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Effect of Low-Cost Technology on Biology Students' Academic Performance in Ilorin, Nigeria

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Abstract: This study examined the effect of Low-cost Technology on Secondary School students' academic performance in Biology. Quasi-experimental research of post-test non-randomized control group design was adopted for this study. This design was adopted to compare the performance of students who were taught the concept of biology with low-cost technology and those taught without the low-cost technology. Two intact classes from two secondary schools were randomly sampled. The instruments used were Lesson Note (LN), Biology Performance Test (BPT) for data gathering, and Low-Cost Technology (3D Model of Plant and Animal Cells). BPT was subjected to pilot testing and a reliability coefficient of 0.87 was obtained using the Kuder Richardson KR-20. Two research questions and two research hypotheses were formulated for the study. Findings show that the 3D Model of Plant and Animal Cell significantly influences the understanding of the topic "Plant and Animal Cells" among students irrespective of their gender and institutional ownership. Secondary school teachers should make use of those low-cost technological resources available in their environment for the production of instructional materials.

Keywords: Academic Performance, Biology, 3D Model, Plant and Animal Cells, Students

INTRODUCTION

It is no more news that the use of technology has permeated all human endeavors, it has been deployed and used in various sectors such as the business sector, industrial, and even the education sector and this has practically changed the ways, practices, and procedures in all of these sectors in which it is being integrated. Before its integration into the educational sector, technological resources were originally limited to environmental activities but now it has crept into the educational system and has had an obvious impact on the curriculum (Nwana et al., 2017).

Ever since the emergence of technological resources in the educational sector, the ways and methods in which teaching and learning are done have changed drastically with new tools and resources being introduced every day to further bring improvement in the educational process. The traditional teacher-centered learning is now fast becoming outdated as new curriculums and methods of teaching which gives more room for student's interest is now being employed for teaching, even the face to face teaching environment is now being moved to a more technology-based learning environment (Liu et al, 2019). In the same vein, Sahin (2017) posited that to achieve the primary aim of education which is to teach individuals how to find and use knowledge for specific purposes. Conventional teaching might be insufficient; this, therefore, calls for the integration of technological resources.

Integration of technological resources in education refers to the use of technology-based tools that incorporates into the daily classroom instructional process as it helps to create a powerful

learning environment and transforms the learning and teaching process in which students deal with knowledge in an active, self-directed, and constructive way. The integration of technology into the educational sector has proven to be a blessing more than a curse, in fact, the benefits it has provided to teaching and learning cannot be overemphasized. Apart from the fact that it enables teachers to select the teaching methods that will increase students' interest and participation in learning, it has also helped students in the assimilation and better understanding of difficult concepts in science subjects like biology (Akinyemi & Ebimomi, 2020).

Biology is one of the Science-based careers and it is made compulsory for science-inclined students in senior secondary school. This is because of its overwhelming importance to human life which cannot be overemphasized (Shayer & Adey, 2014). It is a branch of science that has interconnected series of concepts and conceptual schemes that have been developed as a result of experimentation and observation (Bernard et al., 2017). Biology is conceptualized as a unique life subject that deals with objects that have life, their structure, function, growth, origin, evolution, and distribution. Being a science of life, biology occupies an important position in the school curriculum. It is designed ultimately to educate individuals who may or may not pursue biological-related careers but could at least acquire the knowledge as a prerequisite for pursuing careers in the science-related discipline (Nsofor, 2010).

