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Impact of Computer-Assisted and Science Process Instructions on Performance in Biology Among Secondary School Students of Varied Abilities in Sabon Tasha Education Zone, Kaduna Nigeria

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Abstract: This study investigated the impact of three instructional strategies on the academic performance of senior secondary school (SS) students with varied abilities (high, medium and low) with respect to learnt biological concepts in Sabon Tasha education zone of Kaduna, Nigeria. The research was quasi-experimental in nature, pre-test, post-test, non-equivalents and control group design. A sample of 153 Senior Secondary (SS) II students was drawn from a population of 3841. Biology Performance Test (BPT) was used to collect data. The reliability of the BPT was calculated using the Pearson's Product Moment Correlation Co-efficient (PPMC) to be 0.84. The subjects in the experimental group 1 were taught biology using Computer-Assisted Instruction (CAI) and the experimental group 2 were taught the same biological concepts but using the Science Process Approach (SPA) and their varied performances were compared with those of the control group, who were taught those biological concepts using the Lecture Method (LM). The research question was answered using deferential statistics which showed that the varied performance levels of high, medium and low abilities students exposed to CAI was (H=39.12. M=38.12, L=37.12) and SPA (H=39.12, M=38.12, L=37.12). This indicated a slight difference in their mean scores. However, in the LM (H=39.12, M=33.82, L=24.59) high, medium and low showed some differences in their mean scores in favor of the high and medium abilities students. The hypothesis was tested using the two-ways analysis of variance (ANOVA). The results showed that the 'P' value observed for the CAI, SPA and LM was 0.001 which was less than the alpha P⩽ 0.05. This showed a significant difference in the academic performance of the subjects with high, medium and low abilities exposed to CAI, SPA and LM respectively. However, the observed difference was based on their abilities level. Based on these findings, it was recommended that the CAI and SPA should be used by teachers to teach biology in Nigerian secondary schools because these pedagogy methods allow students to learn at their own pace which takes care of the difficulties in their individual learning abilities.

Keywords: Computer Assisted Instruction, Science Process Approach, Lecture Method

1. INTRODUCTION

Biology as a discipline is an organized body of knowledge and a process of inquiry that can be developed through the use of Science Process Skills (Maikano, 2016). Biology occupies a unique position in the secondary school curriculum. Biology is central to many science related courses, such as, medicine, pharmacy, agriculture, nursing, fishery among others. It is therefore noted, that no student intending to study these disciplines can do without biology (Maikano, 2007). These factors, among others, have drawn the attention of researchers and curriculum planners towards biology as a subject in the school curriculum (Kazeem, 2012). In spite of the importance and the popularity of biology among the Nigerian students, academic performance at the senior secondary school level has been low (Ahmed, 2011). The desire to know the causes of the low academic performance in biology has been the focus of researchers for some time now. It has been observed that the low academic performance in biology is due among other things to the ill-preparedness of biology teachers, overcrowded classrooms and lack of suitable and adequate science equipment (Ogunniyi cited in Kazeem, 2012). Students perform low in biology because the biology classes are usually too large and heterogeneous in terms of ability levels. In order to address this problem, Lakpini (2007) mentioned that grouping students based on their ability level may be done at random

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or in some systematic ways. Ability grouping is usually done by placing students with basically similar cognitive ability in the same group. Bunkure (2012) observed that in the Nigerian situation, middling average or medium ability level students are usually lower than 95% of the group's total population. According to the West African Examination Counci (WAEC) 2003 to 2014 regulation, there are nine levels of performance grades, that is grades 'A' to 'F' comprising six grades with A, B, C, D, E as passes while 'F'as failure. The different grades and their corresponding scores according to the WAEC 2014 include:

- High ability: A1 (75-100%), B2 (70-74%)
- Medium ability: (65-69%), C4(60-64%), C5(55-59%) & C6(50-54%)
- Low ability: D7(45-49%), D8(40-44%) & F9(0-39%) Lakpini (2007) pointed out that the grouping was determined as follows:
- High ability level, upper 25%
- Medium ability level, middle 50%
- Low ability level, bottom 25%, these groupings were based on students' performance on Biology Performance Test (BPT).

