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EFFECT OF GENERATIVE LEARNING MODEL ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY

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ABSTRACT

This study investigated the effect of generative learning model on secondary school students' academic achievement in Chemistry. It covered the topics of kinetic theory of gases and gas laws. Two research questions and two hypotheses were used to guide the study, relevant literature were also reviewed. The study was carried out in Awka Education zone in Anambra State. The population of the study consists of eight thousand five hundred and eighty three SS1 Chemistry students in the zone. The sample size for the study comprised of one hundred and eighty three (73 males and 110 females) SS1 Chemistry students. The study adopted quasi-experimental design. Out of 49 co-educational secondary schools in the zone, four co-educational schools were selected. Two were assigned to experimental group which used GLM instructional strategy while two were assigned to control group which used demonstration instructional strategy DIS. 35 male and 67 female Chemistry students were assigned to experimental group which received treatment involving teaching Chemistry using generative learning model instructional strategy GLM while 38 male and 43 female Chemistry students were assigned to control group which were taught using demonstration instructional strategy DIS. Twenty- five Chemistry achievement test (CAT). The instruments were validated by experts in science education department and education foundation. CAT reliability was established using Kudar Richardson 20 (KR-20) which yielded reliability coefficient of .87. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at .05 level of significance. The findings of the study revealed that, though generative learning model improve students' academic achievement of secondary school students taught Chemistry with demonstration instructional strategy in control group, DIS significantly achieved better than those taught with generative learning model in experimental group. Also the study revealed that, there is no significant difference male and female academic achievement in Chemistry. Based on the findings of the study, it was concluded that the use of generative learning model instructional strategy improves academic achievement of Chemistry students not minding the gender. Based on these findings, conclusions and recommendations were made.

Keywords: STEM, Chemistry, Achievement, Generative Learning Model (GLM)

Introduction

Science, Technology, Engineering and Mathematics (STEM) education was introduced in 2001 by the Scientific Administrators at the US National Science Foundation (NSF) with three major goals; to expand the number of students who ultimately pursue advanced degrees/ careers in STEM fields and broaden participation of woman and minorities in those fields, expand STEM-capable workforce and increase STEM literacy for all students including those who do not pursue STEM related careers or additional studies in STEM disciplines. STEM education is an integration of interrelated discipline which Chemistry is among them.

Chemistry is a discipline in STEM that studies the properties, composition, and structures of matter together with the associated changes as well as how such changes impact on the welfare of man and his environment (Obikezie et al 2020). There is scarcely a single area of man's daily life that is not affected by Chemistry. However, it is disheartening to note that Chemistry students' academic achievement in the senior secondary school certificate examination is nothing to write home about. This is supported by WAEC Chief Examiner's report from 2019 to 2022 which show lots of weaknesses in secondary school physical Chemistry like thermodynamics, Charles' law, Boyle's law and general gas equation.

More so, the achievement of Chemistry candidates in grade $C_6 - A_1$ from 2015 to 2021 revealed that in 2015, Chemistry students' achievement in WAEC were 60.6%, 2016 = 57.74%, 2017=62.68%, 2018=61.95%, 2019=54% 2020=59% and 2021=61.5%. From the figure it was observed that the percentage passes of $C_6 - A_1$ from 2015 to 2021 is not up to 70%. According to Badmus (2018), for any nation to grow in technology the students' achievement in science related subject like Chemistry must be at least 70%. The researcher further asserted that the reason why most nations in some Latin American and Africa continents are still under develop is as a result of below distinctions on academic achievement of secondary school Chemistry students in the external examinations like WAEC and NECO.

Mayra and David (2018) observed that Ecuador is still under developing like most African countries as a result of Chemistry failure in high school examination the country. The authors further assert that due to low distinction in the subject, this has led to high dropout in science related professions in the country especially in the areas of Engineering and Medicine. Alcardo et al (2019) discovered that poor achievement in Chemistry concept especially in external examinations by high school students has contributed to under development of technology in some parts of developing world especially in Africa. However, it can be asserted that any country that lack health workers, infrastructures' and technological advancement, the Chemistry students lack knowledge of understanding science and may not be achieving well in Chemistry subject (Alcardo et al 2019; Obi & Obiadazie 2015). The question now is what could be the possible causes of students' low academic achievement in Chemistry?

Nyamide (2020) observed that poor academic achievement of Chemistry students' in some part of the world is as a result of instructional strategy use to instruct the subject by the teachers. According to Nyamide (2020) conventional instructional strategy like lecture instructional strategy and demonstration instructional strategy has proved to be less effective to innovative instructional strategy like cooperative instructional strategy, think pare share instructional strategy, collaborative instructional strategy and generative learning model e.tc. Nnorom et al (2017) asserted that innovative instructional strategy like cooperative instructional strategy enhances students' academic achievement in Biology. The authors further opined that there exist a significant differences between students taught with cooperative instructional strategy than lecture instructional strategy in favour of students taught with cooperative instructional strategy. Furthermore, there exists a significant difference between Biology students with cooperative instructional strategy in favour of female students.