The knowledge of biology is needed for national development and global competitiveness in the area of medicine, agriculture, and physical and health education, especially in sports and environmental studies among others (Chukwu & Arokoyu, 2019). It will also help to perpetuate desired favorable traits in the production of high breeds of crops and animals through hybridization and cloning respectively, it can also help in the conservation of natural resources and checkmating population explosion. These inherent potentials of biology may explain why biology is recognized and accorded a special position in the school curriculum as the only core science subject that was made compulsory for both arts and science students at the senior secondary school level of the Nigerian education system. Having this in mind one would expect students' performance in biology to justify its continuous popularity among them, but the reverse has been the case. Nsofor (2010) reported that students' performance in the subject is not encouraging at all. The scholar stated that the percentage of passes at credit level and above in Biology in the last two decades fluctuated between 19.3% and 42.2%. It increased from 19% in 2000 to 42% in 2003 and decreased again to 29.08% in 2004. This trend has continued over the years as was reported by the Chief examiner's report of the West Africa Examination Council (WAEC), who stated that the performance of biology students in 2013, 2014, 2015, 2016, 2017, and 2018 has been very poor (Chukwu & Arokoyu, 2019).

This unimpressive performance in biology has been very disturbing and if it is not checked, it might affect the selection chances of students into tertiary institutions not only in biology-related areas but also in other science-based disciplines. Several researchers have carried out studies to know the causes of the problem of poor performance in biology and each of them has provided different results. Nsofor (2010) opined that the reason why students perform poorly in biology is due to the excessive use of the expository method and a teacher-centered method of teaching as one factor that affects the performance of students in Biology. Students blamed their poor performance in biology on the complex nature of most concepts in biology teaching especially those relating to the internally situated organs and systems to which ordinarily they do not have access. Such complex and abstract internal systems include the digestive system, excretory system, respiratory system, nervous system, and blood circulatory system among others.

With the problems highlighted above, it becomes necessary to come up with a solution to how these concepts can be effectively taught in the classroom. Chukwu & Arokoyu (2019) noted that biology should be taught in a way that will help students acquire adequate relevant laboratory skills and management in the subject. One of the ways to achieve this as identified by Asubiojo & Ajayi (2017) is the integration of instructional technology. The scholar defined instructional technology as the projected and non-projected information-carrying technologies that constitute an integral part of the instructional process used for the delivery of educational information very

quickly, widely, and effectively. Mohammad et al. (2015) further stated that the use of instructional media to teach will help improve the students' academic performance as the use of these resources will transform teaching and learning processes from being highly teacher-dominated to student-centered and that this transformation will result in increased learning gains for students, creating and allowing for opportunities for learners to develop their creativity, problem-solving abilities, informational reasoning skills, communication skills, and other higher-order thinking skills.

Regarding this, Nsofor (2010) warned that teachers should not use the absence or inadequacy of instructional resources as an excuse to resort to poor teaching and learning, instead, they should resort to improvisation as an alternative approach to keeping science teaching and learning afloat and meaningful during such a difficult time. Improvisation might include the use of locally produced materials or lesser-cost technologies for teaching Biology in the classroom. Sivakumar (2014) defined low-cost teaching aid as an aid prepared with simple materials costing very little by involving teacher and student, they could be prepared easily with little or no money to make learning effective, comprehensive, and fascinating. The scholar stated further that the benefits of using low-cost technology are that it can serve the needs of the teacher, the student, and the curriculum more effectively and is easier to maintain.

However, for low-cost technologies to effectively serve the purpose for which it is meant, it is important that the teachers have the knowledge of the subject matter to be taught and the skills required to use these resources, this way they will be able to select the best-fit resources to aid in their teaching. Evidence of this can be extracted from the TPACK model proposed by Shulman (1986), which identified Technological Knowledge, Content Knowledge, and pedagogical knowledge as three core categories of knowledge that can affect the efficient and effective integration of technology into teaching and learning. Another factor that might influence learning outcomes is the personal attributes such as students' ability level (high, average, and low) and gender differentials in learning outcomes (Teo et al., 2016). Ahmed & Odewumi (2020) posited that it is a common feature in the conventional classroom to find students of mixed academic ability lumped together to be given the same treatment as if they have everything in common. This phenomenon has been a point of concern to researchers in recent times and this will be investigated in this study.

