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Effects of 3-Dimensional Model of Human Digestive System on Students Performance in Biology Concept in Nigeria

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Abstract: This study examined the effects of 3D model of human digestive system (3-DMHDS) on senior secondary school students' performance in Human digestive system in Ilorin, Kwara State, Nigeria. The research adopted a post-test, control group, non-randomized, and non-equivalent quasi-experimental research design. Two intact classes from two secondary schools were randomly sampled based on institutional ownership. The instruments used were Lesson Note (LN), Biology Performance Test (BPT) for data gathering, and 3D-model of human digestive system (3-DMHDS) as the treatment instrument. The reliability coefficient of BPT was determined using the Pearson product-moment correlation and was found to be 0.84. Three research questions and three research hypotheses were formulated for the study. The mean score was used to answer the research questions while an independent sampled t-test at 0.05 level of significant was used to test the hypotheses. Findings show that 3-DMHDS significantly influence the understanding of the human digestive system among students irrespective of their gender and institutional ownership. It was recommended among others that Biology teachers and students should be motivated to use the 3D model for the teaching and learning of the human digestive system among other biology topics.

Keywords: Human Digestive System, 3D Approach, Academic Performance, Biology Students

INTRODUCTION

Biology is a fundamental subject in sciences offered in senior secondary schools, it is an integral science subject/t that centers on the understanding of living things. It is a primary requirement that needs to be passed by students who want to study Biology related courses such as science, medicine, anatomy, agricultural science, microbiology, medicine, nursing, pharmacy, forestry, and fisheries in higher institutions of learning (Hassan, 2019). Also, biology is a field of science that is presented in theoretical and practical form. The Practical presentations of biological concepts offer students the opportunity to carry out scientific processes in the laboratory and outside the laboratory, which are far different from theoretical presentations of some of its topics (Hamzat et. al, 2017). Biology is enriched with topics like cells, circulatory system, photosynthesis, digestive system, respiratory system, excretive system, organs, and so on. Although there might be problem in teaching these topics due to the unavailability of teaching aids to teach the topics (Chavan, 2016).

The overall low academic success of biology students and other science subjects in both internal and external exams and the reduction in students interested in research-oriented subjects has become a major reason for concern as it has adversely influenced the country's education sector. Also, the persistent deterioration of the educational standard in our secondary school system has left nothing to be desired as it has led to the intellectual deterioration of students. Likewise, this intellectual deterioration has contributed significantly to the huge drop-out in government

secondary schools as students are no longer interested in schooling. However, Psychologists, designers, educators, and many professors around the world are working to improve the quality of education to put a stop to this general academic dilemma (Shukla, 2018).

The tools an instructor uses for teaching plays an important role in how the students learn. Motivation, inspiration, attention, engagement, and actionable learning can differ depending on how these tools are used for the teaching and learning process. These tools may come in textbooks, worksheets, maps, infographics, and models which are items that contribute to the information aspect of learning content (Shukla, 2018). Furthermore, the tools can be called teaching aids which are important in teaching, the aids are quintessential for the learning needs, and interest of the students (Jogan, 2020). The teaching aids need to be carefully selected before use has it is important in enhancing teaching and learning processes in a well-organized way. Moreover, and teachers must make effective use of these instructional materials in a proper way to achieve the desired results in the teaching and learning process (Kapur, 2020).

A model is an epitome of a teaching aid which is a three-dimensional, recognizable representation of an object, It may be of the same scale with the items that it portrays or it might be bigger or smaller, it can be viewed and handled from a variety of angles, it can as well be of different styles (BrainKart, n.d.). Moreover, these Models can be measured in 3 directions, the three directions of these models are volume, distance, and height (or depth or thickness) (BYJUS, 2020). Likewise, Rouse & Haughn (2016), describe 3D models as a three-dimensional graphical representation of an element. The 3D models can be used to represent real-world and technological graphics for media, animation, engineering and architecture, and its use in diverse areas, including augmented reality, video gaming, 3D modeling, advertisement, TV and motion pictures, science and medical imaging, and computer-aided design and production. Examples of models include a globe, a toy airplane, car, heart, skeleton, 3-D geometric cones, and spheres.