Maikano (2016) pointed out that the potential benefits of Computer-Assisted Instruction (CAI) and Science Process Approach (SPA) in the teaching of biology cannot be underestimated in the 21st Century. CAI is a learning process that requires the use of computers and digital knowledge. In CAI, the teacher usually develops a software/courseware using a particular topic or concept, for example germination in biology (Maikano,2016). In CAI teaching, the students are properly guided on the concepts they are expected to learn and they are always allowed to learn those concepts at their own pace. Urdan & Weggen (2010) stated that CAI education and training is one of the most promising delivery methodologies associated with digital knowledge. Schools stand to gain many benefits associated with CAI. Some of these benefits include, decreased travel cost, just-in-time learning and high performance and retention rate through personalized learning, among others. In this study, Individualized Computer-Assisted Instruction (ICAI) was used for the Experimental Group 1, where each student was given a computer to learn the biological concepts with, using a Power Point Presentation (PPP).

Experimental Group 2 learned the concepts of biology using the Science Process Approach (SPA). SPA is a learning process that usually leads to the acquisition of the Science Process Skills (SPS). SPS are intellectual skills needed to learn concepts and broad principles in making valid inductive inferences (Gagne cited in Mari, 2001). The commission on science education of the American Association for the Advancement of Science (AAAS) has identified eleven process skills which are considered to be representative of problem-solving activity (Mari, 2001). These process skills are categorized into two types namely:

•Basic Science Process Skills: these are observing, measuring, inferring, predicting, classifying and collecting and

•Integrated Science Process Skills: these are interpretation of data, controlling variables, defining operationally, formulating & testing hypothesis and experimentation.

As for the research question that guided this study, it basically is the following: What is the effect of CAI, SPA and LM on the academic performance of secondary school students with varied learning abilities (high, medium and low) in biology?. Here the null hypothesis (HO) is that there is no significant difference in the mean academic performance scores of secondary school students with varied abilities (high, medium and low) when taught biology using CAI, SPA and LM.

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

The conceptual framework for this study is based on Constructivism. Constructivism is relevant to this study because the students in this study used their prior knowledge to construct new concepts. According to Glasserfield (2015), constructivism is an idea formed by combining pieces of knowledge. This revolves round the principle that, individuals usually construct meaning in their attempt to make sense of the world around them.The understanding an individual derives from a learning situation depends on both the incoming ideas/knowledge and the individual's organization of the knowledge and deliberate re-structuring of his/her pre-existing conceptual framework. Tobin (2012) and Glasserfield (2015) pointed out that individuals construct their own knowledge as a result of their interaction with specific phenomenon. Such constructs (Prior Knowledge) form the basis upon which new knowledge is anchored.*Abbreviations and Acronyms*

The findings of some researchers who utilized variables that are related to the ones used in this study are briefly included here. Among them is Mari (2001) who investigated the effects of process skills instruction on performance ability among senior secondary school students. The researcher used One-Way Analysis of Variance (ANOVA) as a statistical tool to analyze his data. His findings revealed that chemistry students who were taught through SPA performed better than their counterparts who were taught the same concepts but through the traditional lecture method (LM). Hassan (2013) compared the Impact of the CAI and the LM on the academic performance of secondary school students in biology. The researcher used ANOVA to analyze his data. The findings of this investigation revealed that the participants who were taught biology through CAI performed significantly better than their counterparts who

were taught the same concepts of biology but through LM. Mudasiru (2015) investigated the impact of CAI and LM on the academic performance of secondary school students. The statistical tool used to analyze the data in this study was the Analysis of Covariance (ANCOVA). The study revealed that the students who were taught through CAI performed better than those taught through LM. These reviewed studies showed the superiority of CAI and SPA over LM in improving students' academic performance in the sciences.

