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Graphic Organizers and Students' Achievement in Physics and Chemistry: Integrating Technology in Science Classroom

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Abstract

This study which investigated the effect of graphic organizers on students' achievement in physics and chemistrywas conducted in three Education Zones in Bayelsa State, Nigeria. Three research questions and three hypotheses guided the study. 354 secondary school students participated in the study.The studyadopted a non-equivalent pretest-posttest control group design. Physics and Chemistry Achievement Test (PCAT)instrument used for the study was validated and trial-tested using Kuder-Richardson K-R_{20} and the reliability was established at0.80. Descriptive statistics was used to answer the research questions and analysis of covariance ANCOVA was used to test the research hypotheses. Results revealed that the pretest mean achievement scores of experimental and control groups were 17.14 and 14.83 respectively, while the posttest mean achievement scores for experimental and control groups were40.4423.83respectively, with a mean gain of 23.3 for experimental group and 9.06 for the control group; the pretest mean achievement scores of both male and female students were 17.22 and 17.03 while the posttest mean scores were 40.1 and 40.9 respectively;the pretest mean achievement scores of urban and rural students were 17.72 and 15.25 respectively, whilethe posttest mean achievement scores for urban and rural students were 40.78 and 39.32 respectively.ANCOVA results showed thatstudents taught using graphic organizers had significantly higher achievement scores in selected topics from physics and chemistry than the students taught using conventional method.There was no significant difference in achievement of male and female students taught selected topics in physics and chemistry using graphic organizers. No significant difference was found between the mean achievement scores of urban and rural students taught selected topics in Physics and Chemistry using graphic organizers. Based on the findings of the study a few recommendations were highlighted.

KEY WORDS: Graphic Organizers, Physics and Chemistry, Achievement, Technology

Introduction

Science education is an integrated field of study which considers both the subject matter of science disciplines such as Biology, Chemistry, Physics, Agriculture, etc as well as the process involved in the learning and teaching of science. It includes all education

processes aimed at providing unlimited opportunities for learners to understand and utilize necessary knowledge, skills and attitudes required to operate effectively in a scientific and technological society. Therefore, science education is the application of principles of education in the development and acquisition of processes/procedures required to help others acquire scientific and technological knowledge for ready application to everyday living. Studies have shown that engaging students in inquiry learning activities promote the enhancement of science process skills among them, reduce their perception of science disciplines (example Chemistry and Physics) as difficult and abstract and enhances achievement (1). Furtherance to these merits, students who are motivated to translate skills acquired in the classroom to solving problems in their local communities could be of immense help in promoting entrepreneurship for poverty reduction.

Physics is an important physical science that deals with the fundamental question on the structure of matter and interaction of elementary constituents of nature that are susceptible to experimental investigation and theoretical inquiry. Physics is a branch of science that is concerned with the nature and properties of matter and energy. Physics is very essential in the career development of students and plays a major role in most aspects of our lives. It is an important element in the education of chemists, engineers, computer scientists as well as practitioners of other physical and biomedical sciences. Physics generates fundamental knowledge needed for the future technological advances that will continue to drive the economic engine of the world. The rate of economic and infrastructural development of any nation is determined by the rate of technological advancement of the nations concerned(Ijih, &Ilaye 2017).

The role of chemistry as one of the science subjects in both national and global development cannot be over-emphasized. The study of chemistry offers one the opportunities to develop an understanding of scientific method and the ability to understand the living world of which man himself is a part. This has contributed to its relative popularity among other school subjects especially the sciences. It is important therefore that chemistry, of all science subjects should be given priority attention in our schools. The current development in science and technology of which chemistry is a part, has greatly affected the lives of every human being. To be ignorant of the basic ideas of chemistry which is the physical branch of science that deals with the physical properties and the composition of matter is to live in an empty, meaningless and unrealistic world. Any nation therefore, that is not scientifically inclined, cannot make any reasonable progress in technological advancement needed for economic, political and social development of the nation. Scientific and technological

advancement constitute how nations of the world have been classified as developing or undeveloped. To be fully acquainted with the needs of the society we belong to, chemistry has been made an internal part of the schools' subjects.

In line with this, Bayelsa State and Federal Government of Nigeria initiated certain measures to (i) assuage the perennial failure of secondary school students at the West African Senior School Certificate Examinations (WASSCE) (ii) enhance the admission of reasonable number of students in chemistry in tertiary institutions (iii) promote professional development of chemistry teachers by provision of scholarship for further training (iv) provide standard science laboratories for teaching and learning.

