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EFFECTS OF ICONIC MODELS AND CHARTS ON SCIENCE STUDENTS' ACADEMIC PERFORMANCE IN UYO MUNICIPALITY

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Abstract
This study investigated the effects of iconic models and charts on science students' academic performance in the concept of human circulatory system. Non- randomized pre-test – post-test control group design was used. The study sample was 100 Senior Secondary I (SSI) science students drawn from Uyo Municipality of Akwa Ibom State. Simple random sampling technique was used. Three hypotheses were tested. The instrument used in collecting data was Science Performance Test (SPT). The test had a reliability index of 0.78 determined using test-retest approach. The results of data analysis showed that students taught with iconic models had a better performance than those taught with charts. Gender was not a strong determinant of students' performance in science. Based on the findings, it was recommended, among others, that science teachers should adopt effective use of iconic models in teaching science concepts in view of its high facilitative effects on students' academic performance.

Keywords: Iconic Models, Charts, Students' academic performance.

Introduction

Education is a priority factor for every well meaning society. This is because education has an irreplaceable position in the life of any individual. It is an overall welfare of human existence reflected in political stability, health satisfaction and prosperity of citizens. Because of the importance of education, effective science teaching is necessary for positive outcome that will aid learners' understanding and acquisition of basic science skills and this can be achieved through effective teaching methods, utilization of teaching materials/ resources and enabling environment which are responsible for learning to thrive and can be achieved through science education.

Science subjects offer opportunities for science teachers to transmit meaningful learning through the use of adequate instructional materials to try to reverse poor academic performances of students in the subject. According to Damar, Hulda and Jonah (2016), when a teacher teaches students using different instructional materials, it will help the students to directly develop their skills and experiences. This will also provide opportunity for students to actively participate in the teaching-learning process. The authors stated that a teacher needs to use instructional materials that are very close to reality. Lock and Mogt (2013) asserted that the effectiveness of instructional materials depends on the manner and the degree to which they meet the needs of the teachers and students. Onasanya and Omosewo (2011) observed that students' performance rise and they retain information and concepts taught when their learning experiences are incorporated with instructional materials. Students gain a more realistic understanding of the concepts taught in classrooms.

Onasanya and Omosewo also stated that instructional materials are variety of materials in any format which influence students' learning and instructor's teaching or those items that are designed to instruct students in the teaching/learning process.

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Instructional materials include periodicals, pamphlets, art prints, pictures, charts, transparencies, films slides, video cassettes, CD electronic resources and models.

Model according to Dyoshak (2011) is an abstraction of reality and a representation of a real object or a simplified version of anything. Models, as noted by Dyoshak are divided into three classes on their degree of abstraction and these are iconic, analogous and symbolic models. Iconic model is a least abstract because it is physical and look-alike model. Analogous model is more abstract and have some resemblance of what it represents like charts, graphs and maps; while symbolic model is a most abstract model with no resemblance but only an approximation of what it represents like mathematical equation or formula, financial statement and set of accounts. Lock and Mogt (2013) added that most topics in science are experimental or practical-based and these topics need materials that will make the instruction to be students-centred by giving opportunity for the learners to interact and actively participate in the lesson. Such materials include iconic models.

Vempt (2011) referred to iconic model as a smaller or larger physical copy of an object. Fowler (2005) defined iconic models as a representation in three dimension of an existing person, object or of a proposed structure on a smaller scale. Damar, Hulda and Jonah (2016) highlighted the importance of using iconic models in science teaching to be that models provide an environment for interactive students' engagement. The authors stated that evidence from science education research have shown that significant learning gains are achieved when students participate in interactive engagement activities. Teaching with iconic models will enhance critical thinking abilities and that the knowledge the students will gain using iconic models is long term.

Lock and Mogt (2013) said that the use of iconic models to teach science concepts is a credible way to teach students as it helps the students use their prior knowledge to develop explanations for their hands-on experiences of the scientific phenomena or concept that the model represents. Odenbaugh (2015) stated that though iconic models allow students to explain and reason within specifics that may have previously been unknown; these models are not available in schools for teaching-learning process. He suggested that government and other private organizations should provide models for teaching science concepts and workshops should be organized to train teachers on the effective use of iconic models so as to facilitate effective students' academic performances. Odenbaugh (2015) concluded that iconic models are used to discuss, modify, manipulate and expand students' understanding and if they are not used, it makes the lesson so boring to the learners because it will be a teacher-centered type of instruction since the students will not acquire the basic knowledge and skills required for that lesson.

