feedback but no remediation of selected concept within the unit.

X_3 - teaching, formative testing but no feedback and remediation of selected concept within the unit

X_4 - teaching without testing, feedback and remediation (conventional method)

Table 1. A 4 x 2 Factorial Design

Gender	Treatment			
	X_1 = Teach + test, feedback + remediation	X_2 = Teach + test, feedback + no remediation	X_3 = Teach + test, no feedback + no remediation	X_4 = Teach + no test, no feedback + no remediation
Male				
Female				

Population and sample

The subject

All Junior Secondary Class 2 (J.S.S. 2) students in Ibadan North Local Government Area in Oyo State formed the population for this study. The schools involved were co-educational, and had registering students for junior school Certificate Examination for at least five years. This is to ensure comparability of schools.

Sampling technique and sample

For this study, a random sampling for the selection of eight schools out of 25 in the Local Government Area was carried out. One arm of JS 2 was randomly selected and an intact class was used as samples in each of the eight schools selected. Two schools were randomly assigned to a treatment. This is to ensure that each school had equal chance of receiving any of the four treatments. A total of 128 students participated in the study.

Instrumentation

The following instruments were used in this study

Integrated Science Achievement Test (ISAT)

Formatives Tests (FT)

Integrated Science Achievement Test

This is a 40 – item multiple choice test with four options on the following topics:-

Table 2. Table of Specification

Topics	Knowledge (40%)	Understanding (30%)	Thinking (30%)	Total
The Skeletal (17.5%)	3	2	2	7
Muscular Systems (17.5%)	3	2	2	7
Matter (10%)	2	1	1	4
Water (10%)	1	2	1	4
Separation Techniques (10%)	2	1	1	4
Tools (10%)	1	1	2	4
Forces (10%)	2	1	1	4
Simple Machines (15%)	2	2	2	6
Total	16	12	12	40

The instrument was developed by the researchers and validated by trial-testing the 120-items generated using 120 J.S.S. 2 students who did not take part in the study. The Kuder Richardson 20 reliability coefficient was 0.82. The difficulty index of the items ranged from 0.35-0.58, while the discriminating index ranged between 0.2 and 0.62. Forty good items were selected to serve both as pre-test and post-test. This instrument was scored for one (1) mark per item after

administration. This means that the maximum obtainable score is 40 marks, and the minimum obtainable score is zero (0).

Formative Tests

These are short tests of 10 items testing the selected topics each week during instrument to determine the students' mastery of the topics taught previously and to provide remediation on the item(s) wrongly answered; using the least score to determine topics to be re-taught by the teacher in the following lesson. These instruments were scored on the basis of one (1) mark per items; with the maximum obtainable score as ten (10) and the minimum obtainable as zero (0).

Procedure for administration of Instruments

Integrated Science Achievement Test was administered to the students involved in the study before the commencement of treatments. The instruments were scored and the performance records were used as pre-test scores. The four treatments were then administered in the eight schools (two schools per treatment).

Experimental Group 1

The first lesson (instruction) was presented. At the end of each weeks (last period), the formative test 1 was administered. The scoring followed; areas of difficulties were identified, scripts were distributed to the students. The difficult concepts were remediated before the second presentation followed. The same process was followed till the last instruction. At the end, the integrated Science Achievement test (ISAT) was administered and scored.

Experimental Group 2

The first lesson (instruction) was presented. At the end of each weeks (last period), the formative test 1 was administered. The scoring followed; scripts were given to the students without identifying the difficult concepts and remediating. The same process was followed till the last instruction. At the end, the integrated Science Achievement test (ISAT) was administered and scored.

Experimental Group 3

The first lesson (instruction) was presented. At the end of each weeks (last period), the formative test 1 was administered. The scoring followed; scripts were not given to the students (no feedback). No remediation of any difficult concept was provided. The same process was followed till the last instruction. At the end, the integrated Science Achievement test (ISAT) was administered and scored.