Studies have shown that most students perform poorly in physics and chemistryon a yearly basis and do not seem to improve, despite research studies that had recommended the use of various teaching methods to keep abreast with current education reforms. According to Adegoke (2017), West African Examinations Council, Chief Examiners, reported that most students failed Physics and Chemistry in 2014 – 2017. In the same vein, Ebiye (2017) noted that WAEC Chief Examiners revealed that students failed Physics and Chemistry in 2016-2017 with less than 50% of candidates who registered for the examinations passing with less than "C" grade. Research continues to reiterate that traditional teaching methods persistently used by teachers do not foster conceptual understanding of science concepts and therefore constitute a major factor to students' poor performance in science subjects (Saudat&Umaru, 2015, Opara, 2013, Kamau, 2012). Even though emerging trends show that digital technologies are fast forming new social constructs and shaping the ways in which young people are thinking, communicating, collaborating and operating, the application of digital technologies in teaching and learning in Nigeria is still remote. Yet, Green and Hannon (2007) observed that young people are fully integrating digital technologies into their social lives. Experience has shown that many secondary schools in Nigeria are ill equipped with computers especially schools in rural areas. In some schools situated in the urban which have equipped computer laboratories, teachers do not make maximum use of the computers because of their incompetency in applying digital technologies in the classrooms for teaching various science subjects. Worst still, the epileptic power supply in Nigeria does not create appropriate scenario for teaching sciences with digital technologies during school hours considering the time allotted to classroom teaching. Thus, teachers continue to resort to traditional teaching methods because they are more comfortable with content coverage.

Yet, studies in favour of computer-based instruction, CBI, as against traditional methods abound (Gunes 2010; Kara &Yaka, 2008). Research has shown that computer-

based instruction, CBI, provides enormous tools for enhancing teaching and learning processes in a range of disciplinary fields such as the construction of new opportunities for interaction between students and knowledge, accessing information, online training, computer classes, distance education, web-learning, virtual learning and e-Learning (Punie, Zinnbauer and Cabrera, 2006).Hançer&Yalçın, (2009); Lin, (2009) and Ragasa, (2008) found out that CBI helps studentsto (i) develop meta-cognitive skills (ii) learn in a meaningful way in contrast with rote-memorizationand (iii) enables them to increase their achievements. Thus, by providing drawings, graphics, animation, simulations, music and materials for students to proceed at their own pace taking cognizance of their individual differences and learning abilities, learners are given opportunities to develop their own learning processes as they become acquainted with digital technologies. Hence, the provision of a pictorial display of instructional aids, maps flow charts for teaching topics in electrochemistry (redox reactions, galvanic and voltaic cells could minimize students' lack of conceptual understanding and difficulty in solving related problems in the topics. This is the essence of graphic organizers.

Graphic organizers are a pictorial way of constructing knowledge based on existing knowledge and organizing complex information in a simple-to- understand manner in the mental structures. In the view of Marzano (2018),as students socially interact while creating maps - examining relationships between items in topic at hand, prioritizing information and determining which parts of the material are the most important, they develop creative and critical thinking skills. The net result is the occurrence of meaningful learning which enhances their ability to transfer classroom knowledge to real life situations. Studies such as Vallori (2014), Ajverdi, Nakibogu and Aydin (2014) underscore the relevance of graphic organizers because graphic organizers (i)show how concepts are linked to prior knowledge to aid in understanding. (ii) aid the memory in contrast with mere recall of texts (iii) help retain information readily when higher thought processes are involved (iv) engage the learners with a combination of the spoken word with printed text and diagrams (v) aid science students to convert data/information/ideas into a graphic map which gives them an increased understanding and insight into the topic at hand (vi) facilitate students' abilities to solve problems in Physics and Chemistry and to answer questions that require application and synthesis of the required concepts. It is interesting to note that the addition of colour coding and use of simulations further foster students' readability of visual display, motivates their interest to learn, to be active participators and self –regulators in the learning process.

Consequently, teacher's role shifts from being that of knowledge transmitter to that of a facilitator. The teacher is no longer the center of attention as the dispenser of information, but rather plays the role of facilitator whose support in guiding students working in groups promote their capacity to choose designs, maps and flow charts that succinctly match the concepts under study. Hence, classroom dynamics become learner-oriented as students take the position of defining their own learning goals, performing authentic tasks, making design, taking reasonable decisions and evaluating their progress. Therefore, the integration of technology in the classroom empowers students in myriad ways from learning to be responsible for their own learning to being prepared for the challenges they will meet after school in a competitive market economy.