Oftentimes, direct, and purposeful experiences are not always available and, where available, are not always usable or applicable to make teaching very effective. For example, to teach wildlife ecosystems and its survival, it may not be possible to visit all the wildlife resorts and show the students all the components of the ecosystem. A true human eye or some other human organ may be accessible, but it may prove useless for a thorough analysis, as their handling may be uncomfortable. Sometimes the materials are either too heavy or too small to handle quickly, the only alternative options are provided through improvising objects, specimens, models (2D or 3D), mock-ups, mobiles, and puppets objects (BrainKart, n.d.).

A study by Hruskocy & Foster (2012), investigated the impact of 3D technology on student academic achievement, and retention of learning content. The study noted that when 3D models are used for teaching and learning, students develop high focus towards their learning, it helps to increase their attention and to build the student retentive capacity. However, with the importance of teaching aids, instructional materials like audios, audiovisuals, and models like 3D are unavailable in schools and the teachers are not ready to make any improvisation even with the benefits that this instructional aid provides (Eze & Nwafor, 2012). Another study conducted by Pujol et al. (2016), examines the use of 3D modeling techniques in teaching anatomical concepts, the students suggested that their interaction with 3D models would lead to a better understanding of the concept been thought.

In education the influence of gender on academic performance of students is quintessential, a study conducted by Humble (2020), strongly opined that there is a relationship in gender differences and academic performance of students, and student attitude to learning. Also, a study was conducted to check the effect of gender on the achievement of students in biology using a teaching technique called jigsaw. The study submitted an empirically supported result on gender differences and the result from the study was that the teaching technique was more favorable to the male than the female students has the mean score derived are in favor of male students (Amedu, 2015).

In Spain, an average student benefits more from attending private schools than public schools. They do not only benefits but they outperformed the student in public schools (Choi &

Calero, 2012). Factors such as availability of facilities and the extent to which these facilities are put to use, friendly relationship between student and teacher, students' high parental status, teachers prompt supervision among others are factors that positively influence student academic performance in the private schools than public schools (Kalagbor, 2016). Although studies by Sabitu et al. (2012), revealed that there is no significant difference in the available facilities in schools and student academic achievement irrespective of the school type. However, they suggested that more facilities should be provided in secondary schools to enhance students' academic performance.

Statement of the problem

Students' poor performance in Biology is a recurrence phenomenon that must be addressed through the application of instructional models. Despite the popularity and high enrolment rate of Biology among the students in secondary schools in Nigeria when compared to other science subjects such as Chemistry and Physics, students' performance has been unimpressive. This study evaluated a 3-dimensional model of the human digestive system to teach a biology concept in secondary schools in Ilorin, Nigeria.

Specifically, this study: (i) investigated the effectiveness of the developed 3-dimensional model of the human digestive system on the performance of students taught with the model; (ii) examined the difference in the performance of students taught with the developed 3-dimensional model of the human digestive system in private and public schools and (iii) investigated the influence of gender in the performance of students using the developed 3-dimensional model of the human digestive system. This study provided answers to the following research questions: (i) What is the performance of students taught with the developed 3-dimensional model of the human digestive system and those that were not taught with the 3-dimensional model of the human digestive system? (ii) What is the difference in the performance of students taught with the developed 3-dimensional model of the human digestive system in private and public schools? (iii) What is the influence of gender on the performance of students using the developed 3-dimensional model of the human digestive system?

The following null hypotheses were tested in the study; (i) $H_{01:}$ There is no significant difference between the performance of students taught with the developed 3-dimensional model of the human digestive system (experimental group) and the pupils taught without the model (control group). (ii) $H_{01:}$ There is no significant difference between male and female students' performance when taught with the developed 3-dimensional model of the human digestive system (iii) $H_{03:}$ There is no significant difference between the performance of students taught with the developed 3-dimensional model of the human digestive system in both private and public schools.

