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Interaction Effects of Instructional Mode and School Setting on Students' Knowledge of Integrated Science

Tim E. Agboghoroma[i]
Department of Science Education, Delta State University, Abraka, Nigeria.

Abstract

This study examines the interaction effects of instructional mode and school setting on students' knowledge of integrated science. The sample consisted of 360 JS III students drawn from six secondary schools located in urban and rural school settings. The study design was a quasi-experimental 2 x 2 non-randomized pretest-posttest control group. The test of knowledge in integrated science (TKIS) was used as the instrument and was designed by the researcher. Analysis of covariance (ANCOVA) was used to analyze the data. The null hypotheses formulated were tested at the 0.05 level of significance. Multiple classifications Analysis (MCA) was performed where the main effects were significant. The study revealed that there are significant interaction effects in terns of instrumental mode and school setting on students' knowledge of integrated science.

Keywords: Interaction effects, school setting, instructional mode, students knowledge, intact class, quasi-experiment and pretest-posttest.

INTRODUCTION

Science is an essential tool for any nations' progress and development (Onyeador, 1997; Otini, 1997; Imiere, 2004, Chukwuneke, 2008, Agboghoroma, 2008; Agboghoroma, 2009). Hence, nations all over the world continue to strive to ensure a steady improvement in their science curriculum in classrooms. Globally, science education programmes have afforded tremendous opportunities to young scientists in-training in terms of the acquisition of skills for solving, in particular, environmental problems. Among these skills is the provision of much needed scientific and technological know-how to younger generations.

Integrated science as a science discipline is relatively new in the Nigerian context and is used as a means of inculcating scientific facts and ideas in students. Its introduction in the school curriculum dates back to 1968 and the teaching of integrated science has since gained ground in learning institutions at both the junior secondary school (JSS) and tertiary levels.

Several educators, including Okoye (1989), Adeyemi (1990), Ughamadu (1990), Urevbu (1990) and Umeoduagu (1994), have emphasized that the major objective of science education is the development of science process skills amongst school-aged children. Students' knowledge of integrated science and the sciences in general (or lack thereof) may be attributed to several learning factors including the shortage of scientific equipment, lack of laboratory facilities, cognitive functioning of students, home conditions, peer group behaviour, school conditions, teachers' methodology/pedagogy, and emotional predisposition of students. Additionally, the manner in which the subject is presented to students can significantly influence their interest and knowledge. While the manner of presentation is supposed to be activity-based, but most Nigerian secondary school teachers rely on lecture/expository methods. Studies like those of Ajeyalemi (1983), Kay (1986),

Umeoduagu (1994), Okobia (2000), Akpochafo (2001) and Arisi (2002) have pointed out that despite the thirty year existence of learning style theories (detailing how people learn), most teachers still dispense information using traditional lecture methods without regard to students' learning abilities. These teaching methods are theoretical, extremely didactic and teacher-directed, instead of being experimental or activity-based. A study of teaching behaviour and students' achievement in science by Akuezuilo (1984), shows that student activities are better than teacher activities in promoting authentic learning, at least in junior secondary school integrated science classrooms.

Also playing an important role in students' knowledge is school setting. School setting in this study refers to the location of schools (whether urban or rural). The location of a school can influence a child's knowledge of the sciences (Ozurumba, 1982; Inomiesa, 1984; Teasdale, 1988; Adedayo, 1997 and Akpochafo 2001) as well as general knowledge and attitude. Studies carried out by Adedayo (1997) and Akpochafo (2001) showed that students from urban centres had higher scores on Raven standard progressive matrices than rural students and that the environment influences a child's intellectual development in school.

Arisi (2004), in a related study on the effects of instructional methods and cognitive style on students academic achievement in junior secondary social studies, examined three methods - Advanced Organizer (ADO), Problem Solving Inquiry (PSI) and Activity Discussion Method - and found that all three had significant effects when compared to the Expository Lecture Method (ELM), Students taught with the first three methods out performed those taught with the Exposition Lecture Method. This study, however, differs somewhat and investigates the interaction effects of two teaching methods, Guided-Inquiry (activity method) and Expository Lecture Method, as well as school setting (urban or rural) on students' knowledge of integrated science. That is, the researcher wanted to know what kind of interaction would exist when these teaching methods are used in the context of different settings. It is against this background that this study has been conceived.

