ASSESSMENT OF THE EFFECTIVENESS OF A DEVELOPED DIGITAL NERVOUS SYSTEM MODEL FOR BIOLOGY INSTRUCTION IN SENIOR SECONDARY SCHOOLS IN NIGERIA

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Abstract
The study assessed the effectiveness of a developed digital nervous system model for Biology instruction in senior secondary schools in Nigeria. Design and development research was adopted in which three research questions were raised and answered. The sample consists of 33 Biology teachers, 14 educational technology experts, and 121 secondary school Biology students. Four research instruments were used for this study: Digital nervous system model, Biology Teachers' Digital nervous system model questionnaire, educational technology experts' digital nervous system model questionnaire, and Biology achievement test. The instruments were validated by experts and pilot tested. For the questionnaire, the Cronbach alpha formula was used to measure the internal consistency of the instrument yielding a reliability coefficient of 0.81. Similarly, Pearson Product Moment Correlations (PPMC) formula was used to determine the reliability coefficient of the Biology Achievement Test yielding a coefficient of 0.75. The data collected were analyzed using Mean and Standard Deviation to answer research questions one and two with a weighted mean of 2.50. The t-test statistics was used to test the hypothesis at 0.05 alpha level. Findings revealed that after the implementation and evaluation of the model, it was rated high by Biology teachers (3.47) and educational technology experts (3.45) for meeting the suitability and quality requirement. There was a significant difference in the mean achievement (t= 6.349, P-value < 0.05 of secondary school students taught Biology through the digital nervous system and lecture method. Based on these findings by experts, it was recommended that biology teachers, students, and school administrators should be made aware of the newly developed digital nervous system model and adopt it in the teaching and learning of Nigerian secondary school biology

Keywords: Digital Model, Biology, instruction, nervous system

Introduction

Contemporary developments in science and technology have greatly enhanced the quality of human life in areas like health, nutrition, agriculture and economic development. For continuity of life, Narula (2014) remarked that the knowledge of science and technology should be pursued by nations longing for development. In line with this, policy makers in developed and developing countries have recognized the importance of science to both social and economic growth (Robert, 2011; Dusto, 2013; Narula, 2014). (Aina, 2013). Presently, in Nigeria, science related subjects are taught as integrated science in the junior secondary schools, and as separate subjects; Physics, Chemistry and Biology at senior secondary schools (National Policy on Education, 2004).

Biology is a natural science subject that deals with the study of life and living organisms and it is the subject that enlighten man about himself and the environment he lives in. Considering its characteristics and importance, Biology as a subject continues to expand surface at tertiary

level of education as a course of study and a career. Hartoyo and Abdul-Gafur, (2019) opined that exposure to Biology education offers the learners a wide range of opportunities including careers in agriculture, medicine, surgery, pharmacy, veterinary medicine, human anatomy and a host of all other life sciences. Due to its importance, Biology is made compulsory for all science students in the Senior Secondary School Certificate Examination (SSCE) in Nigeria (James, 2018). At secondary school level in Nigeria, students' failure in Biology is due to poorly equipped laboratories, inexperienced biology teachers, high population in the classes which affects class control and inappropriate choice of instructional delivery among others (Akanbi & Kolawole, 2014). Other researchers have attributed students' poor performance in Biology to the abstract concepts of internally situated organs and systems which ordinarily cannot be easily accessed (Angadi & Ganihar, 2015; Hartoyo & Abdul-Gafur, 2019). Such complex internal structures include blood circulatory system, respiratory system, tissue, supporting systems and the nervous system among others (Singer, 2015).

The nervous system for example, which is internally situated in human body, transmits signals between the brain and the rest of the body. In this way, the nervous system controls the ability to move, breathe, see and think. The basic unit of the nervous system is the nerve cell or neuron, that is why Hartoyo and Abdul-Gafur (2019) described it as abstract in nature because it is difficult to be seen except when dissection is carried out on animals. However, Akanbi and Kolawole (2014) posited that conducting dissection on animals for instructional purposes is expensive and difficult to handle in ordinary Biology laboratories. That is why teachers and students experienced difficulty in teaching and learning internally situated systems such as nervous system. This was advanced to be due to the abstractness of the concepts and inadequate instructional resources (James, 2018). Thus, the quest to make abstract concepts concrete for learners to understand the intricacies involved in nervous system require the use of relevant instructional materials.

