New Approaches
Нови подходи

UNDERSTANDING THE CONCEPT OF DIGESTIVE SYSTEM IN BIOLOGY USING COMPUTER SIMULATION

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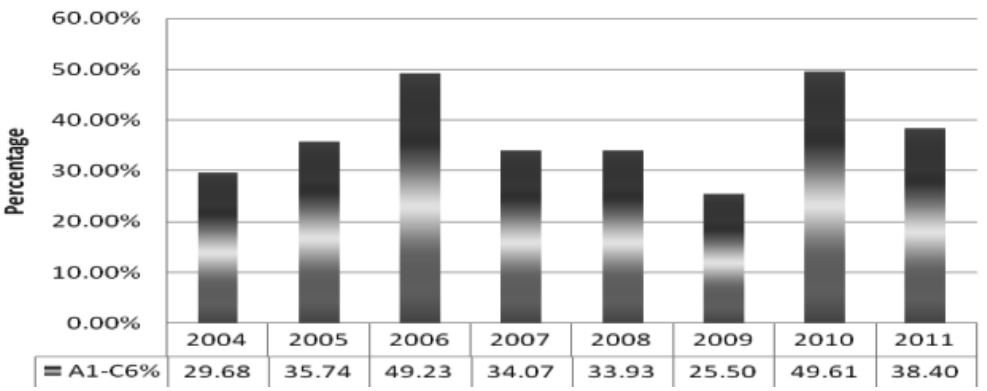
Abstract. This study examined understanding the concept of digestive system in biology using computer simulation. It also determined whether the performance of the students would vary with gender when exposed to computer simulation package (CSP) and biology instructional model (BIM). Participants were 60 senior secondary II (SSII) biology students drawn from three schools in Minna, Niger State, Nigeria. The schools were randomly assigned to experimental and control groups. The experimental group I was taught the concept of digestive system using CSP, experimental group II was exposed to BIM and conventional method was used for the control group. A 20-item Biology Achievement Test (BAT) was validated and its reliability determined as 0.78 using Kuder-Richardson (KR-21). The data collected were analysed with t-test, ANOVA and Scheffe's post-hoc test. The results revealed that there was significant difference in the mean performance scores of students in experimental groups (I & II) and control group. There was no significant difference between the mean scores of male and female students taught biology using computer simulation package, implying that the package is gender friendly. Also, no significant difference was found between the mean scores of male and female students taught biology using biology instructional model. Based on the findings, it was concluded that the use of the computer simulation package was more effective than the biology instructional model and conventional method of teaching respectively. Therefore, it was recommended that use of computer simulation for teaching the concept of digestive system should be encouraged.

Keywords: computer simulation, biology, instructional model, digestive system, gender

Introduction

In Nigeria, biology is one of the core subject taught at senior secondary school level (FRN, 2004). It occupies a unique position in the school curriculum. Biology is central to many science related courses such as medicine, pharmacy, agriculture, nursing, biochemistry and so on. It is obvious that no student intending to study these disciplines can be successful without adequate knowledge of biology.

In spite of the importance of biology at senior secondary school level, the performance of students at national examinations has been quite unsatisfactory over the years. The performance of students in the subject at the Senior Secondary School Certificate Examination (SSSCE) from 2004 to 2011 in Nigeria is revealed below.



Source: WAEC, 2011

Performance of Nigerian students in May/June SSSCE Biology (2004-2011)

The above picture shows a close examination of the performance of Nigerian students in biology in the West African Senior Secondary School Certificate Examination (WASSSCE) results of eight consecutive years. The percentage of students that passed biology at credit and above levels (A1 - C6) had consistently being less than 50% (WAEC, 2011).

The desire to know the causes of the poor performance in biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by the poor quality of science teachers, poor teaching methods, overcrowded classrooms, and inadequate science equipment, among others (Bajah, 2000; Kareem, 2003; Shawl, 2003). A report by Biodun (2004) indicated that science teachers prefer the traditional lecture method of teaching than activity-oriented teaching method which is student-centered. A lot of researches on performance of students have pointed to the ineffective of the traditional method as used by teachers. Current researches have shown the efficacy of computer in assisting students' performance using CAI (Yusuf & Afolabi, 2010)

The potential benefits of Computer-Assisted Instruction (CAI) cannot be underestimated in the contemporary world. Computer simulation is one of the modes of CAI which gives students the opportunity to observe a real life experience. According to

McKinney (2001) one of the most promising computer applications in science instruction is the use of simulations. The use of computer as a complement to conventional instruction produced higher performance than the use of conventional instruction alone (Yusuf & Afolabi, 2010). Furthermore, computer assisted instruction has been found to enhance students' performance than the conventional instructional method in guidance and counseling (Karper et al., 2005). However, students seem to learn instructional contents faster with computer simulation than with conventional instruction alone, and also retain what they have learned.