3. METHODOLOGY

This study was of the quasi-experimental type with a pretest, posttest, non-equivalents and control group design. In this study, three levels of intervention on varied abilities (high, medium and low) groups were used. These were CAI which represented the experimental group 1, SPA which represented the experimental group 2 and the LM which represented the control group. This research design is graphically illustrated as follows:

EG 1: Experimental Group 1
EG 2: Experimental Group 2
CG: Control Group
O 1: Pretest (to ascertain their group equivalences and ability levels (high, medium and low)
O 2: Posttest(to ascertain their performance based on their abilities, high, medium and low levels)
H: High ability
M: Medium ability
L: Low ability

The population of the study was made up of senior secondary school II biology students in Sabon Tasha education zone Kaduna, Nigeria. The total population of the SS II students was 3841 out of which 2079 were males and 1762 females. Representing this population, 153 students were selected as a sample from a total enrolment in Sabon Tasha education zone Kaduna, Nigeria of 810 senior secondary II students. This sample was distributed over two experimental groups made up of 102 students; while, the control group was made up of 51 students. A simple random sampling technique was used to select these samples. This technique used ensured that every member of the population had an equal chance of being selected.

The research instrument used for this study was a Performance Test called, 'Biology Performance Test' (BPT). The reliability of the BPT was calculated using the Pearson's Product Moment Correlation Co-efficient (PPMC) of 0.84. The topics selected for the construction of this instrument were the plant concepts in biology. The 50 items of the BPT were drawn from the plant concepts of biology included in the past question papers of the National Examination Council (NECO) and West African Examination Council (WAEC) which are known to have high validity and reliability. The questions were selected to cover the six levels of mental processes of the cognitive domain as outlined by the Bloom's Taxonomy of Educational Objectives. These six levels are: knowledge (13 questions), comprehension (13 questions), application (7 questions), analysis (4 questions), synthesis (7 questions) and evaluation (6 questions).

To answer the main research question of this study, descriptive statistics were used. Means and Standard Deviations of the post-test scores based on varied abilities were calculated and used as
demonstrated in Table 1.1

4. RESULTS

TABLE 1.1. MEANS AND STANDARD DEVIATIONS OF THE POST-TEST SCORES OF THE HIGH, MEDIUM AND LOW ABILITY GROUPS EXPOSED TO CAI, SPA AND LM INSTRUCTIONAL STRATEGIES

Level	Group	N	Mean	SD	MD
High	CAI	17	39.12	1.616	0.17
	SPA	17	39.12	1.616	0.17
	LM	17	39.24	1.786	0.17
Medium	CAI	17	38.12	2.34217	1.27
	SPA	17	38.12	2.34217	1.27
	LM	17	33.82	3.61017	
Low	CAI	17	37.12	2.088	2.19
	SPA	17	37.12	2.088	2.19
	LM	17	24.59	4.273	

It can be seen from Table 1.1 that the performance level of high, medium and low abilities students exposed to CAI was (H=39.12, M=38.12, L=37.12) respectively and the SPA was (H=39.12, M=38.12, L=37.12). This indicated a slight difference in their mean scores. However, in the LM (H=39.12, M=33.82, L=24.59), high, medium and low showed some difference in their mean scores; these are highability performed highest, medium ability higher and low ability high. This therefore answered the main research question.

However, in order to establish if the difference is statistically significant, inferential statistics were used to test the null hypothesis (HO).

There is no significant difference in the mean academic performance scores of secondary school students taught biology with varied abilities (high, medium and low) using

the Computer- Assisted Instruction, Science Process Approach and Lecture Method.

To test this hypothesis, Two-Ways Analysis of Variance (ANOVA) was used to analyze the post-test performance scores of the nine groups. This provided the means of testing the null hypothesis. A summary of the analysis is shown in Table 1.2

TABLE 1.2. RESULTS OF TWO-WAYS ANALYSIS OF VARIANCE TO DETERMINE THE PERFORMANCE ABILITIES OF HIGH, MEDIUM AND LOW STUDENTS EXPOSED TO CAI, SPA & LM.