In an attempt to ascertain differences in the intelligence level of urban and rural subjects, Obemeata (1976) administered an intelligence test on urban and rural students and found that subjects from the urban schools faired better. Ehindero (1982) believed that the interaction of individuals with their habitat and group-shared behaviour patterns influence the rate of intellectual development. In another study, Abdullahi (1982) constructed a standard test for

schools in urban and rural areas. He sampled 726 students from both rural and urban schools and determined that students from urban schools out performed students from rural schools. In a more specific approach, Adeyemi (1990) carried out an empirical study on the effect of school setting on students' attitude to biology. Although part of her findings seemed not to have supported urban over rural dominance in attitude formation, the posttest score did favour the urban subjects in terms of attitudes towards biology.

In another development Agboghoroma (2005), in trying to ascertain the knowledge acquisition of urban and rural subjects in integrated science, used 360 JSS III students exposed to the guided-inquiry method as well as students not exposed to the inquiry method and, with the use of covariance adjustment, found that there was a significant difference (improvement) in the knowledge acquisition of the exposed urban students. Studies carried out by Okobia (2000), Akpochafo (2001) and Arisi (2002), also on the efficacy of instructional modes on students' achievement in school subjects, corroborated with this finding.

Start's (1972) conclusions, however, do contrast these findings. Start focused on the effectiveness of teaching methods in developing a better knowledge of science and measured students' knowledge before, during and after the use of the inquiry method to isolate the effect of methods on knowledge. The study was conducted with 173 ninth-grade biology students for an eight-week period. Using covariance adjustment, he found that there was no significant difference in knowledge of biology between high ability ninth-grade students exposed to the inquiry technique and similar students not exposed to the technique. Likewise, in an attempt to determine the effect of instructional strategies on the biology knowledge acquisition of Nigerian secondary school students, Ibegbulam (1980) found that there was no difference in knowledge between the two groups who took part in the study. While evaluating the biology component of the Nigerian secondary school science project (NSSSP), Adeyemi (1984) compared the effect of instructional methods (activity-centred versus traditional mode) on cognition, achievement and attitude of students towards biology. Part of her findings revealed that there was no significant difference in the attitude of the two groups of students towards biology. A study carried out by Akpochafo (2004), on the interaction effects of gender and guidance techniques in fostering appropriate occupational choice, using 183 students drawn from four secondary schools and covariance adjustment, found that there was no significant difference between

gender and technique in fostering occupational choice among students.

From the above review, it is clear that some studies favour the use of certain instructional techniques in promoting science knowledge acquisition while others do not. Unfortunately, studies that probe the interaction effects of instructional mode and school setting on students' knowledge in the sciences have not received enough attention in existing literatures. The present study therefore sought to determine if significant interaction effects exist between urban and rural school settings and guided-inquiry and conventional expository modes of instruction on students' knowledge of integrated science. The study was designed to bridge the gap in existing and conflicting findings as well as to add to the literature on interaction effects on students' knowledge of integrated science in urban and rural school settings. It is also the researcher's view that there is dearth of literature on interaction effects, especially in the area of integrated science in Nigeria and elsewhere, hence this study.

RESEARCH HYPOTHESIS

The following null hypotheses were formulated for the study:

1. There is no significant main effect of school setting on students' knowledge of integrated science.
2. There is no significant main effect of instructional mode on students' knowledge of integrated science.
3. There is no significant interaction effect of instructional mode and school setting on students' knowledge of integrated science.

RESEARCH METHODOLOGY

The study design was a quasi-experimental non-randomized pretest-posttest control group design. It made use of a 2 x 2 factorial design with the independent variables being the two levels of instructional mode (guided-inquiry versus expository) and school setting (urban versus rural). The dependent variable was knowledge in integrated science. The following table shows the variable construct of the design:

Table 1: Table showing a summary of the variable constructs

School setting	Treatments (X)	
	Guided-inquiry method E(Experiment group)	Expository Method C(Control Group)
Urban	O_1 x O_2	O_3 O_4
Rural	O_1 x O_2	O_3 O_4

KEY
E	=	O_1 x O_2
C	=	O_3 O_4
E	=	Experiment group exposed to guided-inquiry method
C	=	Control group taught with expository method
O_1 O_3 =		Pre-test measures
O_2 O_4 =		Post test measure
X	=	Treatment

The study employed a 2 x 2 factorial design as shown above. The design was not a "true" experimental design, as the experimental and control groups were not composed through a randomization process. Nonetheless, it was possible to randomly assign members of the groups (classes) of students as either experimental or control. While this approach is capable of creating unequal groups, the Analysis of Covariance (ANCOVA) statistic, where appropriate, is able to adequately address this.