Chart is another instructional material that has the potential to address the problems of effective teaching and learning in science. It is a type of instructional material whose primary functions are to facilitate the teaching of skills, facts, concepts, principles, generalizations, values and attitude in science (Gredler, 2012). Recent trends and emphasis in science education suggest that the teacher should be a "facilitator of learning" as opposed to being a lecturer of facts, concept, principles and generalization in science. As a result of this trend and emphasis, there has been an expansion in the development of visual materials which could assist the science teacher achieve his objectives in the classroom. Charts can be used for real objects and specimens where the real objects and specimens are not readily available or accessible. The use of charts in teaching helps to sharpen student's observation skills and foster interest in learning (Oyen, 2006). Charts are important visual aids, which combine pictorial, graphic, or numerical information and are used to facilitate learning. Charts which may be in form of diagrams and graphs can be used to present facts and information in a condensed form.

James-Inyang (2005) carried out a research on the effects of charts on students' performance in Biology Achievement Test (BAT) given their gender, attitude to Biology and school location and the findings indicated that students taught using charts performed better than those taught with

expository method. Abell and Lederman (2014) observed that students who were taught digestive system using iconic models performed better when compared with students who were taught the same concept using charts. The researchers concluded that students who were taught using charts did not incorporate the hands-on experience, but only saw the drawings of the oesophagus and the stomach whereas students who were taught using iconic model were given the opportunity to touch and correlate how food travel from the mouth through the digestive track to the anus using the model, thus enhancing critical thinking.

The concept of human circulatory system is a science topic that deals with the transportation of blood and oxygen from the lungs to the various tissues of the human body. Wikipedia (2014) indicated that the circulatory system also called the cardio-vascular system is an organ system that permits blood to circulate and transport nutrients (such as amino acids and electrolytes), oxygen, carbon dioxide hormones and blood cells to and from the cells in the body to nourish it, stabilize body temperature and P^H and to maintain homeostasis (body water balance/salt balance). Mifflin (2014) indicated that human beings have closed circulatory system (meaning that blood never leaves the network of arteries, veins and capillaries). Mifflin further stated that the component of the human circulatory system include the heart, blood, red and white blood cells, platelets, blood vessels and lymphatic system (that carries or transport the lymph).

Cliffs (2007) stated that the heart which is the pumping station of the human body has four chambers: two atria and two ventricles. The right atrium is the upper chamber of the right side of the heart. The blood that is returned to the right atrium through the vena cava is deoxygenated (poor in oxygen) and is passed into the right ventricle through the tricuspid valve. The blood is pumped through the lungs through the pulmonary artery for re-oxygenation and gas exchange. The left atrium receives the oxygen rich blood from the lungs through the pulmonary vein which flows through the bicuspid value into the left ventricle from which it is pumped through a major artery, the aorta and then to the different organs of the body. The human circulatory system is divided into two: pulmonary circulatory system and systemic circulatory system. Pulmonary circulatory system is the portion of the cardiovascular system in which oxygen–depleted blood is pumped away from the heart through the pulmonary artery to the lungs while systemic circulatory system is the portion of the cardiovascular system which transports oxygenated blood away from the heart through the aorta from the left ventricle to the rest of the body of both male and female.