According to Ode et al (2020) innovative instructional strategy like think pare share has the ability to enhance students' academic achievement in all field. The authors asserted that the instructional strategy enhances students achievement in both science and act subjects. Achor and Gbadamosi (2020) observed that Physics students display more retention and achievement when taught with think pair share innovative instructional strategy in Benue state Nigeria. The authors further asserted even though innovative instructional strategy may significantly achieve lower than any conventional strategy used in control group, the strategy (innovative instructional strategy) must increase students' academic achievement in any science subject. More so, they observed that there was a significant differences between male and female students taught Physics with think pair share innovative instructional strategy in favour of male students. Igwe (2017) observed that Chemistry students taught with think pare share in Nsukka metropolis achieved better than those taught with lecture method in control group in the same metropolis. The author further asserted that female students taught Chemistry using the innovative instructional strategy achieve better than their male counterpart taught with the same instructional strategy. Ibe et al (2021) observed that students taught Chemistry with collaborative innovative instructional strategy achieved more than students taught with lecture instructional strategy. The authors further observed that there was a significant different between male and female students taught Chemistry with collaborative innovative instructional strategy in favour of male students. Ezeliora et al (2021) asserted that students taught with collaborative instructional strategy and other innovative instructional strategies like GLM instructional strategy tends to achieve better academically than those taught with conventional instructional strategies.

Generative Learning Model (GLM) is a cognitive model of human learning with understanding that was developed by Wittrock, in 1974. It is a constructivist teaching strategy and instructional model that focused on cognitive processes. It widens students understanding when in place. It also

helps to comprehend some difficult concepts in general knowledge. GLM focuses on considering the students previous learning experience and understanding so that the learner can actively generate meaningful relationships between the prior knowledge and new information (George et al 2021). The model provides students' opportunity for active participation in the learning process allows for group and individualized form of learning and empowers learners with ability to express their personal views among genders. Anidi et al (2022) reported that GLM instructional strategy enhances male students' achievement scores than that of female students. The authors further asserted that GML and other innovative instructional strategy is beneficial to male students than female student because it has do with first teaching the students what they have known before in other subject before bring a new knowledge. These are unlike the conventional instructional strategies like lecture instructional strategy (LIS) and Demonstration instructional strategy (DIS), which lack direction or phases, and teacher talks, writes, and do everything in the classroom. Sometimes in demonstration instructional strategy teacher demonstrate but students may not pay attention or even be carried away with funny ways the teacher is demonstrating the subject concept, thereby won't get the needed academic achievement (George et al, 2021). From the look of things it seems that there is limited literature on GLM instructional strategy, this is enough reason to carry out this study in the locality because from the best of researchers knowledge, much studies has not been carried out on it. More so, with all the numerous importance of GML instructional strategy, low achievement of secondary school Chemistry students from year 2015-2021 as reviewed and weaknesses in major topics in secondary school physical Chemistry as reported by WAEC Chief Examiner's individual report from 2019-2022 the researcher wish to investigate effect of generative learning model on secondary school students' academic achievement in Chemistry in Awka Education zone Anambra state, Nigeria.

Research Questions

The study is to provide answers to the under stated research questions:

1. What is the difference in mean achievement scores of students taught Chemistry using GLM instructional strategy and those taught with Demonstration instructional strategy DIS?
2. What is the difference in the mean achievement scores of male and female students taught Chemistry using GLM instructional strategy?

Hypotheses

The following null hypotheses are formulated at .05 level of significance to guide the study

1. There is no significant difference in the mean achievement scores of students taught Chemistry using GLM instructional strategy and those taught using Demonstration instructional strategy DIS.
2. There is no significant difference in the mean achievement scores between male and female students taught Chemistry using GLM.