In the pretest-posttest design, there are factors in the form of extraneous variables capable of lowering the internal and external validity of the design. These shortcomings were however, addressed in this study with the inclusion of a control group. Thus, with the two groups being equivalent, the "clouding" or confounding effects of extraneous variables should ordinarily be equally present in both groups, or should cancel each other out. Still, to ensure ultimate equivalence of the groups, the employment of ANCOVA and Multiple Classification Analysis (MCA) was necessary.

The target population for this study was JSS III students in secondary schools in the Delta State. The

sample was drawn from six junior secondary schools, three urban and three rural. The six schools used were randomly selected through balloting. All of the schools were mixed (attended by both males and females) secondary schools. The sample for the study was made up of 360 JSS III students from urban and rural schools. In each school, an intact class was used as either the experiment or control group. For clarification purposes, intact classes are used in quasi-experimental studies such as this. In this study, no school had more than one treatment group. This decision was taken in order to avoid the problem of contamination, which might occur as a result of having more than one treatment group per school. Hence intact classes were used. Out of the total of 360 JSS III students, 180 were each identified as either urban or rural students. All of the students had an average mean age of 13 years.

The Test of Knowledge in Integrated Science (TKIS) was used as the instrument for measuring in-depth knowledge of the subject matter. The test rated students on knowledge acquisition including their ability to recognize specific and universal elements and recall facts, names, principles and terminologies in a teaching-learning situation. This instrument was designed by the researcher and used during the treatment period. The instrument consisted of two sections. Section A dealt with demographic information such as name of school, name of Local Government Area (LGA) and school location i.e. urban or rural. Section B consisted of a test of knowledge in integrated science, asking students to indicate their level of agreement or disagreement with statements like "plant resources are of four major types", "vegetables are grown for their leaves, fruits, stems and roots", "animals in general are a source of protein, and "the word 'hide' refers to the skin of large animals like cattle, horses and camels while 'skin' refers to the skin of smaller animals like goats, sheep and rabbits". The test employed a modified Likert scale in which respondents were required to place themselves along a four-point continuum of strongly agree (4-points), agree (3-points), disagree (2 points) and strongly disagree (1-point) for positively worded statements and the reverse for negatively worded statements. In order to derive this instrument, a table of specification was made to test the items in terms of whether they met the demands of Bloom's taxonomy of educational objectives in the cognitive domain. Below is such a table of specification for the TKIS.

Table 2: Table of specification for TKIS

TOPIC SECTION	INTELLECTUAL OBJECTIVES (COGNITIVE DOMAIN)						TOTAL
	Knowledge 51%	Comprehension 31%	Application 9%	Analysis 2%	Synthesis 2%	Evaluation 5%	
Resources from plants 9%	2	1	1	-	-	-	4
Resources from animals 7%	1	1	1	-	-	-	3
Resources from cash crops 7%	1	1	-	-	-	1	3
Preservation of food crops and animals 13%	3	2	1	-	-	-	6
Adaptation of mouth parts for feeding 22%	6	3	1	-	-	-	10
The manufacture of food by plants 11%	2	2	-	1	-	-	5
Symbols of elements 11%	2	2	-	-	-	1	5
Chemical formula 9%	2	1	-	-	1	-	4
Chemical equation 11%	4	1	-	-	-	-	5
Total	23	14	4	1	1	2	45

As shown in the table, while the test was made to cover the six objectives, most of the items were clustered around the first three objectives - knowledge 51%, comprehension (31%) and application (9%), all totaling (91%). The last three levels attracted the following degrees of patronage – analysis (2%), synthesis (2%) and evaluation (5%), all totaling (9%).

This was borne from the fact that the junior secondary school level emphasized the first three cognitive domains far more than the last three levels.

