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# Effects of two teaching methods on the achievement in and attitude to biology of students of different levels of scientific literacy

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**Abstract**

The study was designed to investigate the relative efficacy of the guided inquiry and the expository teaching methods on the achievement in and attitude to biology of students of different levels of scientific literacy. Four research questions and four null hypotheses were posed and formulated respectively, to guide the work. It was hypothesized that effects due to teaching methods and their interactions with scientific literacy levels, were not significant ($P < 0.05$), relative to students' mean achievement and attitudinal scores in biology. A pre-test, post-test, non-equivalent control group design was adopted for the study. One hundred and forty-seven Senior Secondary Two (SS11) biology students from eight intact classes, randomly selected from four secondary schools in Nsukka, Enugu State, Nigeria, constituted the sample.

Three instruments namely: Scientific Literacy Test (SLT), Biology Achievement Test (BAT) and Attitude to Biology Scale (ABS), were used for data collection. The research questions were answered using mean and standard deviation scores, while the hypotheses were tested ($P < 0.05$) using analysis of covariance (ANCOVA). The results showed that the guided inquiry method was significantly better than the expository method in enhancing cognitive achievement in biology for students of all levels of scientific literacy, especially the high ones. Students of different levels of scientific literacy showed positive attitude to biology, when the two methods were used. The interactive effects of teaching methods and scientific literacy levels, on both achievement in and attitude to biology, were

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not significant ($P < 0.05$). The educational implications of the findings for biology teachers were highlighted.


Keywords: Guided inquiry; Expository; Achievement; Attitude; Biology; Scientific literacy

## 1. Introduction

The major aim of teaching is to promote the understanding of the concept being taught with a view to applying knowledge of such understanding to real life situations. Science teaching in Nigerian secondary schools is done in two parts: the junior and the senior secondary schools. At the junior secondary school level, science is taught in a holistic form as integrated science, while at the senior secondary school level, science is taught as physics, chemistry, and biology. The integrated science curriculum is expected to provide the relevant foundation on which secondary school students would build careers in science or science related disciplines. Research evidence indicates that there is a great difference between what is taught and what is learned, and that students achieve poorly in secondary school science subjects especially biology (Adegbeye, 1993; Ajaja, 1998) and also show negative attitude to it (Aghadinuno, 1985; Aigbomian, 1987). A number of reasons were given for the trend, some of which include, lack of instructional materials, unconducive teaching and learning environment, and use of inappropriate teaching methods, among others. These result in consistent poor performance in and negative attitude towards science subjects. These also attest to the fact that science teaching has not been properly done. This improper science teaching has led to a vigorous search for appropriate teaching methods that will best achieve the aim of science teaching, thereby improving performance and enhancing positive attitude towards science subjects including biology. The above researchers express the view that teachers shy away from activity-oriented teaching methods that are known to be effective, and rely on the teaching methods that are easy but most times inadequate and inappropriate. Based on this, several attempts have been made to investigate the effectiveness of teaching methods on achievement in biology (Akubuilo, 1995; James & Shaibu, 1997; Oke, 2003). Results from these investigations indicate that innovative teaching methods such as inquiry, problem solving, and concept mapping were more effective than the lecture/traditional method in enhancing cognitive achievement in biology. Some teachers may have tried to use these innovative methods for teaching biology without achieving any appreciable improvement in the general performance of these students.

However, giving that Nigerian secondary school science teachers were not originally trained to use these innovative teaching methods, there is doubt as to their effectiveness in using them. Hence, cognitive achievement of students in science has not been improving (Njoku, 2005). Consequently, the guided inquiry method has been recommended for use in teaching science in both primary and secondary school curricula (Federal Ministry of Education, 1985). The objectives of the current biology curriculum derived from the National Policy on Education (FRN, 2004), strive to prepare the students to:

(a) Acquire adequate laboratory and field skills in biology.
(b) Meaningful and relevant knowledge in biology.

