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EFFECTS OF FORMATIVE TESTING ON JUNIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN INTEGRATED SCIENCE

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Abstract

This study examined the effects of formative testing on students' achievement in Integrated Science. The study adopted a 4 x 2 factorial design with pre-test and post-test control groups in quasi-experimental setting. Treatment was administered at four levels: (teaching, formative testing, feedback and remediation; teaching, formative testing, feedback but no remediation; teaching, formative testing, no feedback and no remediation; teaching, no formative testing, no feedback and no remediation (control group). The moderator variable was parental involvement at two levels (male and female). One hundred and twenty nine junior secondary two (J.S. 2) students from eight selected secondary schools from Ibadan North Local Government Area of Oyo State participated in the study. Three instruments were used: two response instruments- Integrated Science Achievement Test (ISAT) and formative tests and one stimulus instrument (teaching package). The data analysis was done using Analysis of Covariance (ANCOVA) with the pre-test scores serving as covariates. The results indicated that there is a significant main effect of treatment ($F_{(3,119)} = 89.68; P < 0.05$) on students' achievement in Integrated Science, parental involvement also has significant effect on students' achievement in Integrated science but no significant interaction between the treatment and parental involvement was recorded. The implications of this study include the use of formative testing, feedback and remediation to complement teaching.

Keywords: Formative testing, Students' Achievement in Integrated Science, Remediation, Feedback, students' parental involvement

Introduction

In Nigeria, the goal of science education is to develop scientifically literate citizens who can think and act rationally. The National Policy

on Education which was first published in 1977 and revised in 1981, 1998 and 2004 (FRN, 2004 revised) in recognition of the importance of science and

technology in national development states that:

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 has been fixed for 60:40. (p.25).

In support of the need for science and technology, the Science Teacher Association of Nigeria (STAN) in 1979 published the "Curriculum Newsletter No 1" which contained a statement of the philosophy, methodology, content and evaluation of integrated science. Integrated Science was therefore introduced into the Nigerian school system as advised by the United Nations Educational Scientific and Cultural Organization (UNESCO); and as a result of the response to the local cries and challenges within Nigeria to reassess secondary school science teaching.

Integrating Principles (according to the STAN Curriculum Newsletter No. 1) are intended to produce among other things, a course which:

- is relevant to students' needs and experiences
- stresses the fundamental unity of sciences
- lays adequate foundations for subsequent study and
- adds a cultural dimension to science education.

Integrated science is a course which emphasizes the fundamental unity of science in the contemporary society (Inter-Union Commission on Science Teaching (ICSU), 1968). Integrated Science is taught in the Junior Secondary Schools and is prescribed as a basic introductory course to Biology, Physics and Chemistry. Again, Integrated science is undergoing metamorphosis into Basic Science at JSS level. Its full implementation is underway. Integrated science is 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 emphasize the importance of observation for explaining things in their environment. It will also introduce the students to logical thinking and

scientific method. Integrated Science will arouse in the students, curiosity and develop in them, scientific attitudes.

Consequently, attempts have been made in the country to emphasize the process of science and not just factual knowledge. Science educators, through 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 Development Council (NERDC), and the Comparative Education Studies and Adaptation Centre (CESAC) have been custodians of relevant information which is expected to have raised the status of teaching and learning of science in schools. Furthermore, two science equipment centres were established in Enugu, Enugu State and at Minna, Niger state all in the effort to make science more meaningful in the society. In addition, various curriculum innovations were introduced which led to the 6-3-3-4 educational system in Nigeria. One of the features of the 6-3-3-4 educational system is the continuous assessment, which is expected on proper usage to discourage rote learning which had characterized the educational system in the past. The

definitions, mode of administration, prospects and attributes of continuous assessment have been documented in literature (Osokoya & Odinko, 2005; Ogunneye, 1991; FGN, 1998; Ojerinde & Falayojo, 1984 and Ogunniyi, 1984).

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 school science studies being characterized by low enrolment and poor performance at the senior secondary school level particularly in Chemistry and Physics (Adewale 2002).

It is therefore necessary for much research work geared towards improving the quality of science teaching in Nigerian Secondary Schools to be done. These efforts are likely to have maximum impact at the Junior Secondary School level when it is still compulsory for all students to learn science (Integrated Science): It is also expected that any enhanced quality in Integrated Science teaching will motivate a greater proportion of secondary school students to enrol in single science subjects at the senior secondary level; and, hopefully

achieve better at the senior school certificate examination.

Several efforts have been made to improve the lot of science teaching in Nigeria. From the days of the Nigerian Integrated Science Project (NISP) by the Science Teachers Association of Nigeria (STAN) till date, several teaching packages and strategies have been invented and suggested. Some learning models have been suggested which are based on some procedures connected with mastery learning principles. Carrol (1963) proposed an individualized mastery learning strategy which contained the following components:-

- Clearly defined educational objectives
- Small units of study
- Criterion referenced testing
- Remediation for students' problems and
- Competence before proceeding to the next hierarchically related unit of instruction.