The items in the TKIS were scored by weighting positive items from 4 for strongly agree to 1 for strongly disagree. The weights were reverse for negatively worded items. A maximum score of 146 and

a minimum score of 78 were expected from the instrument. While scores below 123 were considered to indicate low knowledge of integrated science, scores between 123 and 146 reflected high knowledge. The test items were validated by specialists in the field of science education, measurement and evaluation as well as experienced integrated science teachers. The test was then administered to 50 JSS III students and their numerical scores were used to determine the reliability co-efficient using the Cronbech co-efficient alpha, which yielded an estimate of 0.87 and was considered adequate for the study. The treatment groups were the experiment and control. The experiment group was taught by the researcher while the control group was taught by the respective teachers in the sampled schools. Before the commencement of the teaching, the TKIS was administered to the experiment and control groups and the scores were recorded as pre-test (covariate). The information gathered in the pretest was used to determine the equivalence of the groups in terms of the knowledge of students on the topics covered during the treatment period. In this study, the experiment group received the guided-inquiry instructional mode while the control group received the conventional expository mode of instruction. As noted earlier, three of the sampled schools served as experiment groups while three served as control groups.

The schools were each allocated three 40-minute lesson periods per week and the materials used for the study consisted of a ten-week instructional unit. A guide outlining instructional strategies aimed at satisfying the objectives of the programme and copies of students' materials were provided to class teachers. The instructional time to be spent on classroom activities was also indicated. At the end of treatment period, the main treatment group and the control group were administered a post-test (the post-test was the TKIS designed by the researcher and administered first as a pretest).

The study's hypotheses were tested using a variety of statistical tests for significance including the Analysis of Covariance (ANCOVA). ANCOVA was selected for a number of reasons. ANCOVA is the best instrument for analysis that is based on adjusted pretest scores using post-test measures. ANCOVA can test the significance of differences among means of final experimental data. It also removes the effect of any environmental source as such variation could inflate the environmental error. Thus, the researcher in this study used ANCOVA to ensure that the results were not attributed to other factors such as differences in individual teaching approaches during the experiment. Multiple Classification Analysis (MCA) was also used to ascertain the direction of the difference when any of the tests were significant. The three hypotheses were tested at 0.05 alpha levels.

RESULTS

The results of the data analysis are presented in relation to the three hypotheses generated for the study.

HO$_1$:   There is no significant main effect of school setting on students' knowledge of integrated science.

Table 3: Summary of ANCOVA Table of Analysis showing main and interaction effects of instructional mode and school setting on students' knowledge of integrated science

Sources of variation	Sum of squares	df	Mean squares	F	P
Covariates	74373.203	1	74373.203	1452.288	0.000
Pretest	74373.203	1	74373.203	1452.288	0.000
Main effects	5030.283	3	1676.761	32.742	0.000*
Instructional Treatment (IT)	1658.426	1	1658.426	32.384	0.000*
School Setting (SS)	272.258	1	272.258	5.316	0.000*
2-way Interaction	3402.402	3	1134.134	22.146	0.000*
IT x SS	320.556	1	320.556	6.260	0.013*
Explained	83223.318	8	10402.915	203.138	0.00
Residual	17975.082	351	51.21		
Total	101198.400	359	281.890		

*Significant at P < 0.05

Table 3 reveals that there was a significant main effect of school setting on students' knowledge of integrated science (F_1, 359 = 5.316; P < 0.05). Thus, Hypothesis One was rejected. This means that there is a significant main effect of school setting on students' knowledge of integrated science. A closer look at the multiple classification analysis (Table 4) indicates that urban students had an adjusted post-test mean score of 124.52

(i.e. 123.60 + 0.92) while rural students had an adjusted post-test mean score of 122.68 (i.e. 123.60 -

0.92). It also shows that school setting accounted for only 0.36% that is $(0.06)^2$ of the variation.

Table 4: Multiple Classification Analysis (MCA) for instructional treatment and school setting on students' knowledge of integrated science

N = 360, Grand Mean = 123.60

Variable + category	N	Unadjusted Dev'n	Eta	Adjusted for independents + covariates Dev'n	Beta
Instructional treatment					
1. Guided-inquiry	180	4.12		2.33	0.14
2. Expository	180	-4.12	0.25	-2.33	(1.96%)
School setting					
1. Urban	180	-0.83		0.92	0.06
2. Rural	180	0.83	0.05	-0.92	(0.36%)
Multiple R				0.785	
Squared Multiple R				0.886	

HO$_2$: There is no significant main effect of instructional mode on students' knowledge of integrated science.