Gender issues also have been linked with the performance of students in academic tasks in several studies. Majuto & Gibert (2015) found that gender affects male and female use of ICT in language teaching and learning while in other studies (Naugah, 2011) no significant was found between male and female use of technology. Despite various studies to examine the relationship between gender and the use of technological resources for learning, the issues are still far from being conclusive. It is, therefore, reasoned that a considerable amount of empirical research evidence is still required before a definite and convincing pattern of relationship can emerge. Along with gender, another demographic factor that influences technology use is school ownership. Saima et al. (2015) noted that private schools have more access to technological equipment thereby making them perform better than those in public schools and this is due to the availability and adequacy of the teaching and learning resources. This shows that teachers of the private secondary will tend to use technological resources compared to those in public schools since successful integration of technology mostly depends upon its availability. To buttress this further, Malero et al. (2015) noted that there is a disparity in ICT usage among public and private school students as the number of computers owned by private schools is twice as much as what a public school could afford. A similar study by Nchunge et al. (2013) in Thika, Kenya, rated private schools far better than their counterparts in terms of internet connectivity and the existence of ICT policy/guidelines.

The importance of biology in the secondary school curriculum cannot be overemphasized, apart from the fact that it is one of three core subjects; it is a study that deals with the life of a man and other living things in his environment. This is why it was written in the revised National Policy on Education (2019) that students are required to have adequate laboratory and field skills in biology, meaningful and relevant knowledge in Biology to develop the ability to apply scientific knowledge to everyday life in matters of personal and community health, agriculture and other

functional scientific attitudes. With this, one would though biology should easily be one of the best subjects in terms of student's examination performance.

However, despite the importance and usefulness of biology in the student's curriculum, the performance of students in biology in WAEC exams hasn't been encouraging at all (Chukwu & Arokoyu, 2019). This makes it paramount to seek a strategy for teaching biology concepts and this includes the integration of technological resources into the teaching and learning of biology. This will help improve the understanding and performance of students in biology. However, due to the high cost of maintenance of these resources which has led to their availability in most secondary schools, scholars (Sivakumar, 2014; Bernard et al., 2017) suggested the use of low-cost technology that can serve the same instructional purpose as the expensive technological resources. It is in this regard that this study aids to investigate the effect of low-cost technologies in teaching Biology to secondary school students in Ilorin, Kwara state. One of the challenges in teaching some concepts in biology is the inability to have the in-depth study of internal organs in the body which is probably because these organs are not visible and accessible. The instructional model can bridge this gap if carefully designed, developed, and validated by experts.

In this study, low-cost technology is the 3-dimensional model of plant and animal cells. Models are direct imitations, images, or duplicates of real, original, or natural objects or figures. They are made in place of the original figure or object for obvious reasons and they are therefore used as such in place of the original objects or figures. Meaningful instruction takes place only with the appropriate use of instructional materials, especially in their real form. Models come in form of 3-dimensional forms; it includes instructional material that has length, breadth, and depth (Olumorin, 2016). 3-dimensional instructional models are those instructional models that have length, breadth, and depth. 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 as the object or figure 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. 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.

However, the 3-dimensional model used in this study was plant and animal cells made from local materials. Such materials include Plaster of Paris (POP), Resin, Accelerator, Catalyst, Fiber Mat, Car Paint, Acrylic Paint, Sandpaper, Painting Brush, and Paraffin Wax. Plant and animal cells are structurally similar since they are both eukaryotic cells. They both have membrane-bound organelles such as the nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, ribosomes, cytoplasm, and peroxisomes. Plant and animal cells contain all the structures and organelles found in animal cells, except the centrioles. The most prominent is the cell wall that gives the plant cell its definite shape. The cell wall is fibrous and has high tensile strength, close to that of steel. It thus provides the plant with mechanical support. Since plants make food by photosynthesis, their cells contain chloroplasts. In-plant cells, starch granules are present while in animal cells, glycogen is present (Sarojini, 2011).

This study sought to achieve three specific objectives: (i) investigate the difference between the post-test score of the students in the control and experimental group in private school; (ii) examine the difference between the post-test score of the students in the control and experimental group in public school; (iii) investigate the influence of school ownership on the academic performance of secondary school student, and (iv) examine the influence of gender on the academic performance of secondary school students in both private and public school. The following null hypotheses were tested in the study; H01: there is no significant difference between the academic performance of the secondary school students based on school ownership and H02: there is no significant difference between the academic performance of the secondary school students based on gender.