Experimental Group 4 (Control)

The first lesson (instruction) was presented. There were no formative tests, no feedback and remediation of any difficult concept was provided. At the end, the integrated Science Achievement test (ISAT) was administered and scored

Data Analysis

The data collected were analyzed using analysis of covariance (ANCOVA). Pre-test was used as covariate to adjust for any difference in the background of the students. The post hoc test using Scheffe's test was employed to find out the direction of significant differences.

Results and Discussion

The three research hypotheses were tested and the research question was answered in this section.

Research Question

What is the performance of students in integrated science before and after the treatment?

Table 3. Pre and Post Test Mean Scores of 4 Treatments by Gender

Treatment	Pre-test				Post-test			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Teaching, testing with feedback and remediation	16.12	3.43	14.19	2.86	32.14	1.98	40.16	1,65
Teaching, testing with feedback and no remediation	14.43	2.45	14.05	2.75	24.05	2.08	22.09	3.12
Teaching, testing no feedback and no remediation	13.68	2.19	12.13	3.01	22.13	2.31	20.17	2.11
Teaching, no testing, no feedback, no remediation (control)	13.98	3.65	13.54	2.97	22.54	2.83	18.58	2.65

Table 3 reveals that post test scores are better than the pre-test scores for both male and female in each of the 4 treatment groups but female performance is better than the boys' performance in teaching, testing with feedback and remediation.

Research Hypothesis 1

There is no significant main effect of treatment on students' achievement in Integrated Science?

Table 4 Effect of treatment and gender on students' achievement in Integrated Science

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Pre-test	101.324	1	101.324	1.439	.231
Treatment	2834.304	3	944.768	13.421	.000*
Gender	363.488	1	363.488	5.163	.005*
Treat * Gender	939.265	3	313.088	4.448	.011*
Residual	8376.886	119	70.394		
Total	12513.940	127			

* Significant (P<.05)

There is a significant difference between students exposed to treatments and those exposed to conventional method of teaching ($F_{(3, 119)} = 13.421$; $P < 0.05$).

Table 5 Multiple Classification Analysis on Students' Posttest Achievement.

Variables	N	Unadjusted Mean	Eta	Adjusted Mean	Beta
Post test:					
Treatment:					
Teaching, testing with feedback and remediation	34	36.15		35.21	
Teaching, testing with feedback and no remediation	34	23.07	.592	22.13	.554
Teaching, testing no feedback and no remediation	30	21.15		20.98	
Teaching, no testing, no feedback, no remediation (control)	30	20.90		20.65	
Gender					
Male	66	25.67		24.56	
Female	62	27.54	.241	26.80	.212
R					.765
R^2					.675

Table 5, the students exposed to teaching, testing with feedback and remediation performed better (36.15) than those exposed to other methods [teaching, testing, feedback, no remediation = 23.07; teaching, testing, no feedback without remediation = 21.15; control i.e. teaching, no testing, no feedback, no remediation = 20.9].

Table 6 Post-Hoc Analysis of the Treatment and Gender on Students' Achievement in Integrated Science

Variable + Category	N	Subset for alpha = 0.05	
		1	2
Treatment			

Teaching, no testing, no feedback, no remediation	30	20.90	
Teaching, testing, feedback without remediation	34	21.15	
Teaching, testing, no feedback, no remediation	30	23.07	
Teaching, testing with feedback and remediation	34		36.15

Table 6 shows that there is no significant difference between the performance of students exposed to teaching, testing, no feedback, no remediation = 23.07; teaching, testing, feedback without remediation = 21.15; control i.e. teaching, no testing, no feedback, no remediation = 20.9.

Research Hypothesis 2

There is no significant main effect of gender on students' achievement in Integrated science

The result in Table 4 reveals that gender has significant effect on students' achievement in Integrated science ($F_{(1, 119)} = 5.163$; $P < 0.05$). Table 3 shows that before the treatment, male students performed better than the female students but the situation changed after treatment, female students performed better (26.8) than male students (24.56) in Integrated science.