For instance, Andria, *et al*., (2018) suggested the use of practical instructional materials in order to clear students' misconceptions and make them to be actively engage in learning. Many instructional materials such as drawings, charts, models and approaches like field trips to abattoirs, dissections have been used for teaching internally situated systems. Recently, video instructions and animation were used to showcase the internally situated organs (Oloyede & Bandele, 2015). However, Alabi (2014) noted that these instructional resources have over the years failed to improve students learning in Biology. Though, it is not surprising to record a failure of these resources owning to the fact that most of these resources are presented to students on a one-time display and may not be touch to feel its dimension. Hartoyo and Abdul-Gafur (2019) noted that developing a model for biology instruction will dramatically change the way knowledge is communicated and deciphered by biology students. Alternatively, an instructional resource that could be developed to remove barriers to meaningful learning and arouse students' interest in biology is the use of a suitable model capable of digitalizing the processes and functions of the internal organs with an opportunity for enhancing students' achievement (Andria *et al.,* 2018).

With the aforementioned challenges of teaching internally situated human organs, a decision to develop a digital nervous system model was arrived at because, models can be excellent tools to explain abstract concepts and for students to better understand these abstract concepts. Digital model is an instructional resource that uses electronic means to replicate an object by simplifying and structuring the reality of an object (Salavati, 2013).

The nervous system digital model was developed to determine it's effectiveness and extent to which it can meet learning objectives. There are different types of models that can be used to develop and evaluate learning. Some of these models are the ACE model, Dick and Carey

model, Kemp Design model, and ADDIE model among others. For this study, the design and development of a nervous system digital model incorporating the methods and approaches of ADDIE model for secondary school biology instructions was used. The ADDIE's adapted model is chosen as the instructional design model for the research as it fits the design and development methods, provides a framework to guide the developer and ensure that the products developed are effective and fit as objectives and approaches to portray a complete picture and understanding, theoretically and practically, of the digital nervous system model.

Nervous system in Biology as concepts identifies by examiners report avoided by most candidates in the West Africa Examination council (WAEC) and National Examination Council (NECO) from 2016-2020. With this concern, James (2018) associated the students' poor achievement in biology as due to the abstract nature of internally situated organs and systems like the nervous system. The consequences of teaching nervous system without a functional instructional resource which can increase students' failure rate in biology. Nervous system being one of these internally situated organs was specifically identified as being more abstract that demands digital modeling in order to make apparent its functions and display its natural working principles. The present study had identified the lack of this instructional resource for teaching nervous system and use ADDIE model to develop a digital nervous system model. In order to bridge the gap between abstract and reality in teaching nervous system. The effectiveness of the developed digital nervous system model was determined and it was found to have improved students' achievement in Biology. Furthermore, the rating on the suitability and quality of the developed digital nervous system model was rated high and suitable and met the quality requirement for teaching and learning of nervous system in secondary schools. Hence, the aim of this study was to evaluate a developed digital nervous system model for Biology instruction in senior secondary schools in Nigeria.

Research Questions

The following research questions were raised and answered in this study:

(i) What are the mean ratings of Biology teachers on the suitability of the developed digital nervous system model in teaching secondary school Biology?
(ii) What are the mean ratings of educational technology experts on the quality of the developed digital nervous system model?
(iii) What is the difference in the achievement scores of secondary school students taught Biology through digital nervous system model and those taught using conventional lecture method?

Research Hypotheses

The following hypothesis was formulated and tested in this study:

HO_1: There is no significant difference in the mean achievement scores of secondary school students taught Biology through the digital nervous system and conventional lecture method.