METHODS

Quasi-experimental research of post-test non-randomized control group design was adopted for this study. This design was adopted to compare the performance of students who were taught the concept of biology (plant and animal cells) with the 3D Model of Plant and Animal cells and those that were taught without. Students' performance in biology was determined using both the control group and the experimental group. The Experimental group was subjected to a treatment using the low-cost technology (3D Model of Plant and Animal Cell) while the Control group was taught without the 3D Model of Plant and Animal Cell. The research design layout is shown in Table 1.

Table 1. Research Design Layout

Groups	Treatment	Post-test
Experimental Group 1	3D Model of Plant and Animal Cell	O_1
Control group 2	Conventional method	O_2

The schematic representation of the research layout is as shown below:

$$\begin{matrix} X_1 & O_1 \\ X_2 & O_2 \end{matrix} \quad (1)$$

where O_1 represents the post-test of the experimental Group O_2 represents the post-test of the Control Group. X_1 represents the treatment for the Experimental Group while X_2 represents the conventional method of the control group.

The population for this study was all senior secondary school students in Ilorin-south, Kwara State. The target population for the study was two randomly selected secondary schools in Ilorin-South. Two senior secondary schools were randomly sampled for the study. One government-owned and one private school were sampled using a simple random sampling technique. Two intact classes were used in the selected secondary school.

The procedural instrument used in the study is the model of plant and animal cells (Low-cost Technology) which was used in teaching plant and animal cells to the experimental group. The measurement instrument called Biology Performance Test (BPT) can be referred to as an objective test formulated on the topic plan and animal cell to test the extent to which students understand the topic. Also, the BPT was developed by the researcher to determine the relevance of the developed model of plant and animal cells (low-cost technology) to the topic "Plant and Animal cell". Twenty (20) multiple choice objective questions were administered to the students in both experimental and control groups. For the effective presentation of the lesson, a lesson note (LN) was developed by the researcher on the topic of plant and animal cells using the Essential Textbook for secondary school.

The 3D Model of Plant and Animal Cell for teaching plant and the animal cell was validated by experts in the department of the Educational Technology University of Ilorin, Kwara State. The" Biology Performance Test' (BPT) was validated by three Biology experts in senior secondary school. BPT was subjected to pilot testing and a reliability coefficient of 0.86 was obtained using the Kuder Richardson KR-20 while the lesson note (LN) was validated by three Biology teachers in senior secondary school.

RESULTS

Demographic Information of the Respondents

Table 2 shows that the total number of students that participated in this study was 60. Out of these 60 students, 26(43%) were male while 34(56.7%) were female. The result from this table shows that female students participated more than male students in the study. Figure 1 further presents the distribution in a pie chart.

Table 2. Distribution of the Participants Based on Gender

Gender	Frequency	Percentage
Male	26	43.3
Female	34	56.7
Total	60	100.0

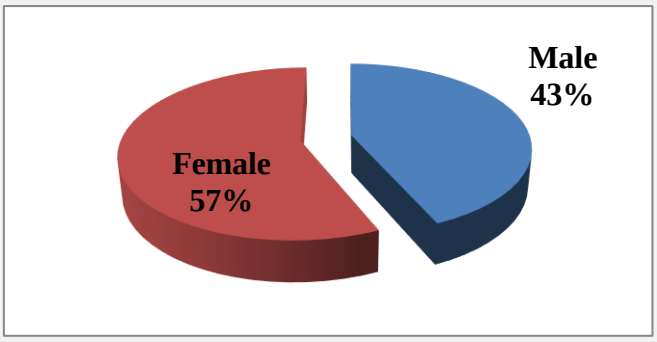

Figure 1. Distribution of the Participants Based on Gender

Table 3. Distribution of the Participants Based on School Ownership

School Type	Frequency	Percentage
Public	49	81.7
Private	11	18.3
Total	60	100.0

Table 3, shows the participants' distribution based on school ownership. The table shows that 49(81.7%) of the participants are from public schools while 11(18.3%) of the respondents are from private schools. Based on the distribution, it shows that more participants came from public schools. Figure 2 further presents the distribution in pie chart.

