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Effects of Instructional Simulation on Secondary School Students' Achievement in Biology

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Abstract
This study explored the effect of instructional simulation on secondary school students' achievement in biology. The study adopted a pretest, post-test, non equivalent control group design. Three research questions and three null hypotheses guided the study. A total of one hundred and thirty nine (139) secondary school biology students drawn from two coeducational schools in Abakaliki Education zone were used for the study. One school was assigned to treatment group, while the other school was assigned to control group through a simple toss of the coin. The treatment group was taught biology using simulated teaching method, while the control group was taught the same topics using the conventional teaching method. A Biology Achievement Test (BAT) was used for data collection. The biology achievement test was developed by the researcher. The instrument was subjected to both face and content validation. The instrument was also subjected to test of internal consistency and item analysis. A reliability index of 0.94 using the K-R 20 approach was obtained after pilot test of the instrument. Three research questions and three null hypotheses guided the study. Research questions were answered using adjusted mean while the hypotheses were tested at 95% confidence level using the Analysis of Co-variance (ANCOVA). Summary of result reveals that simulated instructional approach fostered higher achievement in biology than the conventional approach. Instructional simulation approach is therefore superior to conventional approach in facilitating higher achievement in biology among secondary school students. The study further revealed that the difference in the mean achievement scores of male and female students taught biology using the simulated instructional approach is not statistically significant. In addition there was no statistically significant interaction between gender and instructional approaches on students' mean achievement scores in biology
Key Words: Simulation, Biology, Quasi-experiment, experiential**,** school achievement, intact classes

Introduction

Biology Education is the study that combines knowledge of biology with pedagogy for the purpose of equipping the learners with relevant skills in the production of manpower for teaching biology (Dictionary.com, 2013). The main target of the program is to produce competent biology teachers. Biology education enhances capacity building in science and technology and provides students with employable skills and opportunities, which could lead to employment and sustainable living. This is true because knowledge of biology is applied in various fields like agriculture, medicine and industry. The major objectives of biology education are:

i. To produce well qualified graduate teachers who would be competent in teaching biology.
ii. To produce graduate biology teachers who will be able to teach with the laboratory (Experimental) and discovery methods.
iii. To produce biology teachers and graduates who can work in science related industries.
iv. To produce teachers who can teach their students how to discover new things, especially as it concerns the life sciences and sustainable environments with emphasis on those things that make life better, bearing in mind the ethical responsibilities.
v. To provide teachers and graduates with general education that would help them understand and face the challenging world of science and information technology.
vi. To produce highly motivated and competent biology teachers for all the levels of our education system.

Biology generally is the science of the life of animals and plants (Hornby, 2004). It also has to do with the studies of the inter-relationships between the living organisms and their immediate environment. In all spheres of human activity, biology plays a prominent role. It is indispensable in the fields of medicine, agriculture, brewery and petro-chemical industries and even in geology and mining. Because of the indispensability of biology, much emphasis has been placed on biology instruction especially at the secondary school level. This is to ensure full realization of the objectives of biology education as stipulated in the National Policy on Education (F.M.E. 2007).

The revised biology curriculum for secondary school was derived from a draft by the Comparative Education Study and Adaptation Centre (CESAC), University of Lagos and presented to the National Critique Workshop in December 1984. It is based on a project tested for many years in a number of schools located in different parts of the federation. Based on the experiences gathered over the years, a biology curriculum was proposed for the 6-3-3-4 system of secondary education and presented to the National Critique Workshop. The outcome of the critique was presented to the Joint Consultative Reference Committee on Secondary Education in April 1985 for scrutiny and final recommendation to JCC Plenary.

The objectives of the biology syllabus for secondary schools was derived from the National Policy on Education (1977, 1981, 1999, 2007) and the cardinal objectives of the syllabus are to prepare pupils to acquire:

i. adequate laboratory and field skills in biology;
ii. meaningful and relevant knowledge in biology;
iii. ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture;
iv. reasonable and functional scientific attitudes

In accordance with the stated objectives, the contents and contexts of the biology syllabus for Secondary Schools was intended to provide modern biology course as well as meet the needs of the society through relevance and functionality in its contents, methods, processes and application.