METHOD

This study adopted an experimental research design of the quasi-experimental type. Specifically, a Non-equivalent post-test control group design was adopted. The non-equivalent post-test control group design is represented schematically below:

Experimental Group	:	x	O1
Control Group	:	-	O2

Where (x) represents the treatment (teaching with the 3-dimensional model of the human digestive system) while (-) represents the traditional method of teaching (teaching without the 3-dimensional model of the human digestive system). Where O1 and O2 are the post-test for the experimental and the control groups respectively.

The population for this study comprised all senior secondary school students offering biology in Ilorin, Nigeria. However, the target population was senior secondary school biology students in Ilorin. Two senior secondary schools were randomly sampled in Ilorin. One government-owned and one private school were sampled using a simple random sampling technique.

The instruments for this study are a 3-dimensional model of the human digestive system (3-DMHDS), biology performance test (BPT), and lesson notes (LN). The research instrument for data gathering of the student's achievement is BPT, which was adapted from WAEC past questions. The BPT comprises two sections: Section A and B. Section A contains information on the demographic data of the senior secondary school two biology students. Section B contains twenty (20) biology objective questions adapted from WAEC on the topic Human digestive System.

The 3-DMHDS is a teaching aid that was developed by the researchers according to the real form and features of the original Human Digestive System. Available materials that are easily accessible in the environment were used to produce the model. Those materials include plaster of Paris (POP), fiber, resin, accelerator, catalyst, or hardener, top bond, paraffin wax, fiber(mat), and so on.

The instruments for this study were validated by three educational Technology experts and three Biology Education experts at the University of Ilorin. Educational Technology experts' rating scale was developed by the researchers and validated by three educational technology experts from the University of Ilorin. This was used to ascertain experts' opinions on whether the developed model conformed with the acceptable standards and procedures in the fields of Educational Technology. The experts were requested to express their view on whether they strongly agreed (SA), Agree (A), disagree (DA), or strongly disagree (SD) with the statement on the validation questionnaire presented to them as they responded while observing the model.

The researchers-designed Biology Education experts' rating scale was validated by three selected biology education experts and was used to elicit responses based on their evaluation on the developed model of the human digestive system, mainly to ascertain its accuracy. The experts were requested to express their opinions on whether they strongly agreed (SA), Agree (A), disagree (D), strongly disagree (SD) with the statement on the validation questionnaire presented to them as they responded while observing the model. The twenty (20) BPT objective questions were adapted from WAEC question items in the achievement test are highly standardized and validated. Nevertheless, to establish the reliability of this study, the test-retest method was used. Scores were correlated using Pearson product-moment correlation. The reliability coefficient value of the instrument is 0.84.

The researchers personally visited the school where the study was conducted and officially solicited the approval of the appropriate authorities in writing. Permission was also sought to make use of the classroom and employ the students to partake in the study. The researchers make it clear to the students that their bio-data and any vital information extract from them will be treated with confidentiality and will be strictly used only for this study.

Consideration was made by the researcher not to interfere with the school activities, however, the treatment was administered during the period officially scheduled on the school time table for biology lessons. The consent of the biology teacher was sought for the study. They were obliged to help in the administration of the post-test. The study lasted three weeks. In the first and second week, the groups were taught human digestive organs, the experimental groups were exposed to the treatment 3-DMHDS as a teaching aid, while the control group undergoes regular lessons without the model. The experimental group was asked to relate to the treatment without any assistance from the teacher and the researchers. The third week was utilized to administer the post-test on the two groups. The posttest contains 20 objective questions that lasted for 20 minutes.

RESULTS

Research question 1: What is the performance of students taught with the developed 3-dimensional model of the human digestive system and those that were not taught with the 3-dimensional model of the human digestive system?