(c) Ability to apply scientific knowledge to every day life in matters of personal and community health and agriculture.
(d) Reasonable and functional scientific attitude.

The above objectives are also expected to groom the students, to some extent, for scientific literacy. Therefore, students are expected to acquire a certain level of scientific literacy in the course of their biology learning.

As the nation strives towards science and technological growth and national development in the 21st century, the role of the biology teacher becomes more imperative. Unless the biology teachers are well grounded in the content area, they may not be able to impart the right kind of knowledge and other relevant information that are required by learners in the 21st century. Learners on their own part may not be able to lead the way towards science and technological development, when they are not properly taught (Mkpa, 1999). Based on these, the search for appropriate teaching methods and comparison of their relative efficacies in promoting achievement in and attitude to science subjects, including biology, becomes necessary. Hence this study investigates the relative efficacy of the guided inquiry and the expository teaching methods, on achievement in and attitude to biology, using students' levels of scientific literacy as criteria.

The guided inquiry method is a student-centered, activity-oriented teaching strategy, in which the teacher uses varieties of instructional materials and probing questions, to enable students discover answers to the problems at hand. It allows interactions between the teacher and the students and amongst students themselves. This method is challenging, and facilitates achievement and transfer of what is learned (Ajewole, 1990). The guided inquiry method places the teacher as the overseer and facilitator of learning, and as the mediator between the students and the instructional materials for the lesson. The method is said to have the capacity to promote critical thinking and objective reasoning, which are necessary for successful living in the society.

The expository method on the other hand, is a method of teaching in which the teacher delivers pre-planned lesson to the students with little or no instructional aids. It is a teacher-centered approach, which places the teacher as the sole possessor of knowledge, and the students as passive recipients of knowledge. In using this method, the teacher talks about science while the students read about science (Gbamanja, 1991). Modern expository method, however, allows little interaction between the teacher and the learners. This method is not challenging and may not promote objectivity and critical thinking abilities in the students. It may not also enhance achievement or promote positive attitude to biology.

Achievement in teaching/learning process has to do with the attainment of set objectives of instruction. Most attempts at improving teaching methods aim at helping students to achieve and to develop positive attitude to school subjects including biology. Attitude according to Seifert (1991) is the acquisition of certain feelings about something or someone, either positive or negative that influences his/her choice of action in a consistent way. That something may be a concept/subject like biology. Consequently, a student who shows positive attitude to biology makes many choices favoring biology such as: attending biology lessons, being eager to do biology assignments, liking the biology teacher and loving nature. A combination of some of these factors would constitute his/her attitude to biology. However, both high achievement in and favorable attitude to biology are indicators of scientific literacy.

Lalitha (2001), perceived scientific and technological literacy to mean, developing the ability to creatively utilize science knowledge in everyday life to solve problems, make decisions and hence improve the quality of life. According to the National Science Education Standards (2005, p. 22), scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs and economic productivity. It also includes specific types of abilities. The Content Standards of the National Science Education Standards, went further to state that, scientific literacy means that a person can ask questions derived from curiosity about everyday experiences and has the ability to describe, explain and predict natural phenomena. They also specified a number of things scientific literacy should entail.

Scientific literacy in the context of this study is defined as, ones ability to understand and appreciate the nature and scope of scientific knowledge and apply such knowledge in decision making and problem solving in his/her personal and civic life. It also involves effective communication in science and appreciation of the role of science in the society. Based on this definition, four aspects of scientific literacy were considered in this study, namely: knowledge of science; application of science; communication in science; and appreciation of the role of science in the society.

