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Influence of school location and gender on generative learning model on secondary school students' academic achievement in chemistry

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Abstract

This study investigated the influence of school location and gender on the generative learning model's impact on academic achievement in Chemistry among secondary school students in the Awka Education zone, Anambra State. The study employed a quasi-experimental design and used two research questions and two hypotheses as guidance. The sample consisted of 143 senior secondary school one (SS1) Chemistry students in the zone, comprising 73 males and 110 females. From the 49 co-educational secondary schools in the zone, four were selected using a simple random technique. Two schools were assigned to urban locations (47 males and 67 females), while the other two were assigned to rural locations (26 males and 43 females) through simple random sampling by balloting. Fifty Chemistry achievement tests (CAT) were adapted from West African Examination Council (WAEC) objective past question papers. The instruments were validated by experts in the science education department and education foundation. CAT reliability was established using Kudar Richardson 20 (KR-20), which yielded a reliability coefficient of 0.87. To address the research questions, mean and standard deviation were utilized, while the analysis of covariance was employed to test the hypotheses at a significance level of 0.05. The study found that the generative learning model improved student achievement in both urban and rural schools, with a significant difference in mean achievement scores between the two groups. Specifically, the generative learning model proved more beneficial for students in urban schools, particularly for male students. Based on these findings, the study draws conclusions and provides recommendations.

Keywords

Achievement, chemistry, generative learning model.

INTRODUCTION

Chemistry is a discipline in science technology engineering and mathematics 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 [1]. 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 West African Examination Certificate 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 C6 – A1 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 C6 – A1 from 2015 to 2021 is not up to 70%. Most of these under achievement scores from this examination body which does not support technological growth of a nation come as a result of gender issues and school location. According to Badmus and Omosewo [2] 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.

Nyamida [3] asserted that Ecuador is still under developing like most African countries as a result of Chemistry failure in high school examination in the country. The authors further assert that due to low distinction in the subject, this has lead to high dropout in science related professions in the country especially in the areas of Engineering and Medicine which was caused by poor achievement in Chemistry subject. Barakabitze et al. [4] 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 [4]–[7]. The question now is what could be the possible causes of students' low academic achievement in Chemistry?

Nyamida [3] asserted that teaching methods and school locations are among the causes of poor academic achievement in Chemistry subject. In the area of teaching method the author observed that poor academic achievement of Chemistry students' in some part of the world is as a result of methods use in teaching the subject. According to Obi and Obiadazie [7] conventional teaching method like lecture method LM and demonstration method DM has proved to be less effective to innovative teaching method like cooperative learning method, think pare share teaching method, collaborative teaching method, generative learning model and much more. Okafor and Nnorom [8] asserted that innovative teaching methods like cooperative teaching method enhance students' academic achievement in Biology. The authors further opined that there exist a significant differences between students taught with cooperative teaching method and lecture method of teaching in favour of students taught with cooperative teaching method. According to Obikezie et al. [9] there exists a significant difference in gender between Biology students with cooperative teaching method in favour of female students.

According to Ode et al. [10] innovative teaching method like think pare share has the ability to enhance students' academic achievement in all field. The authors asserted that the teaching method enhances students achievement in both science and act subjects. Achor and Gbadamosi [11] observed that Physics students display more retention and achievement when taught with think pair share innovative teaching method in Benue state Nigeria. The authors further asserted even though innovative teaching method may significantly achieve lower than any conventional method used in control group, but the method (innovative teaching method) 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 teaching method in favour of male students. Igwe [12] 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 teaching method achieve better than their male counterpart taught with the same teaching method. Ibe et al. [13] observed that students taught Chemistry with collaborative teaching method achieved more than students taught with lecture teaching method. The authors further observed that there was a significant different between male and female students taught Chemistry with collaborative teaching method not minding of location in favour of male students. Chinweoke and Chigbo [14] asserted that students taught

with collaborative teaching method and other innovative teaching methods like generative learning model GLM tends to achieve better academically than those taught with conventional teaching methods not minding the school locations. Because of the course of the study, GLM was treated.