Some studies done in Nigeria such as Adegoke (2017), Opara (2013) addressed the problem of students' abysmal failure in Physics and Chemistry using explicitly solving instruction and collaborative method respectively. Others such as Eric (2015) and Ragasa (2008) promoted the importance of advance organizers as important in promoting learning outcomes in Physics and Chemistry, yet, the integration of technology in science classrooms through the use of graphic organizers has not been achieved in Nigeria. The premise of this study therefore, is to investigate the effect of graphic organizers on students' achievement in Physics and Chemistry using selected topics common to both disciplines.

Research Questions: 1. What are the mean achievement scores of secondary school students taught selected topics in Physics and Chemistry using graphic organizers and those taught by conventional method?

2. Whatare the mean achievement scores of male and female students taught selected topics in Physics and Chemistry using graphic organizers?

3. Whatare mean achievement scores of rural and urban secondary school students taught selected topics in Physics and Chemistry using graphic organizers**?**

Hypotheses: 1. There is no significant difference in the mean achievement scores of secondary school students taught physics and chemistry using graphic organizers and those taught using conventional method.

2. There is no significant difference in the mean achievement scores of the male and female secondary school students taught physics and chemistry using graphic organizers.

3. There is no significant difference between the mean achievement scores of urban and rural secondary school students taught physics and chemistry using graphic organizers.

Research Method: The study adopted a pretest-posttest non-equivalent control group design.354 SeniorSecondary Class 2 students from six public coeducational schools

participated in the study.Coeducational schools were used because gender is a variable in the study.Purposive sampling was used to select only three coeducational schools (2 urban and 1 rural) that were reasonably equipped with computers and power supply, out of 60 coeducational schools in the study area. Purposive sampling was also used to select all the students in the three schools offering Physics and Chemistry, given a total number of total 188 students (110 male and 78 female). Random sampling was used to select three coeducational public schools (1 urban and 2 rural) (poorly equipped with computers); also using only students offering Physics and Chemistry in the three schools, given a total of 166 students (100 male and 66 female). The two groups were randomly assigned to control and experimental groups. Thus, the experimental group comprised 188 students while the control group was made of 166 students. Most of the rural schools are poorly equipped with computers and power supply. Hence, one computer and electric generator were made available to the experimental group in the rural setting to conduct the experiment. The total number of students in the experimental class in the rural area comprised 44 students. Hence,urban participants were 144, while rural participants were 44 students.

The instruments used in this study were physics and chemistry achievement test (PCAT). PCAT comprised 60 item instruments prepared for SSS 2 science students (experimental and control groups). The test was based on some selected topics in physics and chemistry based on WAEC Chief Examiners report from 2014 – 2017.

Validation and reliability of the Instrument: The instrument developed was subjected to content and face-validity and trial tested on (40) science students in senior secondary schools in Benue State which was not part of the study area. The data collected from the trial testing were used to determine the reliability of the instrument. The scores from PCAT were analyzed using Kuder-Richardson K-R_{20} reliability statistical method and the reliability was established to be 0.80.

Experimental Procedure: Before the commencement of the treatment, the subject teachers from the six secondary schools were trained onthe useof graphic organizers and how to use the computers for animations, simulations, Venn maps and flow charts. The students selected for the study were grouped into experimental and control groups. Then, the students in the experimental group were taught how to use computers and graphic organizers in different physics and chemistry topics beginning with topics common in both disciplines (redox reactions, electrolytic cell, voltaic cells, calculationsand data collation) while those in the control group were taught same topics using conventional teaching method. Four weeks of class instruction were conducted, and in all, eight lessons of four double periods and four

single periods were used as reflected at the school time table. To determine how the students comprehended the physics and chemistry concepts, at the end of the four weeks, PCAT was administered to the two groups and the outcome was subjected to statistical analysis to establish level of achievement between the students in the two groups.

Method of Data Analysis: The research questions posed were answered using descriptive statistics of mean and standard deviation. The hypotheses formulated were tested at 0.05 level of significance using Analysis of Co-variance (ANCOVA) in the testing of the entire hypotheses. ANCOVA was used because of the following reasons; control factors which cannot be randomized but measurable on an interval scale, to remove the effects of variables.

Results: Results of this study were presented according to research questions posed and the postulated hypotheses.

Research Question: 1. What are the mean achievement scores of secondary school students taught selected topics in Physics and Chemistry using graphic organizers and those taught by conventional method?