Although, the mastery learning strategy is found to be effective in facilitating learning, criticisms against it made Bloom propose another approach to the strategy (Bloom, 1968) which focused on mastery defined in terms of behavioural objectives for each unit of instruction, but on a group-

based method. The group work makes testing and remedial activities easier, but the fact that 90% of students are expected to gain mastery of the instruction still makes this strategy impracticable in the Nigerian situation where repeating a class will likely to discourage the students thereby doing more harm than good.

Therefore, a formative evaluation strategy which involves feedback with remediation is 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 sought to investigate the effects of formative testing with feedback and remediation on JSS achievement in Integrated science.

Formative tests are the tools for educational diagnosis. They have all the characteristics of achievement tests. Bloom (1971) opined that formative tests have diagnostic functions and capacity of providing corrective feedback to both teachers and students. They also reflect units that constitute important learning components and their hierarchical nature; indicating the link between

them. Formative tests are criterion-referenced, that is, students are not scored because they are non-graded tests. But the proportion of students who respond correctly to each of the test item is noted. This proportion is diagnostic because it indicates whether or not majority of the students have attained competence on the step on which the test item is based.

For formative tests to be effective in ascertaining the degree to which students learn what they are supposed to learn, 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 institution and for prescribing group and individual remedial work. Previous researches show that students change as a result of receiving feedback. Afemikhe (1985) reported that formative tests with remediation are more effective in improving students' cognitive achievement.

Apart from the influence of teaching methods or techniques, there are other learner characteristics which can affect students' achievement. One of such characteristics is the home environment, and the learners' relationship with parents. Various researchers have documented factors like occupation and education of parents (Idowu 1990); academic materials in the home e.g. television sets, radio sets (Onocha and Okpala 1985) the use of dictionaries and number of books at home (Comber and Keeves, 1973, IEA 1990) as factors that can affect students' achievement. There is a strong suggestion that parents' involvement in their children's formal schooling is vital for their academic success;

though the research evidence is less than conclusive. This is due to the fact that methodological limitations are prevalent in the majority of parents' involvement research; as itemized by Baker and Soden (1998). However, the cumulative knowledge from existing studies suggests that each of the different forms or types of parent involvement variables facilitates children's academic achievement. There are also indications that they do so in relatively complex ways that interact with family background and social context variables such as ethnicity, family structure, maternal employment status, socio-economic status and parental involvement (Schiamberg & Chin, 1986; Mitne, 1989; Tocci & Englehard 1991; Lee & Croninger, 1994).

The term 'parental involvement' refers to a wide range of activities that have been characterized by a number of typologies. Nye, Turner and Schwarts (2006) define parent involvement as the active engagement of a parent with their child outside the school day in an activity which centers on enhancing academic performance. Christenson, Rounds and Gorney (1992) also define parental involvement as parent participation in educational activities at both school and home.

Epstein (1987) also suggested that parental involvement is multi-dimensional and included:

- 1) parents providing a home environment that supports learning
- 2) communication between parents and teachers on classroom performance
- 3) parents' active attendance at school activities such as PTA
- 4) parents' engagement and monitoring of home learning activities and
- 5) parents' participation in school – based decision making such as school committees.

Parent involvement has been linked with student outcomes which include increased achievement test results a decrease in drop-out rate, improved attendance in school, improved student behavior, higher grades, greater commitment to school work and improved attitude towards school (NMSA, 2000).

Although the impact of parent involvement in a child's growth is generally accepted (Sheldon, 2003); educators, parent groups and policy makers continue to debate the issue on whether or not parent involvement has a beneficial effect on the academic achievement of children. It is on this note that parental involvement was included as a moderating variable.

Statement of the problem

This study seeks to determine the effect of formative testing with feedback and remediation on students' achievement in Junior Secondary Schools (JSS) Integrated Science. It also determines the effects of parental involvement as well as the interaction effect of treatment and parental involvement on students' achievement in JSS Integrated Science.

achievement in Integrated Science?

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

Research Hypotheses

1. There is no significant main effect of treatment on students'

Methodology

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

- O₁ represents pre-test measures
- O₂ represents post test measures
- X₁ - teaching with formative testing, feedback and remediation of selected concept within the unit.
- X₂ - teaching with testing with feedback but no remediation of

- selected concept within the unit.
- X₃ - teaching, formative testing but no feedback and remediation of selected concept within the unit
- X₄ - teaching without testing, feedback and remediation (conventional method)

Table 1 A 4 x 2 Factorial Design

Parental involvement	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
High				
Low				

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 registered 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.

Instrumentation

The following instruments were used in this study

Integrated Science Achievement Test (ISAT)

Formative Tests (FT)

Parental Involvement Questionnaire (PIQ)

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 of the test was established to be 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 treatment 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).