The National Policy statement noted that biology education should ensure adequate laboratory and field skills, meaningful and relevant knowledge to everyday life in matters of personal and community health and Agriculture, while ensuring reasonable and functional scientific attitude. To ensure the full realization of these interesting objectives, the contents and contexts of the syllabus place great emphasis on field studies, guided discovery, laboratory techniques and skills coupled with conceptual thinking.

Unfortunately, available evidence has revealed that students' performance in biology has been quite discouraging (WAEC 2009, 2010 and 2011). A cursory look at the state of poor performance of students in Senior Secondary School Certificate Biology reveals that between the year 2005 and 2012 the percentage pass at credit level in Ebonyi State Secondary Schools has never exceeded 32 percent (See appendix 8)

This situation is particularly disheartening when we realize that the success of our nation in science and technology depends to a great extent on the mastery of this fundamental aspect of science. Also according to the WAEC Chief Examiner's Report (WAEC 2010; 2011 and 2012), the senior secondary school biology candidates' have a number of problems associated with both cognitive and motor skills which have culminated in the poor achievement of students in the certificate examinations.

This stimulated several speculations and arguments at the Science Teachers Association of Nigeria (STAN) workshops, meetings and seminars that prompted the introduction of the new science modules which are now operational at the national workshop levels and during the annual conferences. The target was to juxtapose methods and contents for improving the current state of achievement in biology and other sciences. The concern has been on how to get science teachers depart from the traditional approach of science teaching to a new approach.

Although the current emphasis has been on students' performance in sciences, it must be appreciated that students' achievement in any course is a function of instruction. Approaches to instruction therefore were considered a serious factor in science education especially with the current emphasis on competency based and sustainable science education for Africa. While also the prescription was not specifically tied to the simulated classroom in science teaching recent emphasis in virtual learning open an avenue for making relevant trials on simulation models.

With the development of the Keller's model, which is a Child Centered laboratory Model, and the empirical proofs of its efficacy, much attention in science instruction was geared towards the simulation approach. Skinner in 1954 invented a stimulus for the integrated approach. Skinner's basic argument for simulation was that the learning of any behaviour no matter how complex rested on the mastery of a sequence of less complex component behaviours.

Simulation is conceived as a representation of the behaviour or characteristics of a system through the use of another outlet especially a computer programme designed for the purpose (Coulter, 2009; Krulik, 2010). According to Krulik (2010) it can mean mimicry, making working replicas or representations of machines for demonstration or analysis of problems but clearly illustrates real life or hypothetical situations. Simulation, according to Mitchell, Parsons, and Leonard, (2007) permit the learner to manipulate variables or parameters and then to observe the consequences of their choices. It is a model of what exists or might exist in set or complex physical or social interactions or a representation of a manageable real event in which the learner is an active participant engaged in learning a behavior by applying previously acquired skills or knowledge.

Simulation can bring into the classroom, aspects of the world or universe that are too expensive, dangerous, difficult or too slow or too fast in occurrence to be experienced firsthand (Coulter, 2009). For example, there are simulation that can illustrate the human circulatory system along with its major arteries, veins

and capillaries. Natural occurrences such as earthquakes, radioactivity, predators/prey relationships which occur too rapidly to be observed, can be illustrated through simulation. Simulation may, therefore, make learning more concrete and meaningful. Although simulation has been severally applied in physical sciences and medicine, its relevance in biology instruction is still being speculated.