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 method 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 [15]–[18]. 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 school locations and genders. Anidi et al. [19] reported that GLM enhances male students' achievement scores than that of female students in urban school location. The authors further asserted that GML and other innovative teaching methods is beneficial to male students than female student because it has to do with first teaching the students what they have known before in other subject before bringing a new knowledge. These are unlike the teaching methods like lecture method (LM) and Demonstration method (DM), which lack direction or phases, and teacher talks, writes, and do everything in the classroom [9]. Most times other innovative teaching methods and learning model aside from GLM may not yields the needed support in improving academic achievement of students in Chemistry base on school location and gender [17].

Chinweoke and Chigbo [14] asserted that school location should be one of the things that need to be considered while researching on students' academic achievement in secondary school Chemistry because achievement in the subject should made general not siding any school location. The authors observed that government, teachers and most nongovernmental organization overlook the rural educational development in Nigeria due to most times those locations are not accessible thereby causing those located as the rural areas to achieve below average in times of academics. Ibe et al. [13] opined that due to government non recognitions of some public schools in rural locations, sometimes Chemistry students in that area achievement in those areas are nothing to write home about when to urban located schools. Obikezie et al. [9] reported that students taught practical science using innovative teaching method in urban located schools may or may not achieved better than their rural counterpart taught using the same method in western world. Badmus and Omosewo [2] and Anderson and Wall [20] reported that science students in most located schools do well not minding their gender when taught with innovative teaching method like GLM. George et al. [17] asserted that students taught general science in some urban located schools with innovative teaching method achieved better than their rural counterpart taught the same concept with the same innovative teaching method in Onitsha education zone. The researchers went further to say there is no significant difference between achievement of urban and rural located schools taught general science with innovative teaching methods not minding the gender and there is no significance difference in achievement among male and female students taught general science in both school locations using the same innovative teaching method. More so Asakle and Barak [21] asserted that school location determine academic achievement of students taught newton's laws of motion in western Europe but not when taught with innovative teaching methods. The authors opined that urban students taught newton's laws of motion using innovative teaching method achieved better than their rural and semi urban students not minding their gender and innovative teaching method may equally help in improving other students' academic achievement other than urban students. Similarly, Asakle and Barak [22] noted that a significant difference do not exist in achievement among school locations when students are exposed to generating platform as a means of promoting 21st century skills in Asia using innovative teaching method. Anderson and Wall [20] reported that gender achievement has nothing to do with school location in Physics concept in northern Europe when the students are taught with innovative teaching method GLM.

From the foregoing, it appears innovative teaching methods enhances students achievement in other science subjects but the issues of school

locations and use of GLM in improving Chemistry achievement has not been concisely answered because the empirical studies reviewed in this study have produced diverse and contradictory results on the location and Chemistry subject [23]. Similarly, the issue of gender difference in students achievement in Chemistry with innovative teaching method in the areas of GLM has not been resolved and therefore subject to further investigation. Furthermore WAEC Chief Examiners' report in Chemistry 2019-2022 reported weaknesses in the subject areas of thermodynamics, Charles' law, Boyle's law and general gas equation as mention earlier and low distinction of Chemistry students in WAEC examination in year 2015-2021. The researchers wish to seek if innovative teaching methods like generative learning model GLM can help in increase male and female academic achievement in Chemistry in urban and rural secondary schools, also to seek if school locations and gender has influence in use of GLM in improving students' academic achievement in Chemistry. Finally with the numerous important of GLM to students' achievement, the study was focus on influence of school location and gender on generative learning model on secondary school students' academic achievement in Chemistry.

Purpose of the study

(1) The mean achievement scores of urban and rural students taught Chemistry using GLM, (2) The mean achievement scores of male and female students taught Chemistry using GLM respect to school locations.

Research question

The following research question guided to the study: (1) What is the mean achievement scores of urban and rural students taught Chemistry using GLM?; (2) What is the mean achievement scores of male and female students taught Chemistry using GLM respect to school locations?

Hypotheses

(1) There is no significant difference in the mean achievement scores between urban and rural students taught Chemistry using GLM, (2) There is no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM respect to school locations.