Source of Variation Squares(SS)	Type 111 Sum of Square(MS)	DF	Mean	F	P	Remark
Corrected Model	2987.307	8	373.413	56.588	.001	S
Intercept	201178.458	1	201178.458	30486.868	.001	S
Level	998.993	2	499.497	75.694	.001	S
Group (CAI & SPA)	1054.327	2	527.163	79.887	.001	S
Level2 Group(L M)	933.987	4	233.497	35.384	.001	S
Error	950.235	144	6.599			
Total	205116.000	153				
Corrected total	3937.542	152				

Significant at P≤0.05

From the results in Table 1.2, it is clear that the P value observed for the CAI, SPA and LM was 0.001 which is less than the alpha P≤0.05. This showed a significant difference in the academic performance of the participants with high, medium and low abilities exposed to CAI, SPA and LM respectively. However, the observed difference was based on their abilities level. It was observed that the high group performed highest, the medium group higher and the low group high with the exception of the low group in the LM which performed fairly good. Therefore,the null hypothesis which predicted no significant difference in the performance of the high, medium and low abilities exposed to CAI, SPA and LM is rejected. The direction of significant difference was again determined using Scheffe's test of multiple comparisons. These results are shown in Table 1.3.

TABLE 1.3. RESULTS OF SCHEFFE'S MULTIPLE COMPARISONS POSTTEST PERFORMANCE SCORES OF HIGH, MEDIUM AND LOW ABILITIES STUDENTS EXPOSED TO CAI, SPA AND LM

Scheffe Test	Level I	Level J	Mean difference (I – J)	Std. Error	P	Remark
High	Medium		2.47	.509	.001	S
Low			6.22	.509	.001	S
CAI	Medium	High	2.47	.505	.001	S
Low			3.75	.509	.001	S
	Low	High	6.22	.509	.001	S
Medium			3.75	.509	.001	S
High	Medium		2.47	.509	.001	S
Low			6.22	.509	.001	S
SPA	Medium	High	2.47	.509	.001	S
Low			3.75	.509	.001	S
	Low	High	6.22	.509	.001	S
LM	Medium		3.75	.509	.001	S

Mean difference is significant at P≤0.05 level

Table 1.3shows the observed P value of 0.001 for the abilities group (H, M, and L) for the CAI, SPA and LM, this is less than the alpha P value of 0.05. This reveals that significant differences exist among the nine groups (CAI= H, M, L; SPA H, M, L & LM H, M, L). Between CAI and LM, the difference is in favour of CAI, between SPA and LM the difference is in favour of SPA. This means that on either side the high, medium and low abilities in CAI and high, medium and low abilities in SPA which are the EG 1 and EG2 performed better than their counterparts in the control group (LM). The scores of CAI were (high=39.12, medium=38.12, low 37.12), while those of SPA were (high=39.12, medium=38.12 and low 37.12). These are higher compared to the LM which were (medium=33.82 and low 24.59). Note that, the analyzed results reveal that there was a significant difference in the performance of the high ability students exposed to CAI, SPA and LM. Hence

the null hypothesis is rejected at P≤0.05 level of significance.