The study assumes that at the secondary school level, students may have acquired some level of scientific literacy through science learning, which could be used for assessing their performances when different teaching methods are used. Indeed the goal of science as stated in the Nigeria's National Policy on Education, emphasizes scientific literacy (FRN, 2004). The foundation for achieving this goal is laid in the secondary schools through science teaching. Proper education in science or technology is reflected on the level of achievement in different science content areas. Therefore, educational/curriculum planners should be scientifically and technologically aware, to enable them know the aspects of the contents of science and technology that should go into the secondary school curriculum. This is necessary since the students are being groomed to be able to fend for themselves, and also to live functionally in the modern society that is science and technology oriented.

In biology, scientific topics such as, green house effects, population explosion, depletion of the ozone layer, pollution from acid rains, are already incorporated into the curriculum. If these topics were properly taught and discussed in class, they would create greater awareness in the students and prepare them better for discussions on such issues at the national or global level. Research works have indicated that Nigerian science teachers have a clear perception of what scientific literacy is and are scientifically literate, but the science students are scientifically illiterate (Nwagbo, 1995, 2002). The teachers are therefore in position to inculcate scientific literacy into their science students in the course of teaching. However, secondary school students have some levels of scientific literacy and can be categorized as having high, medium and low levels of scientific literacy, using some acceptable criteria. A study of the interactive effects of students' levels of scientific literacy and teaching methods would reveal the true efficacies of the teaching methods as practically applicable to students of different personality characteristics. Thus, the results of this study are expected to yield more insight into the true effects of the guided inquiry and the expository methods on students' cognitive achievement in and attitude to biology. There was paucity of literature on the use of the above methods on students of different levels of scientific literacy, hence the need for the study.

### 1.1. Research questions

The following research questions guided this study:

1. What are the comparative effects of teaching methods (guided inquiry and expository) on the mean achievement scores of students of different levels of scientific literacy, in biology?
2. What are the interactive effects of teaching methods and scientific literacy levels, on students' achievement in biology?
3. What are the comparative effects of teaching methods (guided inquiry and expository) on the mean attitudinal scores of students of different levels of scientific literacy, in biology?
4. What are the interactive effects of teaching methods and scientific literacy levels, on students' attitude to biology?

### 1.2. Hypotheses

Four null hypotheses guided the work:

1. There is no statistically significant difference ($P < 0.05$) in the mean achievement scores of students of high, medium and low levels of scientific literacy taught biology using guided inquiry method and those taught biology using the expository method.
2. There is no statistically significant interaction ($P < 0.05$) between teaching methods and scientific literacy levels, on achievement in biology.
3. There is no statistically significant difference in the mean attitudinal scores of student of high, medium and low levels of scientific literacy, taught biology using the guided inquiry method and those taught biology using the expository method.
4. There is no statistically significant interaction between teaching methods and scientific literacy levels, on attitude towards biology.

## 2. Methods

### 2.1. Research design

The design of this study is quasi-experimental. Specifically, the pre-test, post-test, non-equivalent, control group design was used. This study was conducted in Nsukka, Enugu State, Nigeria. The sample consisted of one hundred and forty seven (147) SS11 biology students from eight intact classes randomly sampled from four senior secondary schools in Nsukka. Both simple and stratified random sampling techniques were employed in constituting the sample.

### 2.2. Instruments

Three instruments namely: Biology Achievement Test (BAT), Attitude to Biology Scale (ABS), and Scientific Literacy Test (SLT), were used for the study. The Biology Achievement Test (BAT) is a 50-multiple choice test items, developed by the researcher

based on the biology concept taught (the digestive system). A test blueprint (Table 1) was developed based on the relative emphasis on each of the sub-topics in the curriculum.

BAT was subjected to both content and face validity. The content validity was accomplished by making sure that the test items reflected the specifications of the test blueprint. Face validation was accomplished by evaluation of the items by four experts from related fields of study in the University and four-experienced secondary school biology teachers. Through item analysis, a discriminatory power of 0.31–0.72 and difficulty index of 0.3–0.7 were obtained. The estimate of internal consistency of 0.77 was established using Kuder–Richardson formula 21 (K–R21).

