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Geographical information system as educational technology for teaching social studies

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ABSTRACT

The nonchalant attitude of social studies teachers in adopting new and innovative educational technology can be attributed to the high failure rate among students in the subject. Hence the primary aim of the study was to investigate if geographical information system (ArcGIS software) can be used as educational technology for teaching social studies. The study adopted a mixed research design; quantitative (non-equivalent quasi-experimental control group) and phenomenological qualitative (open-ended interview) design. With a sample of 150 students. The data collection instrument was extracted from standardized questions used for basic certificate examinations (BECE). The instrument reported a Pearson product moment correlation (PPMC) coefficient of 0.81 as its reliability index. Mean, standard deviation and analysis of variance (ANOVA) were applied in analyzing quantitative data. While open-ended questions were used as an instrument to collect qualitative data. Quantitative results showed a higher post-test mean score for the treatment group (TG). Similarly, results from the qualitative study were in consonance. Signifying that GIS can be adopted as educational technology for teaching social studies.

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1. INTRODUCTION

A good assessment of education around the world reveals that there are numerous factors that could influence the teaching and learning of school subjects. Teachers' failure to consider these factors, especially the use of educational technology, may result in pedagogical flaws. The continuous usage of passive and teacher-centered methods by teachers and non-application of educational technology while teaching social studies may increase the problem [1]. Since social studies is seen as a critical tool needed for the advancement of people and nations, as well as the most effective means of instilling knowledge, attitudes, skills, and habits into younger generations [2]. Thus the effectiveness of teaching social studies is always judged by the academic performance of its pupils/students as stipulated in the National Policy of Education [3]. Therefore, the efficient teaching of social studies can have a direct bearing on a nation's economic, social, political, and sustainable development. Thus, social studies is essential in developing a high caliber of citizens who will serve as a nation's human resources [2]. Although researchers consider geographical information system (GIS) to be a promising technology that can bring this type of educational reform to social studies, less than 1% of schools have adopted this technology [4]. To address the problem the teaching of social studies with GIS has become necessary, hence this study investigated the instructional usage of GIS in social studies teaching.

A close examination of society shows that educational systems are completely dependent on information and communication technologies (ICT), to which GIS belongs; educational processes have undergone technological advances and revolutions with the exception of the GIS sector [5], [6]. Thus, the adoption of GIS in the teaching of social studies may bring the needed technological advancement to the subject so that the academic performance of students could improve to reflect a development in social studies teaching. Puertas-Aquilar *et al*. [6] posited that adopting GIS in pedagogical practices can introduce positive and structural changes to social studies education by increasing students' productivity and academic performance. Therefore, this study constitutes a relatively emerging solution to a problem that has evolved from the non-usage of educational technology (GIS) for teaching social studies. Therefore, the objective of the study was to examine the effect of GIS as educational technology on the teaching of social studies.

2. THEORETICAL FRAMEWORK FOR THE STUDY

The study was hinged on the technology acceptance model (TAM), a theory postulated by Fred Davis in 1986. The theory advocated for usage and acceptance of technology in learning through learners' perception of its usefulness as well as the ease with which they can use it to learn. TAM also identified the importance of a supportive system in the provision of training, funds, software and technical support, which could enhance the adoption of technology significantly by students and teachers [7]. For instance, Afolabi [8] discovered that ICT usage was perceived to be easy and beneficial by secondary school teachers. In this study, TAM is considered fundamental for social studies teachers and learners in order for them to adopt GIS as an educational technology for enhanced student understanding and performance in the subject. This can only be possible if teachers and students perceive GIS as a positive technology [9]. Similarly, the willingness of social studies students to engage in their lesson with GIS as educational technology depends on their perception and ease of usage.

According to Hodza *et al*. [10], the acronym GIS stands for Geographical Information System, it is relatively broad and interconnected with numerous processes and components. Pucha-Cofrep *et al*. [11] posited that GIS is a collection of tools that allows for the capture, storage, management, and analysis of geographical data. Previous studies [12]–[14] identified GIS as one of the most recent technology tools for geography and social studies education. GIS has specifically been used to teach, present class demonstrations, and laboratory exercises in many developed countries around the world [15]–[18]. Its usefulness in many fields such as engineering, planning, management, transportation, business, telecommunications, insurance, and education cannot be disputed [19], [20]. Aerial photographs, Google Earth, Google Maps, satellite images, field surveys, and existing statistical records have all been used to generate GIS data, which have been explored for educational purposes [21], [22].

According to Bikar *et al*. [22], GIS software allows you to combine massive amounts of data, manage data, and obtain data in a usable format. Generalization, aggregation of data, projection changes, and elimination of data can all be used to manipulate geographic data in GIS [17], [23]. Aguilar [24] revealed that the growth of GIS over the last decades can be attributed to the high demand and achievement of GIS. GIS has been employed successfully for the educational development of many countries. GIS is inextricably linked to society, hence it can be used to achieve a massive educational agenda [24]. This growth and popularity of GIS have created the need to move beyond information collection and processing into a deeper understanding of what spatial data and how it can be creatively incorporated into social studies as educational technology.