RESEARCH METHOD

This study adopted quasi–experimental pretest and posttest research design. The sample consisted of 183 SS1 Chemistry students (73 males and 110 females) from Awka education zones in Anambra State Nigeria. Out of 49 co-educational secondary schools in the zone, four co-educational schools were selected from the zone using simple random sampling. Two intact classes were used from urban area (male 47 and female 67) and two intact classes were used from rural area (male 26 and 43 female) making it a total of 183 sampled SS1 students. Reasons for the use of SS 1 classes are because the topics of thermodynamics, Charles' law, Boyle's law and general gas equation used in the study is SS 1 class work. The instrument for data collection was Chemistry Achievement Test (CAT) which was adapted by researchers from WAEC objective questions. The CAT was produced base on the Chemistry concept of secondary school physical Chemistry.

To ensure the reliability of the instrument, the fifty (50) objective achievement questions were administered on a group of twenty two 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 20 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 0.05 level of significance.

RESULT AND DISCUSSION

This section deals with the analysis and presentation of data collected from respondents to answer the research questions and hypotheses.

Research Question 1

What is the mean achievement score of urban and rural students taught Chemistry using GLM instructional strategy?

Table 1 shows that the pretest and posttest mean achievement scores of urban students

taught Chemistry with Generative Learning Model GLM were 36.0614 and 73.0526 respectively while their standard deviation scores were 24.2899 and 15.1644 respectively. On the other hand, pretest and posttest mean achievement scores of rural students taught Chemistry with Generative Learning Model GLM were 24.2899 and 47.3043 respectively while their standard deviation were 9.8773 and 12.6063. The standard deviation scores for the pretest among urban students taught Chemistry using GLM is higher than the posttest. This suggests more variability in the posttest scores of the students than the pre test scores in urban location. More of the scores near the mean in the pre test than in the posttest of urban students using GLM. More so, the standard deviation scores for the pretest among the rural students taught Chemistry using Generative Learning Model GLM is lower than the posttest. This suggests less variability in the posttest scores of the rural students than the pre test scores. More of the scores near the mean in the posttest than in the pre test of rural students using GLM. Since the pretest mean is smaller than the posttest mean in both locations, it shows that GLM improve achievement in the subject among urban and rural students. Since posttest mean of urban students taught Chemistry using GLM is higher than that of their rural counterpart and since the posttest of standard deviation of urban students taught Chemistry using GLM instructional strategy is higher than the posttest of standard deviation of rural students, GLM is more effective in urban location than rural location.

Table 1. Mean and Standard Deviation Achievement scores of Urban and Rural Students taught Chemistry using GLM

Location	N	Pretest		Posttest		Gain	
		Mean	SD	Mean	SD	Mean	Difference
Urban	114	36.0614	24.2899	73.0526	15.1644	36.9990	13.9846
Rural	69	24.2899	9.8773	47.3043	12.6063	23.0144	

The mean gain score for urban Chemistry students taught with GLM was 36.9990 while that of their rural counterpart was 23.0144. This represents a mean difference of 13.9846 in favour of urban students taught Chemistry using GLM. Though GLM improves academic achievement of both school locations, it had a greater impact on urban schools located students than rural schools located students.

Research Question 2

What is the mean achievement scores of male and female students taught Chemistry using GLM respect to school locations?

Table 2. Mean Achievement Scores of Male and Female Students Taught Chemistry using GLM Respect to School Locations

Gender	Location	N	Pretest		Posttest		Gain
			Mean	SD	Mean	SD	(Mean)
Male	Urban	47	36.0851	12.1867	71.1489	14.5647	35.0638
	Rural	26	21.3846	8.6860	45.5385	10.4201	24.1539
Female	Urban	67	36.0465	13.4350	74.3881	15.5397	38.3416
	Rural	43	26.0465	10.2306	48.3721	13.7685	22.3256