1. **Table 1 Mean Achievement scores and standard deviation of senior secondary Students taught Physics and Chemistry using graphicorganizers and those taught using Conventional Method**

Groups	**N**	**Pre PCAT**		**Post –PCAT**		
		Mean	SD	Mean	SD	Mean Gain
Experimental	188	17.14	4.39	40.44	5.87	23.3
Control	166	14.83	4.78	23.83	6.25	9.06
Mean Diff		**2.31**		**16.6**		
Total	**354**					

Table 1 revealed that the pretest means achievement scores of experimental and control groups were 17.14 and 14.83 respectively, while the standard deviations were 4.39 and 4.78 respectively. The mean difference of both groups was 2.31.The posttest mean achievement scores for experiment group was 40.44 and standard deviation is 5.87 while control group had the mean 23.83 and standard deviation 6.25. The mean gainwas 23.3 for experimental group and 9.06 for the control group. The result indicated that students taught selected topics in physicsand chemistry using graphic organizersperformed better than those taught using Conventional Method.

Research Question 2: What are the mean achievement scores of male and female senior secondarystudents taught selected topics in physics and chemistry using graphic organizers?

Table 2: Mean Achievement scores and Standard deviation of male and female senior secondary school students taught selected topics in Physics and chemistry using graphic organizers

Gender	N	Pre PCAT		Post –PCAT		
		Mean	SD	Mean	SD	Mean Gain
Male	110	17.22	4.33	40.1	5.8	22.9
Female	78	17.03	4.49	40.9	6.0	23.93
Main Diff.		**0.19**	**0.7**			
Total	**188**					

Table 2 revealed that the pretest mean achievement scores of both male and female students to be 17.22 and 17.03 while the standard deviations were 4.33 and 4.49 respectively. The mean difference of both groups was 0.19.The posttest of male and female students taught selected topics in Physics and Chemistry were 40.1 and 40.9 respectively with a mean gain of 1.03.Therefore, though the female appeared to perform better than the male, the mean gain of 1.03. showed that graphic organizers benefitted both male and female students.

3. What are mean achievement scores of rural and urban secondary school students taught selected topics in Physics and Chemistry using graphic organizers?

Table 3: Mean achievement scores and standard deviation of Urban and Rural senior secondary students taught selected topics in physicsand chemistry using graphic organizers

Location	N	Pre PCAT		Post –PCAT		
		Mean	SD	Mean	SD	Mean Gain
Urban	144	17.72	4.36	40.78	5.66	23.06
Rural	44	15.25	3.95	39.32	6.43	24.07
Mean Diff		**2.47**		**1.46**		
Total	**188**					

Table 3 revealed that the pretest mean achievement scores of both urban and rural students were 17.72 and 15.25 while the standard deviations were 4.36 and 3.95 respectively. The mean difference of both groups was 2.47. Hence, both urban and rural students

benefitted from the use of graphic organizers with rural students performing slightly better by 1.01. Also, the posttest mean achievement scores for urban and rural students were 40.78 and 39.32 while their standard deviations were 5.66 and 6.43 respectively. The mean difference was 1.46. The mean gain for urban students is 23.1, 24.0 for rural students.

Hypothesis 1: There is no significant difference in the mean achievement scores of senior secondary students taught selected topics in Physics and Chemistry using graphic organizers and those taught using conventional methods. Table 4 below revealed the result of this hypothesis

Table 4. ANCOVA results of achievement scores between senior secondary students taught selected topics in physics and chemistry usinggraphic organizers and those taught using Conventional Method

Source	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	24845.841[a]	2	12422.921	352.530	.000	.668
Intercept	20724.097	1	20724.097	588.095	.000	.626
Pre-achievement	521.147	1	521.147	14.789	.000	.040
Group	21210.763	1	21210.763	601.905	.000	.632
Error	12369.020	351	35.239			
Total	414515.000	354				
Corrected Total	37214.862	353				

R Squared = .668 (Adjusted R Squared = .666

Table 4 revealed that p =0.00. This is less than 0.05 level ofsignificance. Since p was found to be less than 0.05, the hypothesis which stated that there is no significant difference in the mean achievement scores of students taught selected topics in physics using and Chemistry using graphic organizers and those taught using conventional methods was rejected. Therefore, significant difference in scores between the experimental and control groups occurred.

Hypothesis 2: There is no significant difference between themean achievement scores of the male and female studentstaught selected topics inPhysics and Chemistry using graphic organizers. The result of this hypothesis is presented in Table 5

Table 5. ANCOVA result of the achievement scores of male and female senior secondary students taught selected topics in physics and chemistry using graphic organizers.