Several researches had shown that using computer simulation has a positive effect on students' performance compared to traditional methods. For instance, Rey (2010) found that computer simulation reduced time spent on learning and improved learners' retention. Akpan and Strayer (2010) found that students who used computer simulation to dissect frog outperformed those who dissected a frog conventionally. Riess & Mischo (2010) designed a computer simulated scenario on the topic 'ecosystem forest', and found that those students exposed to computer simulation showed significant increase in their mean scores than their counterparts taught with conventional method. Wekeba (2006) found that students taught cell-theory in biology with computer–based instruction simulation (CBIS) program performed better and had better perception towards the cell division topic in school biology than those taught with traditional teaching method. Other instructional system shown to be effective includes the model.

Model is a three dimensional object or representation of a real thing, which can be used to explain details of both internal and external structure of an object. It is known that it is usually valuable to observe real objects in their natural states or environments; this is not usually possible in practice. Real objects are not always available when and where they are needed. This is because they may be too big, complex and too dangerous to be brought to the classroom. Some are even so small that good observations are not possible. It is based on these difficult circumstances that necessitated the construction of biological models. Araromi (1999) stressed that biology instructional models enhances visual imagery, stimulates and scintillates the learners thereby boosting their perception, creativity, better understanding and high performance. Several researches had shown that instructional models enhanced students' performance than conventional teaching method (Ibrahim, 2008; Nsofor, 2006; Yaki, 2004). This study examined the effects of biology instructional model on student performance.

Gender has been identified as one of the factors influencing science students' performance at secondary school level (Eze, 2007). Researches conducted by Nwaorgu (2007), Gambari (2004), Kara & Kahraman (2008), Gambari (2010), and Yusuf & Afolabi (2010) found no significant difference between male and female students taught mathematics, statistics, physics and history respectively using computer-assisted

instructional package. Similarly, Nsofor (2006), Yaki (2006), Ibrahim (2008) found that there is no significant difference between the mean scores of male and female students taught biology using biology instructional models. However, Joshua (2007) reported that male students performed better than female students using mathematical biology instructional model. The study on gender is not conclusive; hence, this paper discussed the influence of gender on students performance in biology as a moderating variable.

The researches on the use of computer simulation for teaching biology at senior secondary school level in Nigeria are not common. Very little is known about the use of computer simulation instructional package in the Nigerian education system particularly in learning some difficult concepts. In fact, the use of computer as an aid to teaching and learning in most schools in Africa is restricted to very few privately owned schools and public schools where the children of the affluent attend (Adegoke, 2011). Thus, much remains to be empirically researched on the effect of computer simulation in biology education, in Nigeria. It is against this background that paper examined understanding the concept of digestive system in biology using computer simulation instructional package.

Purpose of the study

The study investigated understanding the concept of digestive system in biology using computer simulation. Specifically, the study examined: (i) The effectiveness of computer simulation package, biology instructional model and conventional method on the performance of secondary school students taught the biological concept of digestive system; (ii) The influence of gender on the performance of students taught digestive system using computer simulation package and biology instructional model.

Research questions

The study addressed the following research questions: (i) Are there differences in the performance of secondary school students taught digestive system in biology using computer simulation package, biology instructional model and conventional teaching method? (ii) Is there is any difference in the performance of male and female students taught digestive system using computer simulation package? (iii) Is there any difference in the performance of male and female students taught digestive system using biology instructional model?

Research hypotheses

The following hypotheses were formulated and tested at the 0.05 significant level.

Ho_1: There are no significant difference in the performance of secondary school students taught digestive system using computer simulation package, biology instructional model and conventional teaching method.

Ho_2: There is no significant difference between the performance of male and female students taught digestive system using computer simulation package.

Ho_3: There is no significant difference in the performance of male and female students taught digestive system using instructional model.

Methodology

Pretest, posttest, experimental and control groups design was adopted for this study. Two levels of independent primary variable (two treatments and a control), and two levels of gender (male and female) were investigated on students' performance in Biology. The design layout is as shown in Table 1.