Methodology

The research design of the study is Research and Development design. Although Research and Development design was adopted for the development and evaluation of the developed model. However, this component of the study which assigned the effectiveness of the model employed a descriptive survey and a mini experimental design. The population comprised of three groups of respondents including all Biology teachers, Educational Technology experts, and Biology students in Nigeria. The sample consists of 33 Biology teachers, 14 educational technology experts, and 121 Biology students. Six senior secondary schools were purposively sampled out of 390 secondary schools in the three educational zones (zone A, B & C) in Niger State. Similarly, two schools were purposively sampled based on the conditions of being co-

educational senior secondary schools with the availability of Biology teachers, laboratories, and electricity. Likewise, Biology teachers and educational technology experts were sampled in the same process. However, for students, two intact classes of SSII Biology students were selected randomly and assigned as experimental and control groups.

Four research instruments were used in the study namely; Digital nervous system model, Biology Teachers' Digital nervous system model questionnaire, educational Technology Experts' Digital Nervous System Model Questionnaire and Biology Achievement Test (BAT). The Digital nervous system model was developed by the researcher while the questionnaires were adapted and used to elicit responses from Biology teachers and educational technology experts regarding the suitability and quality of the developed digital nervous system model. To determine the effectiveness of the developed digital nervous system model, achievement test was administered as pretest and posttest on secondary school students before and after the treatment.

The instruments were validated by experts; Educational Technology specialists from the Department of the Educational Technology Federal University of Technology Minna, Biology experts from the Department of Science Education Federal University of Technology Minna Test and measurement experts from College of Education Minna. A pilot test was carried out on the instrument using 10 Biology teachers, 7 educational technology experts, and 30 senior secondary school II Biology students. Cronbach alpha formula was used to measure the internal consistency of the instruments. A reliability coefficient of 0.81 was obtained which shows that the instrument is reliable. Pearson Product Moment Correlations (PPMC) formula was used to determine the reliability coefficient of the Biology Achievement Test. The coefficients between 0.60 - 1.0 was considered reliable. After the analysis, a coefficient of 0.75 was obtained. The data collected was analyzed using qualitative and quantitative analysis.

A four-point Likert rating scale of strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) was used in weighing responses to items in the questionnaire. Mean and standard deviation was used to answer research question one and two with weighted mean of 2.5 and above considered agreed and a weighted mean of less than 2.5 considered disagreed. Similarly, Mean and Standard Deviation were used to answer research question three with mean difference generated from the groups. Statistical Package for Social Sciences (SPSS) was used for data analysis.

Results

Research Questions One: What are the mean ratings of Biology teachers on the suitability of the developed digital nervous system model in teaching of secondary school Biology?
To answer research question one, the developed DNS model was presented to Biology teachers to physically evaluate its suitability for teaching secondary school Biology curriculum. The result was presented in table1.

Table 1: Mean and standard deviations of biology teachers' opinions on the suitability of the developed digital nervous system model for teaching secondary school Biology

S/N	Statements	N	$\bar{X}$	SD	Decision
1	The digital nervous system model is suitable for the level of the students.	33	3.55	.506	Agree
2	The digital nervous system model is appropriate for teaching the nervous system concept.	33	3.67	.479	Agree
3	Use of digital nervous system model will help to achieve the objectives of learning Nervous system.	33	3.61	.496	Agree
4	Contents of nervous system are effectively captured in the digital nervous system model.	33	3.36	.549	Agree
5	Ninety five percent coverage of the concept is covered in the digital nervous system model.	33	3.36	.489	Agree
6	Contents in the digital nervous system model are appropriate and understandable for students' level.	33	3.42	.502	Agree
7	Digital nervous system model put every required step for the students to learn nervous system better.	33	3.48	.566	Agree
8	Use of digital nervous system model will allow the student to gain a better and deeper understanding of nervous system concept.	33	3.61	.496	Agree
9	Content in the digital nervous system model are arranged from simple to complex.	33	3.45	.564	Agree
10	The digital nervous system model is clearly labeled representing of the information included in them	33	3.27	.626	Agree
	Cumulative Mean		**3.47**		

Key; *N= Samples, $\bar{X}$ = Mean, SD= Standard Deviations, Decision mean=2.5 and above.*

Table 1 shows the mean and standard deviation of Biology teachers on the suitability of the developed digital nervous system model for teaching secondary school Biology.The table presented the mean scores for each item and the items were consistently above the decision mean of 2.5. The cumulative mean score of 3.47 was obtained for the 10 items implying that Biology teachers are in agreement with all the statements regarding the suitability of the developed digital nervous system model for teaching secondary schools. This indicates that the developed digital nervous system model is suitable for teaching secondary school Biology.