Source	Type sum of squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	66.528[a]	2	33.264	.966	.383	.010
Intercept	20641.714	1	20641.714	599.136	.000	.764
Pre-achievement	42.698	1	42.698	1.239	.267	.007
Gender	22.457	1	22.457	.652	.420	.004
Error	6373.706	185	34.452			
Total	313836.000	188				
Corrected Total	**6440.234**	**187**				

R Squared = .010 (Adjusted R Squared = .000

Table 5 showed that p =0.42. Since p was greater than 0.05, the hypothesis which stated that there is no significant difference between the mean achievement scores of the male and female senior secondary students taught selected topics in Physics and Chemistry using graphic organizers is not rejected. Therefore, the null hypothesis was accepted.

Hypothesis 3: There is no significant difference between the mean achievement scores of urban and rural senior secondary students taught selected topics in Physics and Chemistry using graphic organizers. The result of this hypothesis is presented in Table 6.

Table 6. ANCOVA result of the achievement scores of urban and rural senior secondary students taught selected physics and chemistry using graphic organizers

Source	Sum of Squares	Df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	151.314[a]	2	75.657	2.226	.111	.023
Intercept	20728.417	1	20728.417	609.764	.000	.767
Pre-achievement	79.514	1	79.514	2.339	.128	.012
Location	107.242	1	107.242	3.155	.077	.017
Error	6288.920	185	33.994			
Total	313836.000	188				
Corrected Total	6440.234	187				

R Squared = .023 (Adjusted R Squared = .013

Result in Table 6 showed that p =0.77. Since p is greater than 0.05, thenull hypothesis which stated that there is no significant difference between the mean achievement scores of urban

and rural students taught selected topics in Physics and Chemistry using graphic organizers was not rejected**.** The result proved that the use of graphic organizers enhanced the achievement of **rural** and urban students equally.

Discussion: Based on the analysis of data from this study, results showed that students taught using graphic organizers had significantly higher mean achievement score inselected topics in Chemistry and Physics than the students taught using conventional method. This agreed withHançer&Yalçın, (2009); Lin, (2009) and Ragasa, (2008) who averred that the use of graphic organizers in computer-based instruction has the capacity to improve students' learning outcomes and achievement. The result could be explained from the perspective that students were not only motivated to learn because of the use of graphic organizers, but also because the process of tapping into their prior knowledge at the beginning of the lesson may have cleared a pathway for meaningful participation.

That male and female students taught using graphic organizers had high mean achievement scores in selected topics in Physicsand Chemistryrevealed that meaningful learning took place which impacted on the achievement of both, showing that graphic organizers can reduce gender disparity in achievement in applied sciences. The positive impact of graphic organizers on the achievement of urbanand rural students taught in the selected topics in Physics and Chemistry confirm that the provision of computers to schools should be a welcome teaching tool among our youth as opined by Marzona (2018). This implied that visual display, presentation of scientific content in simulations and pictorial forms, foster learners' motivation to learn, to brainstorm, to access and analyze data and be actively involved in the learning process. Consequently, location of schools should not be a hindrance to application of technology in science classrooms by teachers. After school, all young people (irrespective of school location they graduate from) enter into the same competitive job market to face the challenges that make demands on their creative potentials and technological skills.

Conclusion: Sequel to the results of this study, the use ofgraphic organizers in science teaching in a technological age is underscored. For conceptual understanding in science to take place meaningful learning must occur. This behooves that teachers should make extra efforts to minimize talk and chalk method of teaching in science and integrate technology in their pedagogy. It is also pertinent to motivate learners to take responsibility of their own learning process while gingering them to be creative and critical thinkers. Whilethe use of

graphic organizers has been found to be gender-friendly, teachers' efforts in ensuring full and equal participation of male and female students in decision-making, in setting their own learning goals and evaluating their learning outcomes cannot be overemphasized. Thus, Nigerian teachers need to be more proactive increating enabling learning environment for integration of technology in their science classrooms and in promoting scientific, technological and soft skills among learners. This is critical if teachers must produce young people fit to meet the challenges of a competitive technological age and if they (the youth) would make their own contributions to national development when they leave school.

Recommendations

Based on the findings of this study, the following recommendations were made:

Science teachers in secondary schools should be encouraged to use graphic organizers in teaching science related subjects like physics and chemistry.

1. Since graphic organizers are found to favour achievement of male and female students, inphysics and chemistry, secondary school teachers should be encouraged to use graphic organizers to enhance students' achievement in all science subjects.
2. Teacher education institutions should be encouraged to include graphic organizers and technologies in science curriculum as well as in the trainingof teaching methods for trainee teachers.
3. Finally, text books writers should be encouraged to incorporate the use of graphic organizers in their writings. This will go a long way in making physics and chemistry fostering the application of technologies in science classrooms.

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