Table 1. Research design layout

Groups	Pretest	Treatment	Posttest
Experimental Group I	O	Computer Simulation Package	O_2
Experimental Group II	O_3	Biology Instructional Model	O_4
Control Group	O_5	X_o	O_6

Based on the nature of this research, multi-stage sampling techniques were adopted. Three secondary schools in Minna metropolis, Nigeria, were purposively selected based on the following criteria: resources (laboratories, facilities and manpower), school type (public schools), and gender composition (coeducational schools). The three schools were randomly assigned to experimental group I (Computer Simulation), experimental group II (Biology Instruction Model) and control group (traditional teaching method) respectively. Finally, stratified sampling technique was used to select the 60 SSII students. Each of the assigned group had 20 participants from each school (10 male and 10 female) students.

A Computer Simulation Package (CSP) was developed for this study. The package consists of six sub-units in human digestive system: Mouth; Stomach; Duodenum; Ileum: Colon; and Anus. The necessity for researcher-made computer package was based on the fact that the commercially produced computer-assisted instructional packages are not common. Even if they were available, they may not be directly relevant to the topic or objectives to be achieved in the study. As a result, developing a computer package for use by the researcher was inevitable.

The CSP was packaged using macromedia flash and fireworks program language. It contained the content of human digestive system which was installed on stand-alone computer in computer laboratories of the sample schools (Fig. 1). During the lesson,

computer displays simulation of human digestive system to the learners on each of the sub-units. Students jot down notes on the processes and activities that happen at each stage of digestion. After each unit/stage of the presentation, students were assessed using multiple choice objective questions to measure their comprehension.

BIM was constructed with wood and contained the details of all parts of human body involved in digestive system. During the biology class, the teacher presented the concept of digestive system and used BIM to support his explanation, reinforce the concept, and process of human digestive system (Fig. 2). Students were given opportunities of interacting with the model by touching it, removing and replacing some of the components parts responsible for human digestion. After the presentation of each unit, students were assessed on the concept been taught.

The researchers' adopted Biology Achievement Test (BAT) in collecting the data for this study. BAT consists of 20-item multiple choice objective items with four options (A–D) adopted from past examinations of West African Examination Council (WAEC, May/June, 1998-2010) and National Examination Council (NECO, June/July, 1998-2010). BAT was validated by experts in biology education, computer science, and test and measurement unit of NECO. The reliability coefficient of BAT was determined as 0.84 using Kuder-Richardson (KR-21)

Fig. 1. Computer simulation package

The treatment was for four weeks. The objectives and the modalities of the two teaching strategies were specified and operational guide was produced before the commencement of the treatment. The researcher administered the BAT on sample students as pretest to ascertain the academic equivalence of the students before the treatment. Treatment was followed immediately; thereafter BAT was administered as posttest to measure the performance of the sampled students in each school. The scores obtained were subjected to data analysis. The data were analyzed based on the stated hypotheses, using mean, standard deviation, t-test, and One-way ANOVA. The significance of the various statistical analyses was ascertained at 0.05 alpha level.

Results

Biology Achievement Test (BAT) was used as a pre-test for determining the academic equivalent of students in terms of academic ability and previous knowledge before the experiment. Pre-test data for the groups were analyzed using One-way Analysis of Variance. The results of the analysis are presented in Table 2.

Table 2. ANOVA on experimental and controls groups pretest

Source of variables	**Sum of Square**	**df**	**Mean Square**	**F-value calculated**	**p-value**
Between group	0.400	2	0.200		
Within group	364.600	57	6.396		
Total	365.000	59		0.031^{ns}	0.969

ns: Not significant at 0.05 level

Table 2 shows the result of ANOVA on the pretest mean performance scores of students in the experimental (computer simulation and biology instructional model) and control groups. From the table, the results revealed that there was no significant difference in the performance scores of students in the three groups ($F_{cal} = 0.031$; df = 59; p = 0.969. This indicates that students in the experimental and control groups were academically equivalent before the experiment.

Hypothesis One

There are no significant difference in the performance of secondary school students taught digestive system using computer simulation package, biology instructional model and conventional teaching method.

To test this hypothesis, one-way ANOVA was employed as shown in Table 3. This is to determine whether the treatment made a statistical difference among the three groups.