Research Hypothesis 3

Is there a significant interaction effect of treatment and gender on students' achievement in Integrated science?

The result shows that the interaction effect of treatment and ability on students' achievement in Integrated science is significant. This implies that students' gender is sensitive to the treatments, this illustrated in Fig 1.

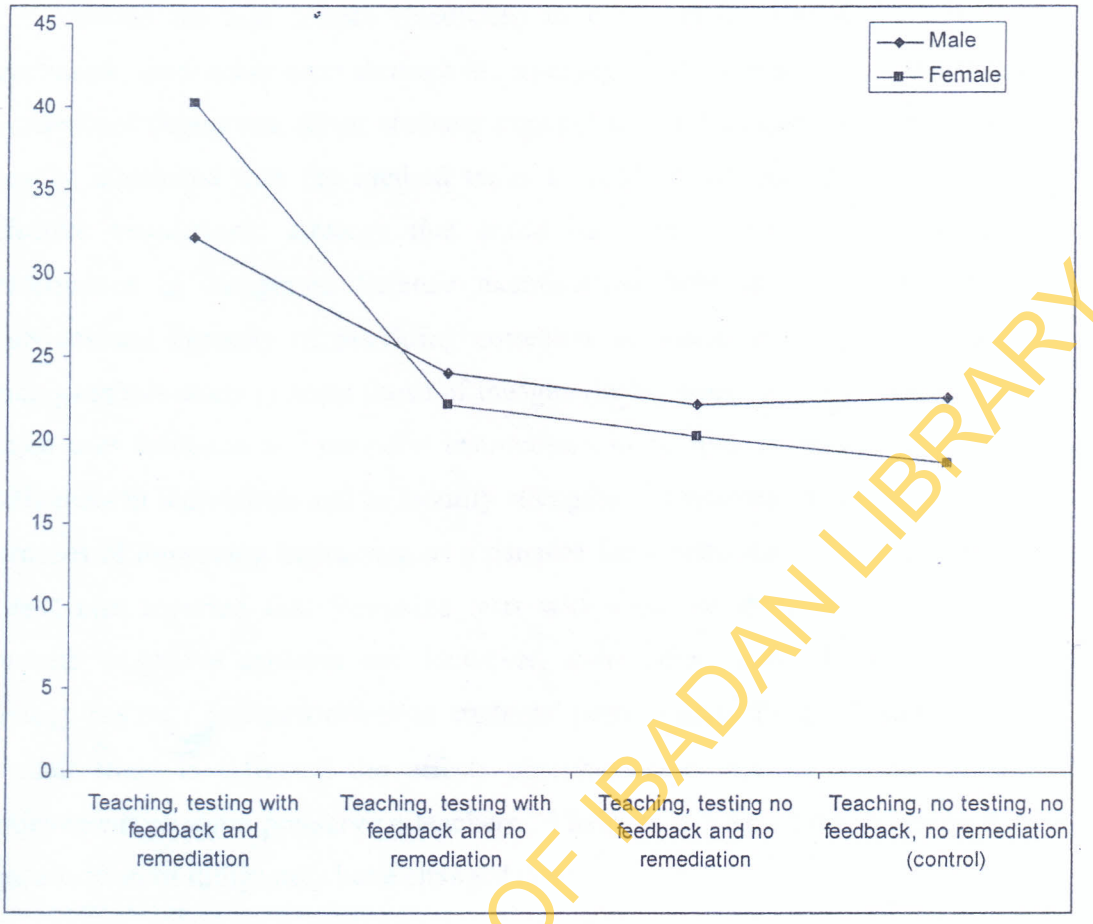

Fig. 1 Interaction effect of Treatment and Gender

Female students gained tremendously from the treatment package – teaching, testing with feedback and remediation, but male students began to show superiority in teaching, testing with feedback and no remediation; teaching, testing without feedback and no remediation; teaching, no testing without feedback and no remediation. This implies that girls can learn science better than boys when they are exposed to teaching, testing with feedback and remediation.