Simulations of one form or another have been used since the early 1900s as a method for training or retraining. The United States Defense Modeling and Simulation Coordination Office identifies three main types of simulation: live, virtual, and constructive. Live (live action) and virtual simulations are primarily used for training purposes, whereas a constructive simulation is used to view or predict outcomes like war gaming or stock market behavior. Each of these types is based on some reality and is intended to provide the user with a pseudo-experience without the danger, expense, or complexity of real life

Although the efficacy of the simulation approach to science instruction is quite pronounced in literature, the practical impact of the instructional approach on students' mastery of units of instruction in biology is still in doubt. In the same vein, because simulations may be gender based (depending on stimulus utilized) it may be worth speculating that instructional simulation may have fascinating implications for male and females in biology classroom.

While it has not been substantiated that the current poor performance of students in Senior School Certificate Biology Examination is as a result of the non application of the simulation model to biology instruction, the extent to which the adoption of the simulation approach could enhance students' achievement in biology is still an issue that need to be subjected to empirical investigations. In fact a thorough analysis of the impact of the simulated instructional model on students' achievement in biology may have interesting implications, which are worth exploring.

Purpose of the Study

The main purpose of the study is to determine the effect of instructional simulation strategy on senior secondary school students' achievement in biology. Specifically, the study explored:

(1). the effect of instructional simulation strategy on students achievement in biology

(2). the differential effects of instructional simulation strategy on the mean achievement of male and female students in biology.

(3). the interaction effect of gender and method on students' achievement in biology.

Scope of the Study

The study focused on the effect of instructional simulation on Senior Secondary School Students' achievement in biology. The unit that were taught during the experiment is energy Relationships in ecological management. The following topics within the unit were covered:

(a). Principles of Energy relationships in Ecological Systems

(b). Symbiosis

(c).Parasitism

(d). Commensalism

The study was restricted to senior secondary classII only. The reason is because the topics that were taught during this experiment are in SS II curriculum. Moreover, SSIII class is an examination class and is not allowed to be used for experiments while SSI class is just being introduced to biology contents having just graduated from junior secondary. In terms of geographical scope the study was restricted to Abakaliki Education zone.

Research Questions

The following research questions guided the study:

1. What is the effect of the instructional simulation strategy on the mean achievement scores of student in biology?

2. What is the effect of the instructional simulation strategy on the mean achievement scores of male and female students in biology?

3. What is the interaction effect of gender and methods on students' mean achievement scores in biology?

Hypotheses

The following null hypotheses guided the study and were tested at an alpha level of 0.05.

HO1: There is no significant difference in the mean achievement scores of student taught biology using instructional simulation method and those taught using conventional method

HO2: There is no significant difference in the mean achievement scores of male and female students who were taught biology using instructional simulation method

HO3: The interaction effect of gender and method on students' mean achievement in biology is not significant.

Research Method

This study employed quasi-experimental design. In a quasi experimental study, there is no random assignment of subjects. Intact classes were used for the study. The specific design the researcher used for this study is a pretest posttest non equivalent control group design. There was treatment group (where students were taught using instructional simulation method) and control group (where students were taught using conventional (chalk-talk) teaching method). The design is presented thus:

Yb x Ya
Yb ~x Ya
yb = Measurement taken before treatment (pretest)
ya = Measurement taken after treatment (Posttest)
x = Instructional simulation approach
-x = Conventional approach

The area for this study is Ebonyi State of Nigeria. This study was carried out within the Abakaliki Education zone of Ebonyi state. A total of one hundred and thirty nine (139) secondary school biology students were used for this study. These comprised both the treatment and control groups. Two co-educational secondary schools were drawn for this study through simple random sampling. One of the mixed schools was assigned to treatment group while the remaining one was assigned to the control group through the toss of a coin. In each school that was drawn for this study all the intact classes of SSII were used for the study.

The instrument the researcher used for data collection is a Biology Achievement Test (BAT).The biology achievement test is a 50-item Multiple-choice type questions that were developed by the researcher from the content area used for the study. The content areas are energy relationships in ecological systems, symbiosis, parasitism and commensalism. The items were drawn using tables of specification from the contents that was covered during the experiment.