Research Method

This study adopted quasi– experimental research design. The sample consisted of 183 SS1 Chemistry students (73 males and 110 females) from Awka education zones in Anambra State Nigeria. The sample was obtained using multi-stage sampling procedure. First, the co-educational schools were listed out according to most populated schools and less populated schools. Reasons were to ensure that the study covered schools not minding the population and to ensure a balanced representation of gender variable in the study. Two schools were selected from most populated coeducational schools while two schools were also selected from the less populated coeducational schools from the zone making it a total of four schools. Finally using random sampling, four ballot papers representing each of the four schools, one out of the two most populated schools was used in the experimental group (17 male and 29 female) who were taught Chemistry concepts using GLM instructional strategy while the second one was used in control group (30 male and 38 female) who were taught Chemistry using DIS instructional strategy, making it a total of 114 students. The same goes to less populated schools, one out of the schools selected was used in the experimental group (18 male and 38 female) who were taught Chemistry concept using GLM instructional strategy while the second one was used in control group (8 male and 5 female) who were taught Chemistry concept using DIS instructional strategy, making it a total of 69 SS1 Chemistry students. The research lasted for six weeks. First week was used to familiarized with the schools selected and training of research assistants and issuing of pretest. Second week to six was used to teach the Chemistry concept under study in both groups (experimental and control groups) then posttest.

Instrument

The instrument for data collection was Chemistry Achievement Test (CAT) which was design by researchers. The CAT was produced base on the Chemistry concept of secondary school physical Chemistry. To ensure the reliability of the instrument, the twenty five (25) objective achievement questions were administered on a group of twenty students outside the place of this study after face and content validation of three expect one from Department of Science Education Nnamdi Azikiwe University Awka, one from Department of Measurement and Evaluation Chukwuemeka Odumegwu Ojukwu University and senior Chemistry teacher in government owned secondary school with ten years' experience as a Chemistry teacher. The results were subjected to Kuder 21 Richardson test to determine the reliability coefficient. A mean coefficient of .81 was obtained indicating that the instrument was reliable. Research question where answered using mean and standard deviation and Analysis of Covariance (ANCOVA) was used to test the hypotheses at .05 level of significance.

Presentation of Results

The result of this study was presented in line with the hypotheses as follows.

Research Question 1: What is the difference in mean achievement scores of students taught Chemistry using GLM instructional strategy and those taught with Demonstration instructional strategy DIS?

Table 1: Mean and Standard Deviation Achievement scores of Students taught Chemistry using GLM and those taught with DIS

Instructional		Pre-test		Post-test			Mean Gain
Strategy	N	Mean	SD	Mean	SD	Mean Gain	Difference
GLM	102	25.5196	9.7845	56.5882	18.7064	31.0686	1.4747
DIS	81	39.3086	15.5620	71.8519	12.7873	32.5433	

The result presented in Table 1 reveal the pretest and posttest mean achievement and standard deviation scores of the students taught Chemistry concept with GLM instructional strategy in experimental group and DIS in control group. The pretests mean scores are 25.5196 and 39.3086 while pretest standard deviation scores are 9.7845 and 15.5620 respectively. The posttest mean scores in both instructional strategies are 56.5882 and 71.8519 while posttest standard deviation scores are 18.7064 and 12.7873. Though GLM instructional strategy increases academic achievement of students in Chemistry concept taught, but not as that of DIS because DIS have a higher mean than GLM in both pretest and posttest.

Research Question 2: What are the mean achievement scores of male and female students taught Chemistry using GLM instructional strategy?

Table 2: Mean and Standard Deviation Achievement scores of Male and Female Students taught Chemistry using GLM.

		Pre-test		Post- test			Mean Gain
	Gender	N	Mean	SD	Mean	SD	Mean Gain Difference
Male	73	30.8493	13.0890	62.0274	18.0477	31.1781	0.9037
Female	110	32.1364	13.1773	64.2182	19.5421	32.0818	

The result presented in Table 2 reveals the pretest and posttest mean achievement and standard deviation scores of male and female students taught Chemistry concept with GLM instructional strategy. The pretests mean scores are 30.8493 and 32.1364 while pretest standard deviation scores are 13.0890 and 13.1773 respectively. The posttest mean scores in male and female Chemistry students are 62.0274 and 64.2182 while posttest standard deviation scores are 18.0477 and 19.5421. This implies that GLM instructional strategy increases academic achievement of female Chemistry students than male counterparts.

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught Chemistry using GLM instructional strategy and those taught using Demonstration instructional strategy DIS.

Table 3: Analysis of Covariance (ANCOVA) of Chemistry Students' Mean Achievement Scores between Instructional Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Decision
Corrected Model	9522.470[a]	2	4761.235	39.290	.000	
Intercept	7130.747	1	7130.747	58.844	.000	
Achievement	938.231	1	938.231	7.742	.006	
Instructional Strategies	5265.815	1	5265.815	43.454	.000	S
Error	21812.514	180	121.181			
Total	214337.000	183				
Corrected Total	31334.984	182				

a. R Squared = .304 (Adjusted R Squared = .296) S= Significant, NS = Not Significant
b. Computed using alpha = .05

Data shown in Table 3 reveal the ANCOVA results of Chemistry students' taught between two instructional strategies. The results show a significant difference F (43, 454) = 5265.815, p = .000< .05. In all, the null hypothesis is rejected. The result shows that there is a significant difference in the mean achievement scores of students taught Chemistry using GLM instructional strategy and those taught using Demonstration instructional strategy DIS favour of students taught with DIS.