Table 1 reveals that the students in the experimental group who were taught with the model performed more than the students who were not taught with the model. This was deduced from the minimum scores of (11.00 and 3.00) and the maximum score of (19.00 and 12.00) obtained by the experimental and the control, respectively. Likewise, the mean scores of 15.96 and 8.67 were

obtained by the experimental and control groups, respectively. This shows that the mean score of the experimental group was higher than that of the control group with a difference of 7.23, in support of the experimental group. Hence, the students in the experimental group benefitted by being taught with the model than the students in the control group who were not taught with the model.

Table 1. Descriptive Statistics of the Experimental and Control Groups

Variable	N	Minimum	Maximum	Mean	SD
Experimental	54	11.00	19.00	15.96	1.85
Control	54	3.00	12.00	8.67	2.47
Valid N (listwise)					

Research Question 2: What is the difference in the performance of students taught with the developed 3-dimensional model of the human digestive system in private and public schools?

Table 2 discloses that the performance of public students who were taught with the model was lower than that of private students taught with the same package. The evidence to support this is seen in the mean of 15.76 and 16.20 obtained by the public and private school students, respectively. This shows that the public-school student's mean score was lower than that of the private school students with a difference of 0.44, in support of the private school students. This means that the private school students benefitted in teaching with the model than the public-school students irrespective of their numbers.

Table 2. Descriptive Statistics of The Difference Between the Performance of Public and Private School Student in The Experimental Group

	Variable	N	Minimum	Maximum	Mean	SD
Experimental	Public	29	11.00	1.82	15.76	2.02
	Private	25	13.00	2.66	16.20	1.63

Research Question 3: What is the influence of gender on the performance of students using the developed 3-dimensional model of the human digestive system?

Table 3 unveils that the male students in the experimental group who were taught with the model performed more than the female students who were taught with the model. This was deduced from the minimum scores of (13.00 and 11.00) and the maximum score of (18.00 and 19.00) obtained by the male and the female students, respectively. Likewise, the mean scores of 16.28 and 15.69 were obtained by the male and female students in the experimental group, respectively. This shows that the mean score of the male students was higher than that of the female students with a difference of 0.59, in support of the male students.

Table 3. Descriptive Statistics of The Difference Between the Performance of The Male and Female Students in The Experimental Group

	Variable	N	Minimum	Maximum	Mean	SD
Experimental	Male	25	13.00	18.00	16.28	1.62
	Female	29	11.00	19.00	15.69	2.02

Hypothesis 1: There is no significant difference between the performance of students taught with the developed 3-dimensional model of the human digestive system (experimental group) and the pupils taught without the model (control group).

Table 4 indicates the t-test analysis of the mean scores of biology students in the experimental and control groups. The table unmask that the calculated t-value (t_{106} = 17.35, p < 0.05) at 0.05 level of significant. This shows that students who were taught with the model performed significantly well than those who were not taught with the model. Thus, the hypothesis was rejected.

Table 4. T-Test Analysis of The Significant Difference Between the Performance Of The Experimental and Control Groups

	Variable	N	M	SD	DF	T	Sig. (2-tailed)
Scores	Experimental	54	15.96	1.85	106	17.35	0.00
	Control	54	8.67	2.47			
p>0.05							

Hypothesis 2: There is no significant difference between male and female students' performance when taught with the developed 3-dimensional model of the human digestive system.

Table 5 reveals the t-test analysis of scores between female and male biology students who were taught with the model. The table unveil that that the calculated t-value ($t_{(50)}$ = 1.59, p > 0.05) was not significant at 0.05 alpha level. This indicates that there was no significant difference between the performance of students taught with the package along gender lines. Therefore, the hypothesis was not rejected.

Table 5. t-Test Analysis of The Significant Difference Between the Performance of Male and Female Students in The Experimental Group

	Variable	N	M	SD	DF	T	Sig. (2-tailed)
Experimental	Male	25	16.28	1.85	52	1.17	0.25
	Female	29	15.69	1.82			
p>0.05							

Hypothesis 3: There is no significant difference between the performance of students taught with the developed 3-dimensional model of the human digestive system in both private and public schools.