The Biology Achievement Test (BAT) was subjected to both face and content validation procedures. The content validation the 50 items that survived the item analysis exercise were subjected to test of reliability using the K-R 20 procedure. The pilot test of the instrument yielded a reliability index of 0.94.

Experimental Procedure

Two instructional approaches were used for the study. Instructional simulation Method was used in teaching the treatment group, while the conventional approach was used in teaching the control group. The researcher used the biology teachers in the school and also trained them on how best to use the method. At the onset of the treatment a pre-test was administered to both the treatment and control groups. The various biology teachers in the sampled schools will act as research assistants. A pre-experimental training conference which served as a guide was organized for the teachers by the researcher. The experiment was carried out during normal school hours using the school timetable. At the end of the experiment which lasted for eight weeks, the researcher administered the post test to the subject in the two groups. The pretest and the post-test were the same for both groups. The data that were collected from the pretest and posttest were used in answering research questions and testing the hypotheses. Mean and standard deviation were used to answer research questions while ANCOVA was used to test the hypotheses at 95% confidence level.

Control of Extraneous Variable

The researcher adopted the following procedure to ensure that extraneous variables which may introduce bias into the study are controlled.

(a). Teacher variable:

In order to control the errors which may arise as a result of teacher difference, the researcher organized a pre-treatment conference for the teachers that were used for the study. Separate conferences were conducted for teachers in the two groups (treatment and control). The conference helped to establish a common instructional standard among the instructors. The researcher will monitor the teachers to ensure that they adhere strictly to the specifications of the manuals. The regular biology teachers of the schools (treatment and control) groups were used

(b). Instructional situation variable:

To ensure that Instructional situation is the same for all the schools the researcher will issue instructional guides to the teachers in each group. The teaching was conducted in all classes of SS II in the various schools that were

used for the study. All the intact SS II classes of the selected schools were involved in the study. This is to avoid Hawthorne effect (a laisser-faire attitude that arises when students realize they are being used for experiment).

(c).Inter-group variable:

Because intact classes were used for the study, it is implied that initial equivalence is impossible for the treatment and control groups. In order to control for errors that could have arisen in comparing effects of treatment on two unequal groups the researcher will employ Analysis of Co-Variance in analyzing the relevant data.

(d), Subject Interaction:

The researcher will not select treatment and control group from the same school to ensure that the students in the treatment and control groups do not mix up at all. This is to reduce the errors that might arise from the interaction and exchange of ideas among research subjects from the two groups and further eliminates the possibility of a John Henry Effect (a spirit of competition triggered in students on realizing that they are being used for experiment that requires comparison at the end).

Results

Research Questions

Research Question 1

What is the effect of the instructional simulation strategy on the mean achievement scores of student in biology?

Data obtained for this research question with the Biology Achievement Test (BAT) for the treatment and control groups were used in answering this research question. The biology achievement test was scored all over one hundred implying that the maximum score is 100% for the test. Mean for pre and post test were adjusted statistical in the analysis to take care of the initial equivalence of the research subjects. This implies that the residual score was the basis for judgment. Summary of result of data analysis is presented in table 1.

Table 1: Mean biology achievement scores of students taught biology using the simulation approach and those taught with the conventional method.

Groups	N	Adjusted Mean	Std Dev.
Treatment Group (Group Taught biology with Simulation Approach)	71	54.44	11.18
Control Group (Group taught biology with conventional method).	68	41.63	10.17

The Summary of result presented in table 1 indicates clearly that the simulation instructional approach in biology yielded a higher mean achievement score than the conventional lecture (chalk talk) approach. As shown in Table 1 the mean achievement score of the treatment group (group taught with the simulation approach) is 54.44 with a standard deviation of 11.18 while the conventional lecture method yielded a mean of 41.63 with a standard deviation of 10.17. This indicates that the simulated biology instructional approach is superior to the conventional lecture (chalk talk) approach in facilitating overall students' achievement in biology as measured by the Biology Achievement Test (BAT). The summary of result however did not reveal very great dispersion among individuals in the two groups as measured by the standard deviation scores implying that although there is a meaningful difference between the two groups individual differences in the respective groups may not raise interaction controversies.