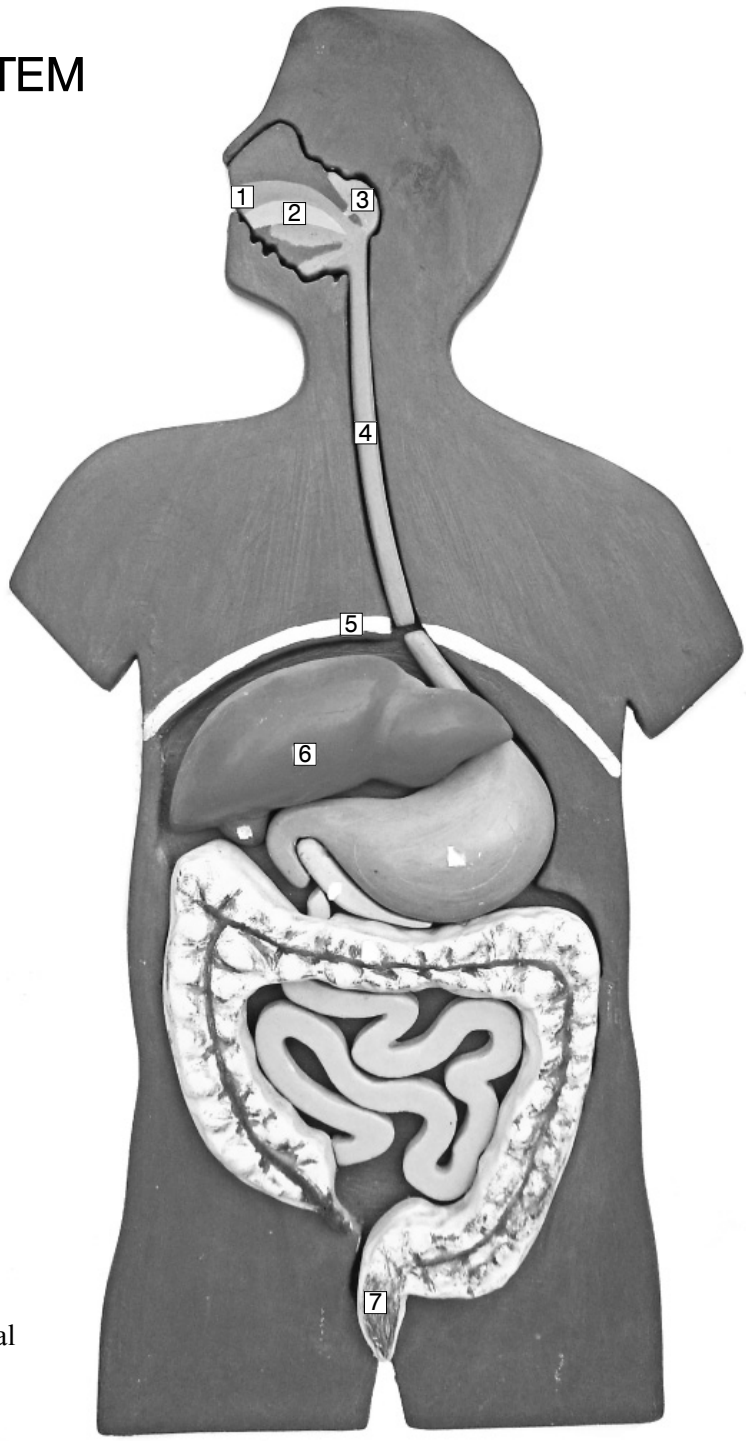


Fig. 2. Biology instructional model

Table 3. ANOVA posttest on experimental and control groups

Source of Variables	**Sum of Square**	**df**	**Mean Square**	**F-value calculated**	**p-value**
Between group	10292.133	2	5146.067		
Within group	733.200	57	12.863		
Total	11025.333	59		400.062*	0.000

*- Significant at 0.05 level

Table 3 shows the ANOVA results of the mean performance scores of students in the experimental and control groups. From the table, the results revealed the difference in the mean performance scores of students in the three groups was significant ($F_{cal.}$ = 400.062; df = 59, p = 0.000). On this basis hypothesis one is rejected. Therefore, significant difference exists in the mean performance scores among the students taught biology with computer simulation package, biology instructional model and conventional teaching method.

In other to ascertain the location of the significant difference between the three groups, Scheffe's Post-hoc test was conducted on the data. The result is shown in Table 4.

The data in Table 4 indicates that there was significant difference in the posttest mean scores of students in BIM Group (X = 78.30) and those in CSP Group (X = 91.30) in favour of CSP group. It also indicates that significant difference exists in the posttest scores of students in CSP Group (X = 91.30) and those in TM Group (59.40) in favour of CSP Group. Significant differences was also established in the posttest scores of students in BIM Group (X= 78.30) and those in TM Group (X = 59.40) in favour of BIM Group.