Table 2 shows that the pretest and posttest mean achievement scores of male urban students taught Chemistry with Generative Learning Model GLM were 36.0851 and 71.1489 respectively while their standard deviation scores were 12.1867 and 14.5647 respectively. On the other hand, in rural school location their pretest and posttest mean achievement scores were 21.3846 and 45.5385 respectively while their standard deviations were 8.6860 and 10.4201. The standard deviation scores for the pretest among male urban students taught Chemistry using GLM is lower than the posttest. This suggests more variability in the pre test scores of the students than the posttest scores in urban school location among male Chemistry students. More of the scores near the mean in the posttest than in the pre test of urban male students taught with GLM. More so, the standard deviation scores for the pretest among the rural male

students taught Chemistry using Generative Learning Model GLM is higher than the posttest. This suggests high variability in the posttest scores of the male rural students than their pre test scores. More of the scores near the mean in the pre test than in the posttest among rural male students taught with GLM. Since the pretest means among male Chemistry students is smaller than the posttest mean in both school locations, it shows that GLM improve achievement in the subject in urban and rural among male Chemistry students taught with GLM. Since posttest mean of urban male students taught Chemistry using GLM is higher than that of their rural counterpart it means that GLM is more effective in urban location than rural location among male students.

Similarly, the above table also shown that the pretest and posttest mean achievement scores of female urban students taught Chemistry with Generative Learning Model GLM were 36.0465 and 74.3881 respectively while their standard deviation scores were 13.4350 and 15.5397 respectively. On the other hand, in rural school location their pretest and posttest mean achievement scores were 26.0465 and 48.3721 respectively while their standard deviations were 10.2306 and 13.7685. The standard deviation scores for the pretest among female urban students taught Chemistry using GLM is lower than the posttest. This suggests more variability in the pre test scores of the students than the posttest scores in urban school location among female Chemistry students. More of the scores near the mean in the posttest than in the pre test of urban female students taught with GLM. More so, the standard deviation scores for the pretest among the rural female students taught Chemistry using Generative Learning Model GLM is higher than the posttest. This suggests high variability in the posttest scores of the female rural students than their pre test scores. More of the scores near the mean in the pre test than in the posttest among rural female students taught with GLM. Since the pretest means among female Chemistry students is smaller than the posttest mean in both school locations, it shows that GLM improve achievement in the subject in urban and rural among female Chemistry students taught with GLM. Since posttest mean of urban female students taught Chemistry using GLM is higher than that of their rural counterpart it means that GLM is more effective in urban location than rural location among female students.

Hypotheses 1

There is no significant difference in the mean achievement scores between urban and rural students taught Chemistry using GLM.

Table 3. Analysis of Covariance (ANCOVA) Mean Achievement Scores of Urban and Rural Students Taught Chemistry Using GLM

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*Sig.*	Decision
Corrected Model	29019.823	2	14509.911	72.011	0.000	
Intercept	74803.118	1	74803.118	371.237	0.000	
Achievement	522.804	1	522.804	2.595	0.109	
Location	2222.401	1	20150.693	100.005	0.000	S
Error	36269.489	180	121.181			
Total	933688.000	183				
Corrected Total	66697.749	182				

Note: S= Significant, NS = Not Significant

Table 3 shown that there is a significant difference in the mean achievement scores between urban and rural students taught Chemistry using GLM $F_{(1,182)}$=100.005, *p*-value=0.000 Since the obtained p-value is less than the stipulated .05 level of significance, the null hypothesis which stated there is no significant difference in the mean achievement scores between urban and rural students taught Chemistry using GLM is rejected. This implies that the mean achievement score of urban students taught Chemistry with GLM is higher than the mean achievement score of rural students taught Chemistry using the same GLM. However, this implies that the significant difference is in favour of urban school located Chemistry students.

Hypotheses 2

There is no significant difference in the mean achievement scores of male and female students

taught Chemistry using GLM in respect to school location.

The result in Table 3 shown that there is no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM in respect to school location $F_{(1,182)}$=0.055, *p*-value=0.814 Since the obtained p-value is higher than the stipulated .05 level of significance, the null hypothesis which stated there is no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM in respect to school location is held. This implies that the mean achievement score of male and female students Chemistry using GLM in respect to school has no difference among gender and locations.