In testing this hypothesis, the 2 x 2 ANCOVA summary data presented in Table 3 was considered. The Table revealed that there was a significant main effect of instructional mode on students' knowledge of integrated science (F_1, 359 = 32.384; p<0.05). Thus, Hypothesis Two was rejected. This means that there is a significant main effect of instructional treatment on students' knowledge of integrated science. A closer look at the multiple classification analysis in Table 4 indicates that the guided-inquiry instructional treatment had an adjusted post test mean score of 125.93 (i.e. 123.60 + 2.33) while the expository mode had an adjusted post test mean score of 121.27 (i.e. 123.60 – 2.33). It also shows that the guided-inquiry (activity-oriented) instructional treatment accounted for (1.96%) or $(0.14)^2$ of the variation on the post-test scores. Based on the results of this study, the instructional treatment

made a difference in terms of students' knowledge of integrated science.

HO$_3$: There is no significant interaction effect of instructional mode and school setting on students' knowledge of integrated science.

Table 3 (above) shows that there was a significant interaction effect of instructional mode and school setting on students' knowledge of integrated science (F_1, 359 = 6.260; P<0.05). Thus, Hypothesis Three was rejected. This means that there was a significant interaction effect of instructional mode and school setting on students' knowledge of integrated science. This, in turn, implies that instructional mode and school setting depend on each other significantly in terms of the knowledge of students in integrated science. The nature of interaction is shown graphically below.

The graph, as shown below, suggests ordinal interaction meaning that there is no appreciable crossing of the lines connecting the means.
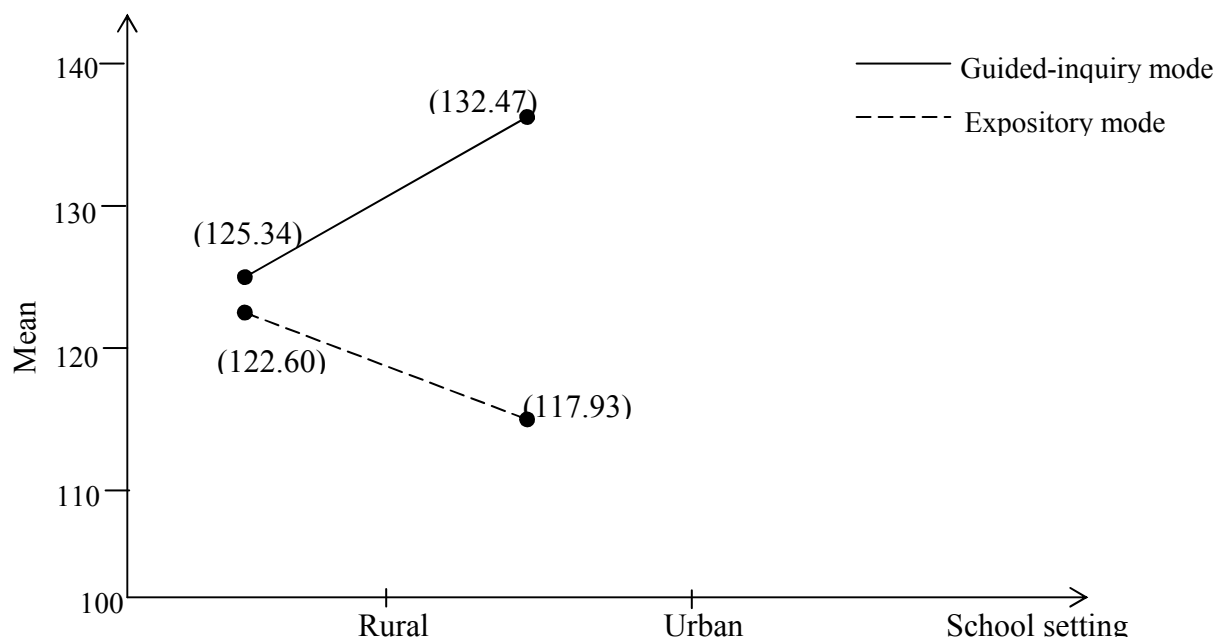
Fig 1: Interaction of instructional mode and school setting (cell means in bracket).