Table 4. Scheffe's post-hoc analyses of the groups mean scores

Groups	Mean Scores	Group I (BIM)	Group II (CSP)	Group III (TM)
Group I (BIM)	78.30		*0.000	*0.000
Group II (CSP)	91.30	*0.000		*0.000
Group III (TM)	59.40	*0.000	*0.000	

* Significant at 0.05 level.

Hypothesis Two

There is no significant difference between the performance of male and female students taught digestive system using computer simulation package.

To test this hypothesis, t-test statistics was used, the result is presented in Table 5.

Table 5. t-test results of male and female students in CSP group

Gender	No of samples	df	Mean X	SD	t-value calculated	p-value
Male	10		92.50	1.900		
		18			3.059^{ns}	0.454
Female	10		90.10	1.595		

ns: Not Significant at 0.05 level

Table 5 presents the test result of male and female students that were taught with computer simulation package. From the table, the mean performance score was 92.50 for the male students and 90.10 for the female group. The male mean performance scores was not significantly different from that of the female when computer simulation package was employed (t_{cal} = 30.59, df = 18, p = 0.454). This implies that there was no significant difference between the performance of male and female students taught digestive system using computer simulation package. Therefore, the null hypothesis two was not rejected.

Hypothesis Three

There is no significant difference in the performance of male and female students taught digestive system using instructional model.

To test this hypothesis, t-test statistic was employed. The result is presented in Table 6.

Table 6 revealed that 80.60 was the mean performance scores for male students and 76.00 for female group. The mean performance scores for male students did not differ significantly from that of female students when both groups were taught digestive system using biology instructional model (t_{cal} = 2.791, df = 18, p = 0.728). On this basis, hypothesis 3 was not rejected. Therefore, there was no significant difference between the mean performance scores of male and female students taught biology using biology instructional model.

Table 6. t-test analysis of achievement scores of the males and females exposed to BIM

Gender	Number of sample	df	Mean (X)	SD	t-value	p-value
Male	10	18	80.60	3.502	2.791[ns]	0.728
Female	10		76.00	3.859		

ns: Not significant at $p > 0.05$ level of significant.

Discussion of findings

The results of hypothesis one revealed that there is a significant difference in the performance of experimental group I, experimental group II and control group. The experimental group I (computer simulation package) performed better than experimental group II (biology biology instructional model) and control group (conventional teaching method) while there was no difference between experimental group II and control group. This result supports the findings of Rey (2010), Akpan & Strayer (2010), Riess & Mischo (2010) and Wekeba (2006) who found that computer simulation enhanced students' performance than the conventional teaching method. The findings also agreed with Nsofor (2006) Yaki (2006) and Ibrahim (2008) who found that students taught biology using biology instructional models performed better than those taught using conventional teaching methods. The superiority of computer simulation over biology instructional models and conventional teaching methods stems from the fact that it gives students the opportunity to observe a real world experience and interact with it (McKinney, 2001). The higher performance by the experimental group could be attributed to the novel nature of computer simulation in the Nigerian school setting and hence was able to captivate the attention of the students.

The results of hypothesis two showed that there is no difference in the performance of male and female students taught biology with CSP. This finding agree with earlier findings of Gambari (2004), Nwaorgu (2006), Gambari (2010) Yusuf & Afolabi (2010) who found no significant difference between male and female students taught mathematics, statistics, physics and biology respectively using CAI package.

The results in hypothesis three agree with the findings of Nsofor (2006), Yaki (2006), Ibrahim (2008) who found no significant difference between the mean performance scores of male and female students taught biology using biology instructional model.

Conclusion

This paper critically highlighted the level of poor performance in biology education at senior secondary school level in Nigeria. It is the view of the authors that there is still a wide gap to be bridged in the area of teaching and learning. Innovative technology using computer simulation package in teaching abstract biological concept such as the digestive system could be used to reduce or bridge the gap. This study showed that computer simulation package enhanced students' performance in digestive system than biology instructional model. The better performance of students in biology using CSP could be attributed to the effectiveness and the interactivity of the computer simulation package. The computer simulation package and biology instructional models are gender friendly.

Recommendations

Based on the findings of the study the following recommendations are made: (1) Computer simulation package should be encouraged for teaching and learning biology at senior secondary school level because it enhanced students' performance; (2) Computer simulation package and biology instructional models could be used to reduce gender differences between male and female students learning in biology.

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