The ABS was adapted from an attitude to science scale developed and validated by Ato and Wilkinson (1979). The scale was established for attitude study in Nigerian Secondary Schools and was adjudged to be suitable. The scale was modified to suit biology students of this study by restructuring the items referring to science/scientists to read biology/biologists. The original instrument consists of 48-items with a reliability coefficient of 0.96 established using the split-halt technique and the Spearman-Brown and Guttman reliability coefficient. The adapted instrument consists of 44 items rated on a 4-point Likert-type scale with the following response types: SA = strongly agree; A = agree; D = disagree, and SD = strongly disagree. For each positive statement, SA = 4, A = 3, D = 2, and SD = 1. The scoring was reversed for negative statements. From the scoring, a student with moderate attitude to biology will score $3 \times 44 = 132$ points because s(he) agrees with all the positive statements and disagrees with all the negative statements. Based on this, a raw score of 132 points becomes the cut-off mark for positive attitude to biology. The reliability of the instrument was re-established using coefficient (cronbach) alpha reliability estimate and the calculated value was 0.90.

Table 1
Test blueprint for BAT construction

| Topic (content) | No. of periods[a] | Sections | | | Total no. of items |
|---|---|---|---|---|---|
| | | Knowledge | Understanding | Higher cognitive process | |
| | | 30% | 34% | 36% | |
| Alimentary tract | 1 | 1 | 1 | 3 | 5 |
| Feeding habits | 1 | 3 | 1 | 1 | 5 |
| Saprophytic and parasitic feeding | 2 | 2 | 2 | 4 | 8 |
| Feeding in protozoa and hydra | 2 | 2 | 5 | 1 | 8 |
| Feeding in mammal | 2 | 2 | 3 | 2 | 7 |
| Digestion in man-including verification exercises | 3 | 4 | 4 | 6 | 14 |
| Absorption and assimilation of food substance | 1 | 1 | 1 | 1 | 3 |
| Total | 12 | 15 | 17 | 18 | 50 |

[a] 1 period = 60 min.

SLT was only used to categorize students into levels of scientific literacy. It consists of four sections—A, B, C, and D, each representing an aspect of scientific literacy being considered in this work as earlier stated. Sections A and B were composed of multiple-choice items based on knowledge and application of science, respectively; section C was composed of short essay questions based on communication in science; and section D was composed of positive and negative scientific statements, based on appreciation of science. Each of the sections was weighted differently, based either on the number or difficulty level of the items, thus:

$$\text{Section A} = 27\%, \quad \text{Section B} = 23\%, \quad \text{Section C} = 30\% \quad \text{and} \quad \text{Section D} = 20\%.$$

The total score for each candidate was converted to letter grade, based on the grading system as found in the students' report booklets. These letter grades formed the basis for categorization of students into levels of scientific literacy thus:

$$70\% \text{ and above} = \text{A (distinction)} = \text{High level of scientific literacy};$$
$$55-69\% = \text{C (credit)} = \text{Medium level of scientific literacy};$$
$$54-0\% = \text{P}-\text{F (pass to fail)} = \text{Low level of scientific literacy};$$

The reliability of each section of the scientific literacy test was established using appropriate statistical test. For sections A and B (multiple choice type)—Kuder–Richardson formula 20 (K–R, 20). According to Eze (2003), this formula is applicable to dichotomously scored items or where students have to make choice from alternative answers. Their reliability estimates were 0.71 and 0.76, respectively. For section C (essay type)—scorer (inter-rater) reliability estimate was used and the value was 0.93; while for section D (differently weighted items)—Cronbach alpha was used and the value was 0.70. Since reliability estimates of 0.65 is considered to be good (Mehrens & Lehmen, 1978), the above reliability estimates are therefore adjudged high enough for this study.