Research Questions Two: What are the mean ratings of educational technology experts on the quality of the developed digital nervous system model?
To answer research question two, the developed DNS model was presented to educational technology experts who physically evaluated the quality of the model. The result was presented in table 2.

Table 2: Mean and Standard Deviations of educational technology experts on the quality of the developed digital nervous system model

S/N	Statements	N	$\bar{X}$	SD	Decision
1	The key concepts in the digital nervous system model is welled emphasized.	12	3.50	.522	Agree
2	The colour used for the digital nervous system model makes it attractive.	12	3.75	.452	Agree

3	The light indicators in the digital nervous system model are functional.	12	3.58	.515	Agree
4	The light used in the digital nervous system model makes no distraction.	12	3.50	.522	Agree
5	The light indicators buttons worked as expected.	11	3.00	.447	Agree
6	The materials used for the digital nervous system model can facilitate learning.	11	3.55	.522	Agree
7	The light indicators control in the digital nervous system model are easy to operate.	12	3.42	.515	Agree
8	The keys buttons provided in the digital nervous system model are easy to understand.	12	3.42	.515	Agree
9	The light indicator indicates each part in the digital nervous system model.	12	3.33	.492	Agree
10	The colours used for the digital nervous system model are quite appealing.	12	3.42	.515	Agree
	Cumulative Mean		**3.45**		

Key; *N= Samples, $\bar{X}$ = Mean, SD= Standard Deviations, Decision mean=2.5 and above.*

Table 2 shows the mean and standard deviation of educational technology experts on the quality of the developed digital nervous system model. The table presented the mean scores for each item and the items were consistently above the decision mean of 2.5. The cumulative mean score of 3.45 was obtained for the 10 items implying that educational technology experts are in agreement with all the statements regarding the quality of the developed digital nervous system model for teaching secondary school Biology. This indicates that the developed digital nervous system modelmet the quality requirement for teaching secondary school Biology.

Research Questions Three: What is the difference in the achievement scores of secondary school students taught Biology through digital nervous system model and those taught through conventional method?

To answer research question three, the developed DNS model was trial tested on secondary school Biology students. The students were taught the concepts of nervous system using the model for a period of four weeks. Another set of students in a different secondary school were taught the same nervous system concepts using conventional teaching method. To establish the difference in the achievement of students exposed to the two conditions, a post-test was given to all the groups. To analyse the post-test, the mean scores and standard deviations of the experimental and control groups were computed. The results of the analyses are presented in Tables 3.

Table 3: Mean and standard deviation of students' achievement taught Biology Through digital nervous system model and those taught through Conventional method

Group	**N**	**Pre-test**		**Post-test**		**Mean Gain**
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental	63	34.95	10.418	73.67	9.499	38.72
Control	58	34.86	10.671	63.55	7.865	28.69

Key: *N= Number in samples, $\bar{X}$ = Mean, SD= Standard Deviations*

Table 3 displays the difference in the mean achievement scores of secondary school students taught Biology through digital nervous system model and those taught through conventional method. The students exposed to digital nervous system model in the experimental group were higher ($\bar{X}$ = 73.67, *SD* = 9.499) than the mean achievement scores of students in the control group exposed to conventional teaching method ($\bar{X}$ = 63.55, *SD* = 7.865). The mean difference was 38.72 for experimental group and 28.69 for control group respectively indicating a major change in their achievement. The finding implies that Biology students who received instruction using digital nervous system model averagely achieved higher than those who received the same instruction using conventional teaching methods.

HO_1: There is no significant difference in the mean achievement of secondary school students taught Biology through digital nervous system and conventional lecture method.