Parental Involvement Questionnaire (PIQ)

The instrument was developed by the researchers to determine how involved the parents are in their children's study of Integrated Science. The questionnaire consists of two sections A and B. Section A dealt with personal information like

age, school and sex of the respondents. Section B consists of nine (9) items on home study conditions and availability of infrastructural facilities provided by parents that can aid the learning of integrated Science. The items of the instrument were examined by test construction experts for content validity. The corrected version was trial tested to determine the internal consistency and construct validity using Cronbach Alpha. A coefficient $\alpha = 0.79$ was established which is judged to be high enough to warrant the use of the instrument. In this instrument every positive response scored one while a negative statement or no response scored zero. Therefore, the maximum rating can be nine (9) while the minimum rating can be 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 I was administered, followed by the scoring. Areas of difficulties were identified, and scripts 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 week (last period), the formative test I was administered and scored. 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 I was administered and scored. Scripts were not given to the students and 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 Hypothesis I

Is there any significant main effect of treatment on students’ achievement in Integrated Science?

Table 3: Effect of treatment and parental involvement on students’ achievement in Integrated Science

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Pre-test	128.591	1	128.591	6.371	.013
Treatment	4634.931	3	1544.977	76.545	.000
Parental involvement	163.488	1	163.488	8.100	.005
Treat * Parental involvement	99.265	3	33.088	1.639	.184
Residual	2401.886	119	20.184		
Total	8099.930	127			

There is a significant difference between students exposed to treatments and those exposed to conventional method of teaching ($F_{(3, 119)} = 76.545; P < 0.05$). From Table 4, the students exposed to teaching, testing with feedback and remediation performed better (36.15) than those exposed to other methods [teaching, testing, no

feedback, no remediation = 23.07; teaching, testing, feedback without remediation = 21.15; conventional strategy i.e. teaching, no testing, no feedback, no remediation = 20.9].

Table 4: Post-Hoc Analysis of the Treatment and Parental involvement 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
Parental involvement			
Low		24.56	
High			26.80
Multiple R		= .838	
Multiple R Square		= .703	
Adjusted Multiple R Square		= .684	

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; conventional strategy i.e. teaching, no testing, no feedback, no remediation = 20.9.

Research Hypothesis 2

Is there a significant main effect of parental involvement on students' achievement in Integrated science? The result reveals that parental involvement has significant effect on

students achievement in Integrated science ($F_{(1, 119)} = 8.100; P < 0.05$). From Table 4, male students performed better (26.8) than female students (24.56) in Integrated science.

Research Hypothesis 3

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

The result shows that the interaction effect of treatment and ability on students' achievement in Integrated science is not significant. This implies

that students' parental involvement is not sensitive to the treatments.

Research Question I

What is the composite contribution of treatment and parental involvement on students' achievement in Integrated science?

Table 4 reveals that there is a high multiple correlations between the students' achievement in Integrated science (dependent variables) and treatment and students' parental involvement (independent variables). A multiple correlation coefficient of 0.838 is observed. Therefore, the coefficient of determination Adjusted R^2 is 0.684. This means that 68.4% of the variance in students' achievement in Integrated science is accounted for by the two independent variables (treatment and students' parental involvement) and the remaining 32.5% of the variance in the students' achievement in Integrated science are accounted for by other variables beyond this study.

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 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 stated objective. 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. The findings of this study corroborate those of Bloom (1971) who stated that formative tests have diagnostic functions and have the capacity of providing corrective feedback to both teachers and students. In addition, 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. Although, the effect of anxiety on students' achievement is inconclusive, regular testing, (like the one used in this study), assists students to eliminate examination anxiety and leads them to be more involved in their studies because formative tests help students to identify the essential areas of the instruction to learn. They also help students to understand the examiner and the nature of tests more, and raise their confidence in their abilities on the instruction before the final examination. Hence, formative tests help in reducing anxiety. 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 finding was that the feedback corrective strategy did not yield statistical significant difference in the achievement of the subjects, although the feedback group performed better than the control group.

The results also show that there is a significant effect of parental involvement in the students' achievement in Integrated science. Students whose parents show high

level of involvement performed significantly better than those students whose parents' were not as involved. It is logical to think that students of parents who provide both materials and suitable psychological environment are likely to perform better than the students whose parents do not provide learning materials and environment. This study supports that of Nye, Turner and Schwarts (2006) where they found that parent involvement is the active engagement of a parent with their child outside the school day in an activity which centers on enhancing academic performance. Christenson, Rounds and Gorney (1992) also found that parental involvement is the parent's participation in educational activities at both school and home. Epstein (1987) found that parents' activities like communicating with the teachers on classroom performance; parents' active attendance at school activities such as PTA; parents' engagement and monitoring of home learning activities and parents' participation in school – based decision making such as school committees provide psychological support for the child and the child can learn better.

Conclusion and Recommendations

Feedback with remediation has been found to be more facilitating in improving learning outcomes than feedback alone; which in turn has been found to be more facilitating than teaching with formative testing alone. 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 current 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. There is a significant effect of parental involvement in the students' achievement in Integrated science in favour of the involved parents (high level of involvement) it is therefore recommended that parent should be involved in provision of educational materials that can be used by students in their academic work.

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