On the issue of gender difference on students' academic performances in science subjects. Thersaurus (2002) saw gender as a range of physical, mental and behavioural characteristics pertaining to and differentiating the masculinity and feminity of an individual. In the process of teaching and learning science-based subjects, some researchers have shown that male performed better especially in practical aspects than the female students but Sparks (2013) argued that in a classroom setting where students are actively involved in an interactive lesson with the teacher, there will be no difference in their academic performance. Dyoshak (2011) investigated gender difference in academic achievement and observed that male students are highly engaged in constructive educational activities while female students fall between the extremes. Sparks (2013) stated that there is a sex difference in the intelligent quotient-girls are superior to boys up to the age of fourteen (14) while boys take the lead from fifteen (15) years and above. Bandura (2007) confirmed that intellectual capability and motivation are significant factors of academic performance. Bandura concluded that male students are usually both internally and externally motivated to learn causing them to have higher performances than the female students. Udoh (2015) found no significant difference in gender and students' academic performance and retention in Biology when taught nervous coordination using computer simulation and charts. The findings of Udoh (2015) were also in agreement with the findings of Oludipe (2012) and Thomas (2006). However in the contrast, Etiubon (2011) showed that female students performed better than male students in Chemistry. In view of the controversial findings, this study seeks to investigate effect of

gender on academic performances of science students on the concept of iconic models and charts.

Statement of the Problem

Students' academic performances in sciences have not improved in Nigeria despite the awareness of different instructional materials available for use by science teachers for content delivery in the curriculum. This has really been a serious concern for educators. Science subjects are the bedrock of science and technology, hence, personal and national developments are directly linked to the subjects and they play fundamental roles in economic development of any country including Nigeria.

Despite these benefits on the subject matter, the observed deteriorating students' academic performance has attracted alarming concern at every level. It should be noted that the instructional resources adopted by teachers influence both the students' learning styles and their acquisition of science process skills which is greatly needed for science and technological accomplishment. The use of appropriate instructional resources could enhance academic performance and the most prominent factor responsible for students' poor performance in science has been identified to be the inability of the students to recall what had been learnt due to poor teaching resource used by the teachers (Udoh, 2015). It therefore becomes inevitable for the researchers to compare different resources with a view to reversing the resultant poor learning outcomes and for enhancing students' academic performance in sciences, hence, the effects of iconic models and charts on science students' academic performance on the concept of human circulatory system in Uyo municipality.

Purpose of the Study

The study assessed the effects of using iconic models and charts on students' academic performance in science. Specifically, the following objectives were raised:

1. To determine the difference in academic performances of students taught human circulatory system using iconic models and those taught with charts.
2. To determine the difference in academic performances of male and female students taught human circulatory system using iconic models.
3. To determine the difference in the academic performances of male and female students taught human circulatory system using charts.

Research Questions

The following research questions guided the study:

1. What difference exists between the academic performances of students taught human circulatory system using iconic models and those taught with charts?
2. What difference exists between the academic performances of male and female students taught human circulatory system using iconic models?
3. What difference exists between the academic performances of male and female students taught human circulatory system using charts?

Null Hypotheses

The following null hypotheses were raised and tested at .05 level of significance:

1. There is no significant difference between the academic performances of students taught human circulatory system using iconic models and those taught with charts.
2. There is no significant difference between the academic performances of male and female students taught human circulatory system using iconic models.
3. There is no significant difference between the academic performances of male and female students taught human circulatory system using charts.

Research Method

The design adopted for this study was non randomized pre-test – post-test control group quasi-experimental design with 2 treatment groups. Group 1 was the experimental group taught with iconic models and group 2 was the control group taught with charts. The study was conducted in Uyo Municipality of Akwa Ibom State. Uyo Municipality is the headquarters of Uyo Local Government Area. The population of Uyo Municipality is made up of mainly civil servants. It has one (1) Federal University – the University of Uyo, Uyo City Polytechnic and twenty (20) secondary schools, out of which thirteen (13) are government owned. The researchers decided to choose Uyo Municipality for the study because of proximity and based on the assumption that secondary schools are equipped with instructional resources.

The population for this study comprised 15,325 senior secondary one science students in the 13 public secondary schools in Uyo municipality in 2015/2016 academic session. A sample of 100 senior secondary one (SS1) science students drawn from two intact classes in two co-educational public secondary schools out of thirteen (13) was used for the study and fifty (50) students were sampled in each school. The intact classes in the two schools were randomly assigned as experimental group and control group respectively. Simple random sampling technique was used.