DISCUSSION

This study investigated the interaction effects of instructional mode and school setting on students' knowledge of integrated school. The first hypothesis predicted that there would be no significant main effect of school setting on students' knowledge of integrated science. The findings of the study reveal that there was a significant effect of school setting on students' knowledge of integrated science. This finding corroborates Obemeata (1976), Ozurumba (1982), Inomiesa (1984), Abdullahi (1982), Teasdale (1988), Adedayo (1997) and Akpochafo (2001) who reported that school location has significant effects on a child's knowledge, attitude, performance and achievement in the sciences and other school subjects. The findings also concurs with Adedayo (1997) and Akpochafo (2001) who reported that school location and the environment significantly influence students' performance and achievement in school. The finding conforms with Agboghoroma (2005), who reported that urban students significantly out performed rural students' in the acquisition of knowledge in integrated science.

Nonetheless, Adeyemi (1990) has not agreed with these many findings. In her study, she concluded that urban subjects did not perform better than rural subjects in biology achievement when covariance adjustment was used in the analysis. These findings imply that the effect of school setting on students' knowledge of integrated science has not received sufficient attention by researchers and hence this researcher advocates that more studies be carried out in this area.

Hypothesis Two postulated that there would be no significant main effect of instructional mode on students' knowledge of integrated science. The findings of the study showed that there was a significant effect of instructional mode on students' knowledge of integrated science. The finding aligns with the conclusions od Okobia (2000), Akpochafo (2001), Arisi (2002) and Agboghoroma (2005) who reported that the use of instructional modes/strategies significantly enhanced the performance of students' in secondary school. The finding implies that the use of instructional strategies has positive effects on student's academic performance.

Hypothesis Three predicted that there would be no significant interaction effects of school setting and instructional mode on students' knowledge of integrated science. The findings revealed that there was a significant interaction effect of school setting and instructional mode on students' knowledge of integrated science. This finding differed from the findings of Adeyemi (1990) and Akpochafo (2004) in terms of the interaction of school setting and instructional mode on students' attitude towards biology and the interaction of gender and guidance techniques in fostering appropriate occupational choice among students. This was because no significant interaction effects existed between school setting and instructional mode in terms of students' attitude to biology and likewise no effects existed between gender and guidance techniques in fostering appropriate

occupational choices. The implication is that interaction studies, especially in the area of school setting and instructional strategies in the sciences, have not received enough attention as the literature thus far reports very few findings on the interaction effect of school setting and instructional mode on students' knowledge in the sciences and on integrated science in particular.

In terms of the effect of the interaction of school setting and instructional mode on students' knowledge of integrated science, the findings suggest that school circumstances require well-suited types of instructional modes. This, in turn, implies that teachers should plan learning activities that best suit their school setting when selecting the materials to be used in the teaching of integrated science. Since the guided-inquiry mode of instruction has been found to enhance students' knowledge in integrated science learning, more than the expository mode of instruction, it becomes clear that a balance should be made between the two modes of instruction when planning learning experiences for students in different school settings. Teachers should consider these variables dependently when selecting and presenting integrated science learning materials in the classroom.

CONCLUSION AND RECOMMENDATIONS

This study established that the effects of school setting and instructional mode as well as the interaction effects of school setting and instructional mode significantly influence students' knowledge of integrated science. The study revealed that the school setting (urban or rural) influences students' knowledge of integrated science. This study has determined that urban school location does positively influence students' knowledge of integrated science. Students in urban schools significantly out-performed students in rural schools in their knowledge of integrated science. This study also revealed that instructional mode has a significant influence on students' knowledge of integrated science. The findings revealed that guided-inquiry (activity-oriented) instructional strategies promoted a deeper knowledge of integrated science amongst students in the classroom. The study also revealed significant interaction effects of school setting and instructional mode on students' knowledge of integrated science implying that both variables should be considered when presenting integrated science materials in the classroom.

Based on the findings of the study, it is recommended that integrated science teachers and science teachers in general take into consideration these variables when presenting integrated science and science materials in the classroom. Since the efficacy of instructional mode has been established in this study, integrated science teachers, as well as science teachers more broadly, are advised to use the guided-inquiry instructional mode in teaching as students' interest, positive attitude formation and knowledge of the sciences would be enhanced. The author also recommends that more studies be carried out on interaction effects of school setting and instructional mode in Nigeria with a view to adding to the sparse literature on scientific education.

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[i] Dr. Tim E. Agboghoroma is a lecturer in the Department of Science Education, Delta State University, Abraka, Nigeria. He can be reached on Tel: +23408034062706, +23408027944716, Email: timagbos@yahoo.com