Discussion

The results revealed that students exposed to teaching, testing, feedback and remediation performed significantly better than those in the other three treatments. The results show that testing, feedback and remediation strategy has positive contribution to the students' achievement in Integrated science. It is logical to think that this method is potent is raising students'

achievement because the teacher first taught the lesson, then (s)he administered test, marked the test, returned the test scripts (feedback) to the students. Using the least performers as a benchmark, the teacher went through the teaching again in order to help the students achieve the instructional objectives. Since students exposed to this treatment performed in this way, it can then be concluded that the method tends to confirm the potency of treatment procedure as effective instructional strategy that could be used to reverse the current trend of poor performance in Integrated Science examinations because formative tests have diagnosis functions and capacity of providing corrective feedback to both teachers and students. The findings in this study confirm those of Ibeagha (2002) where he concluded that formative testing which uses feedback and remedial instruction can be seen as an attempt to diagnose learning difficulties in individuals and to identify strengths and weaknesses in group performance for the purposes of improving instruction as a panacea for a better educational achievement. Afemikhe (1985) also reported that formative tests with remediation are more effective in improving students' cognitive achievement. However, some other studies have indicated that feedback strategy has no significant effect on students' performance. Yeany, Waugh and Blalock (1979); in their study investigated the effects of achievement diagnosis with feedback on science achievement of some pre-service teachers. Their study was conducted more than two decades ago, situation of things may have changed now.

The results of effect of gender on students' achievement in Integrated Science show that there is a significant main effect of gender on students' achievement in Integrated Science. The results show that female students (M = 26.28) are superior in Integrated Science achievement than male students (M = 24.27). The findings in this study is not consistent with those of Adigwe (1993) who found that male students excelled above their female counterparts in the following processes – problem understanding construction and execution of solution plans; exhibition of structural errors and evaluation of solution processes. However, Becker (1989) concluded that the magnitude of gender differences in science varies according to the subject matter studied. However, in their own study conducted to investigate whether differences in Integrated Science achievement exists at the junior secondary schools in Nigeria using 1454 boys and 1336 girls; they concluded that there were real differences in achievements between male and female students as indicated in this study. Gorman (2006) and Olatoye (2003) reported a significant difference in favour of male students. On the other hands, there are studies that did not record

any significant difference is male and female achievement in science, examples are Jules and Kutnick (1990) and The Equal Opportunities Commission and Office for Standards in Education (1996). Olatoye (2009) also found that there is no significant difference between male and female students' achievement in science.

The interesting finding of this study is that the method (to teaching, testing, feedback and remediation) is potent enough to raise female students' achievement in Integrated science than the boys. The reason could be that boys tend to get bored more easily than girls thus requiring more stimulation to keep them attentive and on task. In addition, girls do better in repetitive activities (teaching, testing, feedback and remediation is more of repetitive activities because teachers uses the test as a diagnostic tool, (s)he re-teach the concept again) but repetitive activities are often difficult for boys. Boys are adventurous, they tend not have new experience when the concepts are taught again after the testing (remediation). Moreover, Pizzo (2000) observed that males tend to learn less by listening, on the other hand, girls, on like boys, tend to be auditory-oriented and significantly more quiet while learning which helps their performance.

Conclusion and Recommendations

The study has shown that a combination of formative testing, feedback and remediation used alongside teaching will prove to be an effective instructional strategy that could be used in reversing the trend of poor performance in Junior Secondary Certificate Examination in Integrated Science. It is therefore recommended that teaching + testing + feedback + remediation should be used in Integrated science classes as this will improve students' achievement. More importantly, this method should be used for girls as it has the potential to improve female students' achievement in Integrated science.

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