## 2.3. Procedure

The regular biology teachers of the selected schools trained by the researcher were used for the study. The training lasted for four weeks, covering 2 h per week, to ensure uniformity and mastery of the teaching guide. Each teacher was given copies of the validated lesson plans and also copies of the three instruments used for the study. The training for the two groups involved going through the lesson plans one after the other. For the guided inquiry group, varieties of instructional materials were used by the researcher, to illustrate the teaching while it was not so for the expository method group. Questions and suggestions were entertained from the teachers.

The SLT was administered, only as a pre-test, used for categorizing students into high, medium, and low levels of scientific literacy, according to the specifications given by the researcher. After this, the BAT and the ABS, were administered as pre-tests, before treatment commenced.

The main treatment for the study was teaching using guided inquiry and expository methods and lasted for six weeks. The experimental group was taught a biological concept—the digestive system, using the guided inquiry method. This involved grouping the students into five or six with each group provided with instructional materials (charts, real specimens, models etc.) needed for the lesson. The teaching featured introduction of

the topic, drawing attention to the instructional materials, use of probing questions, student questioning, and drawing of conclusions, and the teacher directing students' inconsistencies. Each activity was followed by a class discussion. The control group was taught the same biology concept, using the expository method. Here, the regular biology teacher delivered the pre-planed lesson to the students with little or no instructional materials. Interaction between the students and the teacher was minimal. The students listened and assimilated principles and procedures for the correct solutions to the problems.

Immediately after treatment, the BAT and the ABS were again administered to the students as post-tests and their scores were recorded.

## 3. Results and discussions

The results of the analysis of data are presented and discussed according to the four research questions and null hypotheses of the study.

Research question I, sought information on how teaching methods (guided inquiry and expository) affect the mean achievement scores of students in biology at different levels of scientific literacy. Hypothesis I states that, there is no statistically significant difference ($P < 0.05$), in the mean achievement scores of students of high, medium, and low levels of scientific literacy, taught biology using the two methods.

Comparison between the pre- and post-test mean achievement scores in Table 2, reveal that the guided inquiry method appears to significantly benefit students of high level of scientific literacy (HLSL) more than those of medium and low levels of scientific literacy (MLSL and LLSL), respectively. The benefits to the last two groups of students were minimal. The expository method on the other hand, favored (though little) the students of medium level of scientific literacy, more than the high and low level groups, respectively. As derived from Table 2, the changes from pre- to post-test scores for

> Guided inquiry method were : 33.5 (HLSL); 21.5 (MLSL); 17.1 (LLSL) and for Expository method : 16.1 (HLSL); 20.0 (MLSL); 14.9 (LLSL)

Table 2
Pre-test and post-test mean achievement and standard deviation (SD) scores of students in BAT due to teaching methods and scientific literacy levels

| Teaching methods | Types of test | Statistics | Scientific literacy levels | | |
|---|---|---|---|---|---|
| | | | High | Medium | Low |
| Guided inquiry | Pre-test | $\overline{X}$ | 29.23 | 28.00 | 20.18 |
| | | SD | 7.98 | 12.91 | 10.19 |
| | Post-test | $\overline{X}$ | 62.69 | 49.53 | 37.26 |
| | | SD | 9.07 | 16.02 | 10.45 |
| | | n | 13 | 34 | 38 |
| Expository | Pre-test | $\overline{X}$ | 38.65 | 23.12 | 21.67 |
| | | SD | 14.23 | 12.22 | 10.45 |
| | Post-test | $\overline{X}$ | 54.78 | 43.13 | 36.61 |
| | | SD | 12.75 | 14.13 | 15.74 |
| | | n | 23 | 21 | 18 |

These changes in scores indicate that, for each level of scientific literacy, the guided inquiry method produce a better score than the expository method, although small for medium and low levels. However, data in Table 3 reveal that the differences in the mean achievement scores of the different levels of scientific literacy students, taught using the two methods, were significant.