Research Question 2

What is the effect of the instructional simulation strategy on the mean achievement scores of male and female students in biology?

The researcher made use of the treatment group only in answering this research question. Male and females in the treatment group were separated and used to answer this research question. The pre and posttest scores of males and females who were taught biology using the simulation instructional approach were adjusted in the analysis. The adjustment ensured that that the residual score was the determinant of the judgment for the two groups (male and females of the treatment group). The summary of result is presented in table 2.

Table 2: Mean biology achievement scores of males and females taught biology using the simulation instructional method

Gender Categories	N	Adjusted Mean	SD
Male Students	30	55.27	11.04
Female Students	41	53.83	11.38

The mean achievement scores of male students that were taught biology using simulation instructional approach is 55.27 with a standard deviation of 11.04 while that of the female students that were taught the same biology topics using the same simulated instructional approach is 53.83 with a standard deviation of 11.38 as measured by the Biology Achievement Test. Although the mean score of males is higher than those of their female counterparts, the difference is obviously and comparatively negligible.

Research Question 3

What is the interaction effect of gender and methods on students' mean achievement scores in biology?

The adjusted mean for the two levels of gender that were subjected to the simulation approach and those subjected to the Conventional lecture approach were used to determine the interaction. Summary of result is presented in table 3.

Table 3: Summary of interaction effect of gender and teaching method on students' mean achievement scores in biology.

GENDER GROUPS	Adjusted Mean for Treatment Group	Adjusted Mean for Conventional Method
Males	55.27	42.63
Females	53.83	40.84

As shown in Table 3 the simulation method is superior to the control method at the two levels of gender. This is a clear indication that there is no interaction effect of gender and teaching method on students' means achievement scores in biology as measured by the Biology Achievement Test (BAT). Result presented in table 3 shows that the simulated instructional approach in biology yielded a mean score of 55.27 for males and 53.83 for females wile the conventional approach could yield only a mean of 42.63 for males and 40.84 for the females. This is an indication that at the treatment level the mean scores of both males and females are higher than those of the control group. The simulated instructional approach is therefore superior to the conventional approach at the two levels of gender (male and female) implying a situation of no interaction.

Hypotheses

HO_1: There is no significant difference in the mean achievement scores of student taught biology using instructional simulation method and those taught using conventional method

HO_3: The interaction effect of gender and method on students' mean achievement in biology is not significant.

These two hypotheses were tested using Analysis of Co-Variance. Summary of the analysis for these two null hypotheses is shown in table 4.

Table 4: Analysis of Co-variance for students overall biology achievement scores by teaching methods and by gender

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}
Covariates	13745.424	1	13745.424	573.810	
Main Effects	4387.810	2	2193.905	91.586	
Teaching Methods	4384.518	1	13745.424	183.034	3.89
Gender	3.115	1	3.115	.130	3.89
2 – Way Interaction					
Teaching Methods & Gender	34.701	1	34.701	1.449	3.89
Explained	18167.934	4	4541.983	189.608	
Residual	3209.922	134	23.955		
Total	21377.856	138	154.912		

Summary of results in Table 4 indicates that for the comparison of teaching methods the calculated F-value is 183.034 while the critical value at an alpha level of 0.05 is 3.89. The decision rule is to reject the null hypotheses if the calculated value exceeds the critical value at a given alpha level. Since the calculated value is greater than the critical value, the null hypothesis was rejected. The researcher, therefore, concludes that there is a significant

difference in the mean achievement scores of students taught biology using the simulated instructional approach and those taught biology using the conventional lecture approach.

For hypothesis 3, result in table 4 reveals that for two way interaction, the F-cal is 1.449 while the critical value at 5% probability level is 3.89. Based on the decision rule, the researcher upholds the null hypothesis and concludes that there is no significant interaction between gender and instructional approach on students' mean achievement in biology.