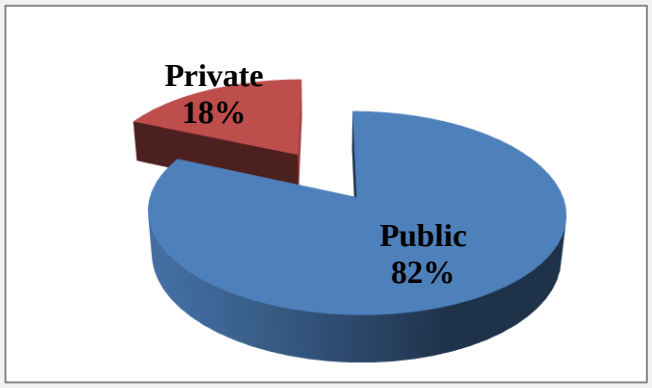

Figure 2. Distribution of the Participants Based on School Ownership

Table 4. Distribution of Participants Based on Treatment Groups

Group	Frequency	Percentage
Experimental Group	35	58.3
Control Group	25	41.7
Total	60	100.0

Table 4, shows the number and percentage of the participants in each of the two groups (Experimental and Control Group) that were used for this study. The table shows that 35(58.3%) of the participants were in the Experimental group while 25(41.7%) were in the Control group. This result is an indication that more students 35(58.3%) participated in the Experimental group than in the Control group. Figure 3 further presents the distribution in pie chart. Data collected were subjected to descriptive statistical analysis; using simple percentages and mean scores.

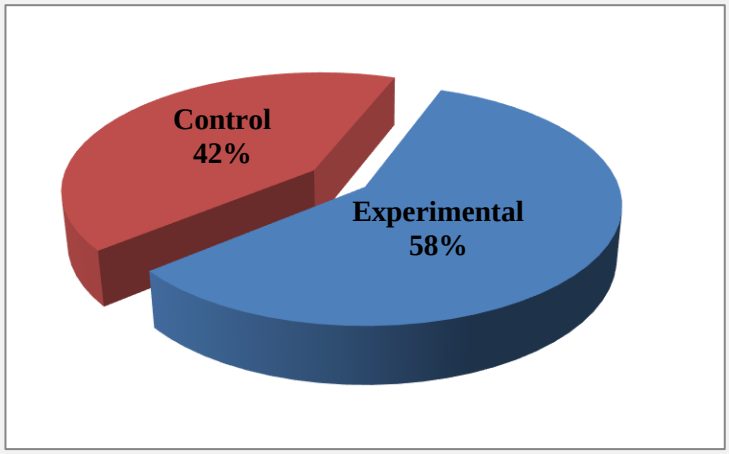

Figure 3. Distribution of Participants Based on Treatment Groups

The Difference Between the Post-Test Score of The Students in The Control and Experimental Group in Private School

Table 5. Mean and Standard Deviation of the Students in the Control and Experimental Groups in Private School

Variable	N	Mean	Std Deviation
Control	4	10.25	3.30
Experimental	7	15.14	2.04

Table 5 shows the mean and standard deviation of the students in the control and experimental groups in private schools. The Control group with a mean score of ($\bar{x}$ = 10.25) while the experimental group had a mean score of ($\bar{x}$ = 15.14). Based on the mean score of each group, it can be inferred that the difference between the posttest score of the students in both control and experimental groups is ($\bar{x}$ = 4.89). That is, the mean of the experimental group is greater than that of the control group with 4.89. This shows that the experimental group performed better than the control group in the private school.