From the data, the main effect, teaching method, with F -value of 4.464 at 1 and 140 degrees of freedom, was significant ($P < 0.05$); the main effect, scientific literacy level with F-value of 7.666 at 2 and 140 degrees of freedom was also significant ($P < 0.05$). Based on these, the null hypothesis of no significant difference between teaching methods and scientific literacy levels on achievement in biology is rejected.

Since the difference in the mean achievement scores due to scientific literacy levels is significant, a post-hoc multiple range test (scheffe) was employed to determine the direction of the difference and is presented in Table 4.

The results show that, the mean achievement score for each scientific literacy level group differs significantly from each other, when the two teaching methods were employed. Therefore, the guided inquiry method is better than the expository method in enhancing cognitive achievement in biology.

Table 3
Analysis of covariance (ANCOVA) of students' overall achievement scores by teaching methods and scientific literacy levels

| Source of variation | Sum of squares | DF | Mean square | F | Signif F | Remarks |
|---|---|---|---|---|---|---|
| Covariates pre-test | 5645.117 | 1 | 5645.117 | 39.014 | 0.000 | |
| Main effects | 2469.057 | 3 | 823.019 | 5.588 | 0.001 | |
| Teaching method | 645.973 | 1 | 645.973 | 4.464 | 0.036 | * |
| Scientific literacy level | 2218.539 | 2 | 1109.269 | 7.666 | 0.001 | * |
| 2-way interaction | 211.737 | 2 | 105.868 | 0.732 | 0.483 | |
| T. method × sc. lit. level | 15652.066 | 6 | 2608.678 | 18.029 | 0.000 | |
| Explained residual | 20257.43 | 140 | 144.696 | | | |
| Total | 35909.496 | 146 | 245.955 | | | |

*Denotes significant difference at 0.05 level.

Table 4
Scheffe post-hoc multiple comparison test between three mean scores on overall achievement

| | Scientific literacy levels | | |
|---|---|---|---|
| | Low** | Medium* | High |
| Means | 37.2321 | 47.4545 | 57.2500 |

*Denote pairs of groups significantly different at the 0.05 level.

**The result of the test indicates that each of the levels of scientific literacy differs significantly from the other in terms of achievement in biology when the two teaching methods were employed. Thus the mean achievement scores of the low level group were significantly different from that of the medium and high level groups respectively. The mean achievement score of the medium level group also differed significantly from that of the high level group.

This finding is in agreement with results obtained in earlier studies (Akubuilo, 1995; James & Shaibu, 1997), which showed that the guided inquiry method produced higher mean achievement scores than the expository method for all cognitive ability levels. The researcher reasoned that although the students' cognitive ability level may not necessarily be the same as students' scientific literacy level, the two may have much in common. Based on this assumption, the result of this study may not be out of place. It may be that the guidance given to the guided inquiry group and the variety of instructional materials used for teaching, gave them an edge over their expository counterparts, by providing channels for objective reasoning and creative thinking ability that are likely to enhanced achievement in biology.

Research question 2 sought to know if there is interaction between teaching methods and scientific literacy levels, on achievement in biology.

Hypothesis 2 states that, there is no statistically significant interaction between teaching methods and scientific literacy levels on achievement in biology.

Data in Table 5 indicate that for all levels of scientific literacy students, the guided inquiry method seemed to have recorded higher mean achievement scores in BAT than the expository method. However, data in Table 3 confirm that there is no significant interaction between teaching methods and scientific literacy levels on achievement in biology. Studies on interactive effects of teaching methods and scientific literacy levels were not available to the researcher at the time of this study, so, there was no basis for comparison. However, science teachers need to select methods that enhance achievement and have the potentials for developing critical thinking and creative abilities in the students.

Research question 3 sought to find out the effects of teaching methods on the mean attitudinal scores of students of different levels of scientific literacy.

Hypothesis 3 states that, there is no statistically significant difference in the mean attitudinal scores of students of different levels of scientific literacy, taught biology using the two methods.