Hypothesis 2: There is no significant difference in the mean achievement scores between male and female students taught Chemistry using GLM.

Table 4: Analysis of Covariance (ANCOVA) Mean Achievement Scores of Male and Female Students Taught Chemistry Using GLM

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Decision
Corrected Model	8968.889[a]	2	4484.445	14.332	.000	
Intercept	57664.546	1	57664.546	184.296	.000	
Achievement	8758.287	1	8758.287	27.991	.000	
Gender	99.759	1	99.759	.319	.573	NS
Error	56320.422	180	312.891			
Total	799576.000	183				
Corrected Total	65289.311	182				

a. R Squared = .137 (Adjusted R Squared = .128) S= Significant, NS = Not Significant
b. Computed using alpha = .05

The data presented in Table 5 show the ANCOVA results on the effect of GLM between male and female students in Chemistry. The results show no significant difference p = .573> .05. In all, the null hypothesis was upheld. Hence the result shown there is no significant difference in the mean achievement scores between male and female students taught Chemistry using GLM instructional strategy.

Discussion of Findings

The finding has shown that though there was increase in academic achievement of students' in experimental group taught with GLM instructional strategy but students taught in conventional group using Demonstration instructional strategy achieved better. Indicating that students in DIS achieved significantly better in CAT than students in GLM instructional strategy. This may as a result that those students in control group pay attention in all the demonstration done by the teacher. This finding is in contract with George et al (2021) who reported that students taught with demonstrational instructional strategy may likely be carried away by the funny demonstrations of the teacher, thereby making students taught with GLM instructional strategy achieving better than conventional instructional strategy. This finding is in consonance with the research of Achor and Gbadamosi (2020) who viewed that even though innovative instructional strategy may significantly achieve lower than any conventional strategy used in control group, the strategy (innovative instructional strategy) must increase students' academic achievement in any science subject. The findings is also not in line with Nnorom et al (2017) who asserted that innovative instructional strategy like cooperative instructional strategy and others enhances students' academic achievement in Biology and other science subjects than conventional instructional strategy. The findings of students in DIS achieving better than the once in GLM may be as a result that Chemistry students in the control group where not

carried away by the demonstration of the teacher. The result from the GLM instructional strategy suggested the need to also adopt other instructional strategies in addition that would likely develop adequate content understanding in Chemistry in our secondary schools. This implies that the students in the treatment group have high gain but control group have significant higher gain in their content understanding than those in the treatment group. Also, the ANCOVA analysis indicated that there is a significant difference between the treatment groups and control group in favour of control group.

The gender issue in science has been very controversial as some study go in favour of male while some in favour of female but the result of this research shows that there is no significant difference in academic achievement of male and female students taught Chemistry using GLM instructional strategy. the findings is not in line with researchers who reported that there was a significant difference in academic achievement of male and female students taught science subject using innovative instructional strategy in favour of female students (Nnoro et al 2017; Igwe 2017). Also, the findings of the study is not in consonance with other researchers who observed that there was a significant difference in academic achievement of male and female students taught science subject using innovative instructional strategy in favour of male students (Achor and Gbademosi 2020; Ibe et al 2021). This reason for this non-significant in gender achievement in usage of GLM instructional strategy could be as a result that GLM instructional strategy encourages equal participants.

Conclusions

The findings of the study revealed GLM instructional strategy improved academic achievement of students in Chemistry irrespective of gender. The conclusion is that GLM instructional strategy is effective strategy for the teaching and learning of Chemistry though DIS shows higher mean gain. It can also be concluded that when Chemistry teachers adopt any or both strategies for students it may increase interaction among them thereby making students to take responsibility for their learning.

Recommendations

The researcher formulated the following recommendations based on the findings and conclusions made from the study:

1. Chemistry teachers should know where and how to incorporate generative learning model as one of the instructional strategy in teaching Chemistry concept.
2. Counselors should organize orientation for Senior Secondary year one (SS1) students on how and where to use GLM instructional strategy for general science improvement. This will serve as a significant practical approach to explain to the students the importance of academic achievement in science learning.
3. The government should utilize the services of various bodies like Science Teachers Association of Nigeria (STAN), Chemical Society of

Nigeria (CSN) and others to organize seminars, workshop and conferences to inform and train Chemistry teacher and other science teachers on where and how to use GLM instructional strategy in teaching and learning. This will make teachers and other stakeholders update their knowledge.

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