Table 6. Summary of the t-test of Private and Public School Students' Academic Performance

School Type	N	X	SD	Df	t	Sig.(2-tailed)	Remark
Private	11	13.36	3.44	58	-.180	.86	Not rejected
Public	49	13.14	3.71				
Total	60						

Table 6 indicates that [df (58), t= -.180, p=.86, p > 0.05]. This means that the null hypothesis was not rejected. This was as a result of the t-value of -.180 resulting in .86 significance value which is greater than 0.05 alpha value. Thus, the stated null hypothesis was established: there was no significant difference between the academic performances of the secondary school students

based on school ownership. The mean score for private school students' academic performance is 13.36 while the mean score of public school students' academic performance is 13.14. The values of the mean scores do not reveal any appreciable difference.

The Difference Between the Post-Test Score of The Students in The Control and Experimental Group in Public School

Table 7. Mean and Standard Deviation of the Students in the Control and Experimental Groups in Public School

Variable	N	Mean	Std Deviation
Control	21	10.14	2.82
Experimental	28	15.39	2.53

Table 7 shows the mean and standard deviation of the students in the control and experimental groups in public schools. The Control group with a mean score of ($\bar{x}$ = 10.14) while the experimental group had a mean score of ($\bar{x}$ = 15.39). Based on the mean score of each group, it can be inferred that the difference between the posttest score of the students in both control and experimental groups is ($\bar{x}$ = 5.25). That is, the mean of the experimental group is greater than that of the control group with 5.25. This shows that the experimental group performed better than the control group in public school.

Table 8. Summary of t-test of Male and Female Students Academic Performance

Gender	N	X	SD	Df	T	Sig.(2-tailed)	Remark
Male	26	13.31	3.16	58	.23	.82	Not rejected
Female	34	13.09	4.01				
Total	60						

Table 8 indicates that [df (58), t= .23, p=.86, p > 0.05]. This means that the null hypothesis was not rejected. This was a result of the t-value of .23 resulting in .82 significance value which is greater than 0.05 alpha value. Thus, the stated null hypothesis was established: there was no significant difference between the academic performances of the secondary school students based on gender. The table shows that the mean score for male students is 13.31 while that of female students is 13.09. The values of the mean scores do not reveal any appreciable difference.

DISCUSSION

The research question on the difference between the post-test score of the students in the control and experimental groups in private schools showed that the mean of the experimental group is greater than that of the control group with 4.89. Likewise, in the public school, the difference between the post-test score of the students in the control and experimental group in public school is ($\bar{x}$ = 5.25). Overall, this shows that the students performed better when taught with low-cost technologies. This supported the earlier findings of Daniela (2015) where the scholars reported that using low-cost technology allows for hands-on experiments and practical activities in students learning which further helps to improve students' learning, practical skills development, problem-solving, and analytical skills, and positive attitudes towards science.

The hypothesis tested on school ownership shows no significant difference between the academic performances of the secondary school students based on school ownership which goes against the findings of Yasmeen et al. (2015) which stated that private school students perform better than their counterparts in public school and this is due to the fact that private secondary schools are more properly managed and more equipped compared to public schools. Lastly, the hypotheses tested on gender show no significant difference in the academic performances of secondary school students in relation to their gender. The finding supported that of Ameen & Willis

(2019) who opined that gender role does not exist in technology use an academic performance of students.

CONCLUSION

The results of this study provided a clear indication that biology students can acquire adequate knowledge of plant and animal cells through the utilization of locally made 3D instructional models. It is a relevant teaching aid that serves as a substitute for the actual biological structures of plant and animal cells. Technologies have the potential to play powerful roles in enhancing teaching and learning preparing students to acquire fundamental skills, knowledge, and competencies to enable them to compete in the emerging global knowledge of digitalization, however, due to the expensive nature of some of these technologies, it becomes a little difficult to be used by schools with low funding. With the use of the 3-dimensional instructional model, learning objectives can be achieved. Therefore, it is important to emphasize the usage of these resources to be used by teachers in secondary schools, especially in public where most of these technological resources are absent. This will allow teachers to present lessons to students in a more understandable and concrete manner.

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