Data in Table 6 reveal that the two methods affect attitude towards biology very little. Comparison between the pre- and post-test mean attitudinal scores suggests that there is a marginal loss of attitude from the guided inquiry method and a slight gain of attitude from the expository method. The changes in attitude are:

| | High | Medium | Low |
|---|---|---|---|
| Guided Inquiry | –0.5 | –0.3 | –0.1 |
| Expository | 0.1 | 0.3 | 1.3 |

From the scores, it is obvious that the students in the guided inquiry group consistently lost scores across the scientific literacy levels after treatment, while the students in the expository group consistently gained scores. Although the changes in scores are minimal across the different scientific literacy level groups, they indicate that guided inquiry method tends to cause a negative shift in students' attitude to biology. That is, the higher the scientific literacy level, the more negative the shift, and vice versa. On the other hand, the expository method tends to produce a positive shift in students' attitude to biology. In this case, the higher the scientific literacy level, the less positive the shift and vice versa. These shifts in scores were shown not to be statistically significant in Table 7.

Table 5
Adjusted mean and standard deviation scores of students' achievement in biology by teaching methods and scientific literacy levels

| Teaching methods | Statistics | Scientific literacy levels | | |
|---|---|---|---|---|
| | | High | Medium | Low |
| Guided inquiry | n | 13 | 34 | 38 |
| | $\overline{X}$ | 23.46 | 21.62 | 17.42 |
| | SD | 8.18 | 16.55 | 11.70 |
| Expository | n | 23 | 21 | 18 |
| | $\overline{X}$ | 15.52 | 20.00 | 14.94 |
| | SD | 13.24 | 10.90 | 13.76 |

Table 6
Pre-test and post-test mean attitudinal and standard deviation (SD)

| Teaching methods | Types of test | Statistics | Scientific literacy levels | | |
|---|---|---|---|---|---|
| | | | High | Medium | Low |
| Guided inquiry | Pre-test | $\overline{X}$ | 81.77 | 80.4 | 79.04 |
| | | SD | 6.86 | 6.15 | 7.86 |
| | Post-test | $\overline{X}$ | 81.29 | 80.05 | 78.89 |
| | | SD | 5.47 | 8.51 | 7.86 |
| | | n | 13 | 34 | 38 |
| Expository | Pre-test | $\overline{X}$ | 84.36 | 79.74 | 76.96 |
| | | SD | 6.13 | 6.21 | 9.00 |
| | Post-test | $\overline{X}$ | 84.46 | 80.03 | 78.28 |
| | | SD | 12.88 | 6.97 | 8.01 |
| | | n | 23 | 21 | 18 |

Scores of students in ABS due to teaching methods and scientific literacy levels.

Table 7
Analysis of covariance (ANCOVA) of students' overall attitudinal scores by teaching methods and scientific literacy levels

| Source of variation | Sum of squares | DF | Mean square | F | Signif F |
|---|---|---|---|---|---|
| Covariates pre-test | 7719.727 | 1 | 7719.727 | 42.328 | 0.000 |
| Main effects | 246.036 | 3 | 82.012 | 0.450 | 0.718 |
| Teaching method | 77.314 | 1 | 77.314 | 0.424 | 0.516 |
| Scientific literacy level | 103.459 | 2 | 51.730 | 0.284 | 0.753 |
| 2-way interaction | | | | | |
| T. method × sc. lit. level | 25.904 | 2 | 12.952 | 0.071 | 0.931 |
| Explained | 9465.988 | 6 | 1577.665 | 8.651 | 0.000 |
| Residual | 25532.398 | 140 | 182.374 | | |
| Total | 34998.387 | 146 | 239.714 | | |

The data reveal that, the F-value for the main effect, teaching method is 0.424 at 1 and 140 degrees of freedom and is not significant ($P < 0.05$). For scientific literacy level, F-value of 0.284 at 2 and 140 degrees of freedom is also not significant ($P < 0.05$). Based on these, the null hypothesis of no significant difference between teaching methods and scientific literacy levels, on attitude to biology, is upheld.