HO_2: There is no significant difference in the mean achievement scores of male and female students who were taught biology using instructional simulation method

This hypothesis was also tested using the Analysis of Co-variance. Summary of result is shown in Table 5

Table 5: Analysis of Co-variance for students overall biology achievement scores by teaching methods and by gender

Sources of variation	Sum of squares	Df	Mean Squares	F	F_{cv}
Covariates	6211.380	1	6211.380	166.957	
Main Effects (GENDER)	6.247	1	6.247	.168	3.89
Explained	6217.627	2	3108.814	83.562	
Residual	2529.838	68	37.203		
Total	8747.465	70	124.964		

For hypothesis 2, summary of results in table 5 reveal that F-cal (.168) is less than the critical value (3.89) at alpha level of 0.05. Since the calculated value is les than the critical value at the given alpha level, the null hypothesis is accepted. The researcher, therefore, upholds the null hypothesis and concludes that there is no significance difference between the mean achievement score of male and female students taught biology using the simulation instructional approach.

Summary of Results

Results presented in this chapter reveal the following:

1. Simulated instructional approach fostered higher achievement in biology than the conventional approach. Instructional simulation approach is therefore superior to conventional approach in facilitating higher achievement in biology among secondary school students.
2. The difference in the mean achievement scores of male and female students taught biology using the simulated instructional approach is not statistically significant
3. There is no statistically significant interaction between gender and instructional approaches on students' mean achievement scores in biology.

Discussion

The effects of simulated instruction on secondary school students' mean achievement in biology.

The result of data analysis shown in Table 1 of chapter four reveals that the simulated instructional approach is superior to the conventional approach in fostering secondary school students' achievement in biology. As shown in Table 1 students taught biology using the simulated instructional approach had a mean score of 54.44 with a standard deviation of 11.18 while their counterparts in the control group who were taught the same topics in biology using the conventional approach had a mean score of 41.63 with a standard deviation score of 10.17 as measured by the Biology Achievement Test (BAT). On the test of hypothesis, summary of result in Table 3 also reveals a statistically significant difference in the mean achievement scores of secondary school students taught biology using the simulated instructional approach and those taught using the conventional lecture approach.

This finding is in line with the earlier findings of Barney, Bishop, Adlong, and Bedgood (2009). Their revelations are that in simulated classrooms the students are actively involved in the experiential learning. These groups of students were always engaged during the lectures, got involved in discussions, asked and answered questions, role - played, engaged in video clips simulations, clarifications, 5-minute paper, group work and game shows and additionally thought about the things they did. Thus, they understood the tenets of the various topics discussed during the lectures and therefore developed deep understanding of the important ideas learnt. In that particular study it is not surprising therefore to see that the majority of the students reported that they were

actively involved in the lesson when the strategies were incorporated and the PowerPoint presentation was used as the tool.

The findings of this study also corroborated the reports of Mantyla, (2009) which show that active learning strategies facilitates greater emphasis on students' exploration of their own meaning, attitudes and values and therefore developed deep understanding of the important ideas.

Another interesting aspect of this study is that the standard deviation scores for both the treatment and control group are moderate and not at much variance implying that the efficacy of the treatment is sustainable. The probability of the methods discriminating across other moderator variables could be ruled out. That is to say that the simulated instructional approach is not only efficient but also stable in fostering secondary students' achievement in biology.

The effect of simulated instructional approach on the mean achievement scores of male and female secondary school students in biology.

Summary of result presented in table 2 of chapter four shows that the simulated instructional approach does not discriminate obviously across gender. As shown in the table male students had a mean score of 55.27 while their female counterparts in the same group had a mean of 53.82. Although the achievement of the male students in the Biology Achievement Test (BAT) is higher than those of their female counterpart, the test of significance revealed that the difference in their achievement scores is not statistically significant.