Table 4: Summary of t-test Results of students' achievement exposed to Biology through digital nervous system and conventional lecture method

Group	N	Df	Mean	SD	*t*-value	*p*-value	Decision
Experimental	63	119	73.67	9.499	6.349*	0.000	Ho_1 Rejected
Control	58		63.55	7.865			

Key: *N= Number in samples, $\bar{X}$ = Mean, SD= Standard Deviations*

Table 4: An independent sample t-test was used to compare the achievement of secondary school students taught Biology through digital nervous system and conventional lecture method. The difference between the two groups were found to be statistically significant *t* = 6.349, *P*-value = 0.000 at *P* < 0.05. In favour of the experimental group. Hence, hypothesis one was rejected.

Discussion

The finding of this study on the mean ratings of Biology teachers' opinion on the suitability of the model for teaching secondary school Biology was encouraging implying that the model will not suffer adoption challenges. Furthermore, additional information for enhancing its adoption in Nigeria's secondary schools is the availability of the model, the cost effectiveness and government intervention in form of funding for mass production. The finding is consistent with Hartoyo and Abdul-Gafur (2019) whose results showed that the products developed were suitable for learning based on alpha testing and beta testing with very good and effective results to improve student learning outcomes.

Educational technology experts rated the developed digital nervous system model as being of high quality for teaching secondary school Biology. The experts were specific in their ratings regarding the colour used for the model as being attractive as entrenched with light indicators which makes it interactive and functional. On experts' suggestion for enhancing the quality of Digital Nervous system model implies that emphasis was directed on the levelling of the nervous system parts to be boldly written in order to enable students seating behind view them clearly. The finding also infers that educational technology experts are comfortable with the developed Digital Nervous system model as having the quality for meeting its objectives. In furtherance to its inherent quality, the power source for the model was suggested to be imbued with rechargeable batteries considering the need to use the model in situations of power outage and village schools.

The finding of research question three on the difference in the achievement scores of secondary school students taught Biology through digital nervous system model and those

taught through conventional method revealed that Biology students who received instruction using digital nervous system model averagely achieved higher than those who received the same instruction using conventional teaching methods. The finding evaluated the effectiveness of the digital nervous system model after satisfying its suitability and quality requirements. Though, the evaluation was at an experimental intervention on a small sample, the finding confirms the superiority of the model against the conventional teaching method routinely practiced in teaching secondary school Biology. The finding was consistent with the earlier finding of Hartoyo and Abdul-Gafur (2019) whose findings showed that using model has a significant effect on the academic achievement of the students in auto-mechanic work. It was also supported by Yaki and Babagana, (2016) whose study of Technology instructional package mediated instruction and senior secondary school students' academic performance in biology concept, reported that Technology Instructional Package employed for teaching Biology was gender friendly.

The finding of hypothesis one revealed that a statistically significant difference exists between the achievements of secondary school students taught Biology through digital nervous system and conventional lecture method. The finding was supported by Hartoyo and Abdul-Gafur (2019) whose findings showed that using model has a significant effect on the academic achievement of the students in auto-mechanic work.

Conclusion

Based on the findings of this study, the following conclusions were drawn; Biology teachers rated the developed digital nervous system model as high and suitable for teaching secondary school students. Moreover, Biology teachers' opinion on the suitability for teaching secondary school Biology was positive with few suggestions for enhancing its adoption in teaching and learning secondary school Biology. Regarding the quality of the model, educational technology experts rated the developed digital nervous system model high and suggested that rechargeable batteries should be used to serve as an alternative source of power rather than using electricity. Biology students who received instruction using digital nervous system model averagely achieved higher than those who received the same instruction using conventional teaching methods. Additionally, the reported achievement was statistically significant favouring Biology students exposed to digital nervous system model.

Recommendations

Based on the findings of this study, it is recommended that biology teachers, students and school administrator should be made aware of newly developed digital nervous system model and adopt it in teaching and learning of Nigeria secondary school biology, Federal and State Ministries of Education should produce the model in large quantity for teaching secondary school Biology. This is to ensure that the science concepts taught in secondary schools are freed from theoretical teaching approach to what is more practical and real. Similarly, as the digital nervous system model proved to be effective in increasing the achievement of secondary school Biology students, Ministries of Education should organise a workshop focusing on training teachers on the importance of using models for teaching science concepts and how to use models in enhancing students learning outcome.

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