Table 6 unveils the t-test analysis of scores between public and private school biology students who were taught with the model. The table unveil that that the calculated t-value ($t_{(52)}$ = -0.87, p > 0.05) was not significant at 0.05 alpha level. This denotes that there was no significant difference between the performance of students taught with the package both in the public and private schools. This implies that the hypothesis was not rejected.

Table 6. T-test analysis of the significant difference between the performance of public and private school students in the experimental group

	Variable	N	M	SD	DF	T	Sig. (2-tailed)
Experimental	Public	29	15.76	2.03	52	-0.87	0.39
	Private	25	16.20	1.63			
p>0.05							

Below is the summary of major findings of this research:

1. The experimental group had a higher mean score than the control group, with a difference of 7.23 in support of the experimental group.
2. The public students who were taught with the model had a lower mean score than their private school counterparts with a difference of 0.44 against the public school.
3. The male gender in the experimental group had a higher mean score than their female counterpart, with a difference of 0.59 in support of the male students
4. The students who were taught with the model had significantly performed than those taught without the model.
5. There was no significant difference between the performance of female and male students taught the human digestive system with the model.
6. There was no significant difference between the performance of public and private school students taught the Human digestive system with the model.

DISCUSSION

The major findings of this study revealed that 3-DMHDS is significantly effective in the teaching of human digestive systems: It thus vindicates the findings of similar studies (Hruskocy & Foster, 2012; Kapur, 2020; Pujol et al., 2016). This finding demonstrates that the model provides the opportunity for the student to have a better understanding of the topic (human digestive system). It suggests that the 3D model serves as a reality and cognitive bridge required by the learners to identify and understand all the organs that made up of the human digestive system. Also, the study is compatible with the assertion of Agarwal et al. (2014), who stated that teachers, academics, students, and other professionals show their interest in the 3D model because such learning aids help students to better understand the fundamental basic biological structures and processes. Furthermore interaction with 3D models led to a better understanding of the shape and spatial relationships among structures and helped illustrate anatomical variations from one body to another (Pujol et al., 2016)

In the present study, no gender difference in student's performance when taught biology with the 3D model. In contrast, another study Kamkhedkar et al. (2017), has reported that females scored better than males when taught with 3D models. This shows that the use of a 3D model benefits a gender to the other. The result implies that the 3D model of the human digestive system is gender-friendly, its usage is applicable in a gender-mixed educational classroom.

Results of the Choi & Calero (2012), study showed that students who attend private schools perform better than their counterparts in public schools. Although the reason for this was the unavailability of resources in these schools (Kalagbor, 2016). However, Sabitu et al. (2012), opined that there is no significant difference in the performance of students taught with necessary facilities irrespective of the institutional ownership. It thus validates the findings in this study, which reveals that there is no considerable significant difference between the performance of students taught with the developed 3-dimensional model of the human digestive system in both private and public schools.

The results of this study provided a clear indication that students can acquire adequate knowledge of internal tissues, organs, and system of living things through the utilization of 3D model; hence, it is a relevant teaching aid which serves as a substitute for the actual biological structures. This study will offer priceless information to the school administrators, teachers, and all other stakeholders regarding the importance of 3D model in the teaching and learning process.

CONCLUSION

Based on the major findings of this study, the researchers concluded that the utilization of the 3D model is efficient for teaching biology and significantly influences the performance of students in human digestive system. It was also concluded that students' gender and school type did not influence the performance of students in human digestive system. 3D model can, therefore,

be utilized to develop a meaningful degree of biology knowledge and improve the performance of students in biology despite the gender and the institutional type.

RECOMMENDATIONS

According to the findings, the following are therefore suggested:

1. Biology teachers should be motivated to use 3D model to teach human digestive system among other biology topics.
2. Teachers should encourage students to get themselves familiar with the use of 3D model as a learning aid, by making use of available 3D models.
3. Curriculum planners and policymakers should include the use of 3D models as essential instructional material or teaching aids in teaching biology topics in senior secondary schools.
4. Regular professional development programs should be introduced to train biology teachers by relevant bodies and other major stakeholders in education and science education as a whole to enable biology teachers to update their pedagogic skills

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