Table 4. Analysis of Covariance (ANCOVA) Mean Achievement Scores of Male and Female Students Taught Chemistry Using GLM in Respect to School Location

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	29387.611	4	7346.903	36.426	0.000	
Intercept	74355.714	1	74355.714	368.654	0.000	
PretestCAT	470.675	1	470.675	2.334	0.128	
Gender	299.498	1	299.498	1.485	0.225	NS
Location	19028.069	1	19028.069	94.341	0.000	
Gender*Location	11.166	1	11.166	0.055	0.814	
Error	35901.701	178	201.695			
Total	799576.000	183				
Corrected Total	65289.311	182				

Note: S=Significant, NS=Not Significant

Influence of school location on Chemistry students taught with GLM

The findings revealed that generative learning model improves academic achievement of students in both school locations (urban and rural school locations). The finding also revealed that the GLM favour more students in urban school locations than students in rural school locations being that fact achievement scores of students taught with GLM is higher than that of mean achievement scores of students in rural located schools. the above findings is in line with the findings of George et al. [17] who observed that students taught general science in urban located schools with innovative teaching method achieved better than their rural counterpart taught the same concept with the same innovative teaching method in Onitsha education zone. But the findings in contrast with finding of researchers like Obikezie et al. [9] who observed in their various studies that students taught practical science using innovative teaching method in rural school location achieved better than their urban counterpart taught using the same method in western world. The findings also contradict with that of Nyamida [3] who observed that science students in rural located schools achieved better than their urban counterpart not minding their gender when taught with innovative teaching method like GLM. The high achievement that was observed from urban school locations in use of GLM in teaching Chemistry could be as result of the ability of students in urban located school students to understand the prior knowledge of being offered by GLM than their rural counterpart.

From Table 3, it is observed that significant differences exist between the school locations. From the table could be deduced that there is a significant difference in the mean achievement scores between urban and rural students taught Chemistry using GLM in favour of urban students. The finding is not consonance with the findings of George et al. [17] who observed that there is no significance difference in achievement among male and female students taught general science in both school locations using innovative teaching method like GLM. But the findings is in line with that of Asakle and Barak [22] who noted that a significant difference do not exist in achievement among school locations when students are exposed to generating platform as a means of promoting 21st century skills in Asia using innovative teaching method like GLM. The significant differences that exist between the two school locations could be as a result of urban located school students understanding more of known thing in other subject area before going to unknown things in the Chemistry concept used in the study which GLM is known for.

Influence of gender on Chemistry students taught with GLM in respect to gender

From the findings in Table 2 shown that male and female students in urban located schools achieved better than their counterpart in rural located schools. the results also shown that female Chemistry students in urban located schools has the highest mean scores in the Chemistry concept taught using GLM followed by male students in urban located schools then female students in rural located schools and lastly male students in rural located schools. the findings is in line with Igwe [12] who observed that female students taught Chemistry using the innovative teaching method achieve better than their male counterpart taught with the same teaching method. But the findings in contrast with the findings of Anidi et al. [19] who observed that GLM enhances male students' achievement scores than that of female students in urban school location. The more achievement of female students in both urban and rural located against their male counterpart could be as a result of female students' ability to be keen in learning the known knowledge in other subject areas before the Chemistry concept used in the study.

This study also proved no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM in respect to school location. The findings are not in line with the findings of Ibe et al. [13] who observed there is a significant different between male and female students taught Chemistry with collaborative teaching method not minding of location in favour of male students. But the findings is in line with the findings of Anderson and Wall [20] who observed that gender achievement has nothing to do with school locations in Physics concept in northern Europe when the students are taught with innovative teaching method like GLM. The non significant differences that exist among the genders and school location could be ability of GLM in taking of gender and locations equal achievement.

CONCLUSION

The findings of the study revealed that GLM improved students' achievement in both urban and rural located schools and there is a significant difference in mean achievement score between students taught in both urban and rural located schools using GLM in favour of those in urban located schools.

More so, the findings of the study revealed that GLM improved female students academic achievement in urban located schools followed by their male counterpart in urban located school, then female students in rural located schools and lastly male students in rural located schools but there is no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM in respect to school location.

Based on the conclusion of the study, the following are appropriate recommendations. First, government and curriculum planners should inculcate use of GLM in teaching difficult concepts in urban and rural located schools in the states. Second, generative learning model GLM should be used in teaching other subject especially science subject in various school locations because it proved to be gender friendly. From the finding it is observed there is no significant difference in the mean achievement scores of male and female students taught Chemistry using GLM in respect to school location.

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