The instrument for data collection was Science Performance Test (SPT) developed by the researchers. The SPT had two Sections: A and B respectively. Section A obtained personal information from the students, while section B contained 20 multiple choice question items that reflected the topic human circulation. Each correct answer was scored five points and the incorrect answer, zero. Hence, the maximum score was 100 and minimum zero. The instrument was face and content validated by two (2) lecturers from the Department of Science Education, Measurement and Evaluation. The evaluators were required to look at the appropriateness and content coverage of the items and provide necessary opinions, suggestions and corrections. All their various corrections and comments made were incorporated into the final draft of the research instrument. The instrument was trial tested using 20 students who were in the population but were not selected for the study. The reliability coefficient of the test was 0.78 determined using test-retest method.

The researchers used the science teachers in the selected schools as research assistants after duly briefing them on the use of the validated instructional packages developed by the researchers. The research assistants, after administering SPT as pre-test, taught the students in their respective intact class groups, using instructional packages during the normal class periods. The experimental group was taught the concept of human circulatory system using iconic models, while the control group was taught the same concept using charts. The assistants administered the reshuffled version of SPT as post-test after treatment. The classroom investigation lasted for two weeks. Both the teaching of the concept and the administration of the pre-test and post-test were strictly supervised by the researchers. The pre-test and post-test scripts were collected immediately after each test by the research assistants and handed over to the researchers for marking. The data obtained from both the experimental and control groups were analyzed using descriptive statistics (mean and standard deviation) and Analysis of Covariance (ANCOVA).

Results

Research Question 1

What difference exists between the academic performances of students taught human circulatory system using iconic models and those taught with charts?

Table 1: Mean and standard deviation scores of students' pre-test and post-test performance taught human circulatory system classified by instructional resources

Instructional Resources	Pre-test			Post-test		
	N	$\bar{X}$	SD	$\bar{X}$	SD	Mean Gain
Iconic Models	50	23.20	7.15	60.44	8.57	37.24
Charts	50	22.76	6.72	56.72	9.29	33.96

In Table 1, the mean gain score for iconic models is 37.24 and the use of charts is 33.96. These results indicate that students taught with iconic models performed better than those taught with charts.

Research Question 2

What difference exists in the academic performances of male and female students taught human circulatory system using iconic models?

Table 2: Mean and standard deviation scores of male and female students' pre-test and post-test performance taught human circulatory system using iconic models

Gender	N	Pre-test		Post-test		Mean Gain
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	
Male	24	23.58	6.75	62.00	7.39	38.42
Female	26	22.85	7.61	59.00	9.45	36.15

In Table 2, the results shows that male students taught human circulatory system using iconic models had a mean gain of 38.42 and their female counterparts taught circulatory system using iconic models had a mean gain of 36.15. The result indicates that male students performed better than their female counterparts when both groups were taught human circulatory system using iconic models.

Research Question 3

What difference exists in the academic performances of male and female students taught human circulatory system using charts?

Table 3: Mean and standard deviation scores of male and female students' pre-test and post-test performance taught human circulatory system using charts

Gender	N	Pre-test		Post-test		Mean Gain
		$\bar{X}_1$	SD_1	$\bar{X}_2$	SD_2	
Male	23	23.13	5.81	57.74	10.54	34.61
Female	27	22.44	7.51	55.85	8.19	33.09

In Table 3, the results show that male students taught human circulatory system using charts had a mean gain of 34.61 and their female counterparts taught human circulatory system using charts had a mean gain of 33.09. The result indicates that male students performed better than their female counterparts when both groups were taught human circulatory system using charts.

Testing of Hypotheses

Hypothesis 1

There is no significant difference between the academic performances of science students taught human circulatory system using iconic models and those taught using charts.

Table 4: Summary of analysis of covariance (ANCOVA) of students' post-test performance classified by instructional resources with pretest as covariate

Source	Sum of Squares	Df	Mean Square	F	Sign at P < .05	Decision
Pre-test (Covarate)	341.241	1	314.241	4.054	.047	*
Resources	367.025	1	367.025	4.735	.032	*
Error	7518.159	97	77.507			
Total	351340.000	100				

* = significant at .05 level of significance, NS = Not significant at .05 level of significance

In Table 4, the calculated probability value (P-value) .032 of the main effect of instructional resources is less than the declared Probability value (alpha level) .05. Therefore, the null hypothesis one is rejected. This implied that there exists a significant difference between the academic performances of science students taught human circulatory system using iconic models and those taught using charts.