The findings of this study are also in line with the studies conducted by Kasimowo (2010) and Olariwaju (2007). Although the study of Kasimowo (2007) centered on secondary school students achievement in mathematics it revealed that instructional simulation is not gender biased. There was no significant difference in the mean achievement scores of male and female secondary school students who were taught mathematics using the simulated instructional approach. In the same vein also, Maduagwuna (2012) revealed that there was no gender discrimination in students' achievement in mathematics using the gaming approach. In her study gaming was employed as a simulation mode. Although Greenfield and Feldman (1997) argued that simulated games are masculine and as such will favour males more than females recent studies have proved that simulation approaches are not gender stereotyped.

The finding of this study was also corroborated by Olariwaju (2007). In his study which was conducted using physics students it was observed that there was no significant difference in the mean achievement of male and female students who were taught the concept of point discharge using the simulation approach. This finding lends a lot of credence to efficacy of the simulated instructional approach in science classroom. This is particularly very important because of initial arguments that physics is gender stereotyped (Amos, 1998; Akinola, 2001). Fayombo (2012) also provided substantial evidence that active learning strategies are not gender biased. It is therefore, necessary that science teachers should consider the adoption of this approach at the secondary school level.

The interaction effect of gender and instructional approaches on secondary school students' mean achievement in biology.

The Summary of result shown in table 3 shows that the mean scores of male and female students in the treatment group is higher than those of their counterparts in the control group. This implies that at the two levels of gender, the simulated instructional approach is superior to the conventional approach in enhancing secondary school students' achievement in biology. The test of hypothesis in Table 4 of chapter four also reveals no significant interaction of method and gender on secondary school students mean achievement scores in biology as measured by the Biology Achievement Test (BAT). The essence of treatment interaction analysis is to verify whether different learners with different characteristics may profit more from one type of instructional than the other and also to explore the likelihood of separating instructional techniques to suit learners characteristics. The need to find a match for learners' characteristics so as to maximize learning outcomes has become very imperative in current dispensations irrespective of the cost implications.

The finding of this study is quite interesting in the sense that there was no interaction and no cause to separate biology instruction along gender lines. The finding is also in line with that of Maduagwuna (2012), Fayombo (2012) and Olariwaju (2007). These studies reveal no interaction between method and gender on students mean achievement scores. This is an indication that simulation approach is not only efficacious but also cost effective in science classrooms. As Maduagwuna (2012; 67) rightly pointed out "although the goal of research in treatment interaction is to find significant disordinal interaction between alternative treatments and personal variables, it must be emphasized here that any approach which yields a superior no-interaction is cost effective and better in all ramification". It is also interesting to note that in biology the simulated instruction has now been found to be cost effective.

Conclusion

This study centered on the effects of instructional simulation on the achievement of secondary school students in biology. Based on the findings of this study which utilized three research questions and three null hypotheses the following conclusions were drawn:

(i). Simulated instructional approach fostered higher achievement in biology than the conventional approach. Instructional simulation approach is therefore superior to conventional approach in facilitating higher achievement in biology among secondary school students.

(ii). The difference in the mean achievement scores of male and female students taught biology using the simulated instructional approach is not statistically significant

(iii). There is no statistically significant interaction between gender and instructional approach on students' mean achievement scores in biology.

Recommendations

Based on the findings of this study, the researcher made the following recommendations:

(a). Simulated instructional approach should be adopted as a medium of instruction at all levels of the Nigerian educational system. Both primary and secondary school biology teachers should be encouraged to adopt this approach as part of their teaching methods.

(b). State and Federal Government should equip all schools with necessary facilities for the application of simulated instruction. This will include laboratories, computers and accessories.

(c). State and Federal Governments should encourage and sponsor in-service training for science teachers on the application of simulation. Most importantly the government should beef up computer literacy programmes for both students and teachers because simulation utilizes computer programmes to a large extent.

(d). There is a need to review the existing curriculum in biology to ensure that simulation approaches are enshrined it. This gesture should be extended to basic science and also basic science and technology so that as the students progress from basic level in science to the post basic level they are already familiar with the approach.

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