Research results on the relationship between attitude and achievement in science (biology) among different ability level groups have not been consistent. The results of the present study are not in support of those of (Ajewole, 1991), which found a positive relationship between attitude and achievement in science among different ability level groups, in this case, scientific literacy level groups. The findings of this study indicate that, although all the students of different scientific literacy levels showed positive attitude for the two methods, there was a slight negative change in attitude for the guided inquiry group, and a slight positive change for the expository group. The reason for this trend may be attributed to the fact that there are more to scientific literacy than just inclination to or likeness for science/biology. Positive attitude to biology may not necessarily be attributed to high level of scientific literacy, just as negative attitude to biology may not be said to be as a result of low level of scientific literacy. This may probably be because, as had been earlier stated, scientific literacy is not only acquired through functional science/biology learning but also through informal activities such as involvement in scientific discussions, decision making in science and technology matters, and reading of scientific articles in newspapers and magazines.

Research question 4 sought information on the interactive effects of teaching methods and scientific literacy levels, on attitude to biology.

Hypothesis 4 states that, there is no statistically significant interaction between teaching methods and scientific literacy levels, on attitude to biology.

Table 6 data would seem to indicate some level of interaction between teaching methods and scientific literacy levels on attitude to biology, but data in Table 7 indicate that there is no statistically significant interaction between the two. From Table 7 data, the two-way interaction between teaching methods and scientific literacy levels is 0.071 at 2 and 140 degrees of freedom. This value is not significant ($P < 0.05$). Therefore, the null hypothesis of no significant interaction between teaching methods and scientific literacy levels on attitude to biology is upheld. It could be said that the differential loss in attitude for the guided inquiry group and the slight gain in attitude for the expository group, had no serious effect on the students of different levels of scientific literacy. Therefore, any of the teaching methods could be used for any of the levels.

Studies on interactive effects of teaching methods and scientific literacy levels on attitude to biology was not available to the researcher during the time of this study and therefore, there was no basis for comparison. However, one can say that since attitude, unlike interest, is cultivated over a long period and is not easily influenced, the biology students of this study may not have been affected much by the treatment (teaching using the two methods) giving the short period. Also, since almost all the science students in Nigeria offer biology for Senior Secondary Certificate Examination (SSCE), they may note likely show negative attitude to it. This may probably be because they must have to offer at least one science subject in their final examination, and biology is preferred to physics or chemistry, because they erroneously perceive it to be easier. This wrong perception may have resulted to the students taking the subject for granted, thereby performing poorly in it in spite of their positive attitude to it. One may therefore conclude that, the poor

performance of students in SSCE biology may not necessarily be as a result of negative attitude to the subject. There may be some other variables such as: overloaded curriculum, rigid school calendar, lack of laboratory equipment etc. that may lead to poor performance in biology.

## 4. Conclusions, summary and educational implications

The findings and discussions of the study served as the basis for making the following conclusions:

1. The guided inquiry method was significantly better than the expository method in enhancing cognitive achievement in biology for all levels of scientific literacy students.
2. There was no statistically significant interaction between teaching methods and scientific literacy levels on achievement in biology, based on BAT.
3. The guided inquiry method produced negative attitudinal shift in score while the expository method produced positive attitudinal shift in score, across the various levels of scientific literacy students. All the groups, however, showed positive attitude to biology for the two teaching methods.
4. There was no statistically significant interaction between teaching methods and scientific literacy levels on attitude to biology, based on ABS.

Based on the above conclusions, the following educational implications for science teachers were drawn. Science teachers should:

1. Endeavor to use guided inquiry method for teaching biology especially for high-level scientifically literate students.
2. Teach for inculcation of scientific literacy.
3. Teach for acquisition of positive scientific attitudes.
4. Select methods that will enhance achievement and has the potential for development of critical thinking and creative abilities in the students.

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