5. DISCUSSION

The study investigated the impact of CAI and SPA as methods of instruction on the academic performance of secondary school II students with varied learning abilities in biology. To achieve this purpose, the students in the experimental group 1 were taught biology using CAI, the students in the experimental group 2 were taught the same concepts of biology but using SPA; while, the subjects in the control group were taught the same biological concepts but using LM. The three groups were posttested and their varied academic performances were compared according to the variables being measured. The results of the study indicated that the students of all ability groups performed significantly better in classrooms where CAI and SPA teaching strategies were used. This finding is in agreement with that of Chinwe (2009) who had reported that an effective teaching strategy can circumvent problems with low ability groups while maintaining high performance with the high achievers. It can thus be inferred from the results of the present study that low performance among low ability students can be improved by exposing them to CAI and SPA instructional strategies. The findings from this study indicated that CAI and SPA instructional strategies can enhance academic performance among students of all ability levels. It also showed that teaching through CAI and SPA instructional strategies can influence students in a given ability group to perform significantly better than others of the same group taught through the traditional LM. These findings also agreed with the study of Mari (2001) who investigated the effects of SPA on academic performance ability among senior secondary school students in chemistry. The findings revealed that when SPA is used instead of LM, the performance of the students is enhanced across their learning ability levels. This is in agreement with the findings of this study which showed that SPA is an innovative pedagogical strategy that promotes academic performance among students of varied ability groups. Similarly, Hassan (2013), who compared the impact of CAI and LM, discovered that CAI as a pedagogical approach is good at improving academic performance among secondary school students of varied learning ability. Mudasiru (2015) also investigated the impact of CAI and LM on the academic performance of secondary school students in biology. The outcome of his investigation revealed that CAI is an innovative instructional strategy which takes care of the learning ability of students, thereby enhancing their academic performance compared to LM.

The results from testing the null hypothesis showed that there was no significant difference in the mean academic performance scores of students with respect to ability grouping (high, medium and low ability groups) when taught biological concepts using the CAI and SPA instructional strategies. The insignificant difference between the three mean scores of CAI and SPA were as follows: CAI (high 39.12, medium 38.12 and low 37.12) and SPA (high 39.12, medium 38.12 and low 37.12) obtained for high, medium and low ability students respectively. This suggests that the CAI and SPA instructional strategies led to more effective learning of biological concepts than the traditional lecture method of instruction. The summary of the differences of the three ability groups with respect to academic performance using the two-ways ANOVA test showed no significant difference in the academic performance of the three groups of students in the CAI and SPA, thus, revealing the effectiveness of the pedagogical strategies. The findings of this research agree with those of Ansalone (2012) who compared the academic performance of students in varied ability based and mixed ability groups in science and reported a higher student academic performance when exposed to physics instruction using the CAI and SPA instructional strategies than when taught through LM.

6. CONCLUSION AND RECOMMENDATIONS

The findings of this study revealed that students with varied abilities (high, medium and low) perform better when biology is taught using CAI and SPA because these instructional strategies allow students to learn at their own pace; they also take care of the weaknesses associated with the low ability group. The present situation of teaching biology in Nigeria needs to shift from the traditional method of teaching, that is, the LM to more innovative pedagogical strategies like the CAI and SPA, which were discovered through this study to be student-centred and also found to improve the academic performance of secondary school students of different ability levels, to the advantage of the low ability group of students. This will help make the teaching and learning of biology more effective at the secondary school level in Nigeria. Additionally, the following recommendations to the relevant authorities in Nigeria can help enhance further the teaching of secondary school biology:

- The teaching of biology at the secondary school level should be carried out using innovative teaching strategies, like CAI and SPA.
- Training of secondary school teachers on the effective use of CAI and SPA is hereby recommended to the Nigerian Federal Ministry of Education, to be carried out across all the federating states of the nation.
- The Nigerian Federal Government should ensure that the science laboratories in the secondary schools are well-equipped and functional.
- An adequate number of computers should be provided to all secondary schools in Nigeria, in order to promote digital learning in conformity

with the 21st Century learning paradigm shiftin the country.

- Research should be carried out in the future to studyhow CAI and SPA can be effectively used in Science, Technology, Engineering and Mathematics (STEM) education in Nigeria.

Finally, since at the end of secondary school all students in West Africa take the same examination-the West African Examination Council Senior Secondary Certificate Examination (WAEC/SSCE), countries in the region other than Nigeria (e.g. Gambia, Ghana) may find the recommendations of this study also useful for the improvement of science teaching and learning in them as well.

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