Hypothesis 2

There is no significant difference in the academic performances of male and female students taught human circulatory system using iconic models.

Table 5: Summary of analysis of covariance (ANCOVA) of science students' academic performance scores using iconic model classified by gender with pre-test as covariate

Source	Sum of Squares	Df	Mean Square	F	Sign at p < .05	Decision
Pre-test (covarate)	1.168	1	1.168	.016	.901	NS
Gender	110.829	1	110.829	1.493	.228	NS
Error	3488.832	47	74.230			
Total	186252.000	50				

* = Significant at .05 level of significance, NS = Not significant at .05 level of significance

As shown in Table 5, the calculated p-value .228 of gender is greater than alpha level .05. Therefore, the null hypothesis is retained. This implies that there is no significant gender difference in the academic performances of male and female science students taught human circulatory system using iconic models.

Hypothesis 3

There is no significant difference in the academic performances of male and female students taught human circulatory system using charts.

Table 6: Summary of analysis of covariance (ANCOVA) of science students' academic performance scores using charts classified by gender with pre-test as covariate

Source	Sum of Squares	Df	Mean Square	F	Sign at p < .05	Decision
Pre-test (Covarate)	783.235	1	783.235	10.819	.002	*
Gender	65.285	1	65.285	.902	.347	NS
Error	3402.607	47	72.396			
Total	165088.000	50				

* = Significant at P < 0.05 alpha, NS = Not significant at .05 level of significance

As shown in Table 6, the calculated P-value .347 of gender is greater than alpha level .05. Therefore, null hypothesis is retained. This implies that there is no significant gender difference in the academic performances of science students taught human circulatory system using charts.

Discussion of Findings

The study was on the effects of iconic models and charts on science students' academic performance in the concept of human circulatory system given their gender differences. The results in Tables 1 and 4 showed that students taught using iconic models had a better performance than students taught with charts. The better performance of students taught using iconic models than charts underscores the importance of greater involvement of the learners in the teaching and learning process of science because of interactive environment with the resources. This agreed with Lock and Mogt (2013) who identified that the use of iconic models to teach science concept is a credible way to teach students as it helps the students use their prior knowledge to develop explanations for their hands-on experience of the scientific phenomenon or concept that the model represents. Odenbaugh (2015) stated that though iconic models allow students to explain and reason within specifics that may have previously been unknown; these models are not available in schools for teaching-learning process. It should be noted that iconic models allow learners to work in a dynamic interactive environment which facilitate their knowledge reformulation and concept attainment besides evoking and sustaining interest, concretizing learning and making learning less stressful. The observed facilitative effect of iconic models on students' concept attainment in science supports Udoh's (2015) assertion that instructional resources holds great potential for enhancing students' performance.

On gender difference, Tables 2, 3, 5 and 6 showed that there is no significant difference between the academic performances of male and female students in science when taught using iconic model and charts. Hence, hypotheses 2 and 3 are upheld. A comparison of these performances indicated that both male and female students taught human circulatory system with iconic models had the best performance, followed by those taught with charts. These comparable performances of male and female students observed agreed with Udoh (2015) which showed no significant difference in gender on students' academic performance and retention in Biology when taught nervous coordination using computer simulation and charts. The findings of Udoh (2015) were also in agreement with the findings of Oludipe (2012) and Thomas (2006). However, James-Inyang (2005) indicated that gender is not a strong determinant of students' academic performance in science rather the instructional resource used to facilitate learning.

Conclusion

Consequent upon the findings from this study, it is concluded that iconic models have greater enhancing effects on students' academic performance than the use of charts and that students' academic performance in science is significantly dependent on teaching resource adopted rather than gender differences among students.

Recommendations

From the findings of this study, the following recommendations were made:

1. Science teachers should adopt the use of instructional resources like iconic models in teaching science concepts in view of its high facilitative effects on students' academic performance.
2. Government and other private organization should provide iconic models for teaching science concepts and workshops should be organized to train teachers on the effective use of these materials so as to facilitate effective students' academic performances.
3. Similar study should be conducted in other parts of the country and in other subject areas to allow for meaningful generalization.

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