For instance, spatial data of places and people from various parts of a country or the world can be studied using an easy interface with GIS. This can provide a wealth of information about people, their location, and their interaction to social studies learners [25]–[28]. Yang *et al*. [27] also viewed GIS as an educational technology that can ameliorate underachievement of students and aid mastering of lesson content. Yang *et al*. [27] discovered that students taught with GIS were highly motivated and achieved significantly higher academically than those not exposed to GIS. Mzuza and Westhuizen [29] and Duarte *et al*. [30] suggested GIS integration into a country's educational curriculum at the colleges faculties of education so that the benefits of GIS can be leveraged upon by teachers and students early. The review so far has shown that GIS can assist in the creation, sharing, and application of useful information for social studies. In the same vein, Bernhauserova [31] and Jo and Hong [32] opined that GIS inspires incidental learning of spatial relationships. Schulze [33] described GIS as an interactive tool that can be maximized for enhancing interactions in social studies. Atubi [34] agreed that GIS can be incorporated into social studies as a multimedia learning technology because of its compelling effect in promoting students' learning.

Over the years, implementation of GIS has primarily focused on technological development of the geographic space, with little or no attention paid to its application for educational practices [16], [35]. Though initiatives such as organizing workshops for geography-related disciplines and associations to leverage the benefits of GIS have been carried out, these initiatives have not been extended to educational

pedagogy. It is also pathetic that the benefits of GIS in developing infrastructure, building human capacity, and promoting educational development have not been harnessed. Likewise, research into the role of GIS technology in enhancing the teaching of social studies to enhance academic performance is scarce.

Despite the gains, the use of GIS for teaching social studies appears to have received scanty attention from stakeholders. As far as these researchers know, there is little evidence of research on GIS and social studies. In addition, no research to the best of our knowledge, has considered carrying out a mixed research method on the problem, thereby filling a methodological gap. As a result, it became critical that this knowledge gap be filled using this study to examine the application of GIS as educational technology for teaching social studies education. Two research questions and two hypotheses were formulated in this study. Research questions: i) how will GIS as an educational technology affect the teaching of social studies students? and ii) what will be the difference in the mean score and perception of students taught with GIS and those taught without GIS? Hypotheses: i) Ho1: there is no significant effect of GIS as an educational technology on the teaching of social studies students and ii) Ho2: there is no significant difference in the mean score of students taught with GIS and those taught without GIS?

3. METHOD

3.1. Research design

The study utilized a mixed research approach because the weakness of one method could be offset by the strength of the other method. Similarly, mixed research methods helped to present a complete understanding of the problem under study by providing comprehensive details of the issue. As a result, quantitative (non-equivalent quasi-experimental control group) and phenomenological (qualitative) research data provided equal opportunity for data collection and objectivity, with a focus on generalizing results. The study had two groups of students: a control group (CG) and a treatment group (TG). The CG had 75 students, while the TG also had seventy-five 75 students.

3.2. Sample and sampling technique

The study's population was 47,812 upper basic three, sourced from Delta State Ministry of Basic and Secondary Education. Purposive sampling technique was employed to select two schools with standard ICT laboratories furnished with computers. While random sampling was applied in selecting 150 participants, this constituted the sample for the study. Random sampling techniques was used because according to Kothari and Garg [36] this sampling type gives an entire population equal opportunity of being a part of the sample. The sample was made up of both male and female students in upper basic 3, between the ages of 12 and 14 years. In the qualitative study, the authors considered the total sample of 150 students will be too much; hence, only 20 students were selected for the qualitative study from both the control and experimental groups.

3.3. Instrumentation

The studies had two research instruments. The first instrument was an academic test used for the quantitative study was titled "GIS academic test" (GAT), with 20 multiple-choice questions selected from past basic certificate examinations (BECE). The instrument was properly validated by two senior colleagues of the researchers. While the reliability of the GAT was established through the utilization of the test-retest method. To achieve this, 20 copies of the questionnaire were administered twice, within an interval of 2 weeks. The reliability test was carried out outside the study area; the scores obtained from the first and second administrations of the instrument was subjected to correlation analysis using the Pearson product moment correlation coefficient (PPMC). A coefficient value of 0.81 was obtained, signifying that the instrument for the study was reliable.

The second instrument was used for the qualitative study was open-ended questions, as seen in the result section. In order to adhere to the standard, the second instrument was used to interview 20 of the participants; these participants were randomly selected from both groups. The open-ended questions underwent double coding by two experts of measurement and evaluation independently to mitigate any form of bias and lead to a richer understanding of the phenomenon. This was also to ensure that the questions address the research questions and hypothesis raised in the study.

3.4. Method of data collection

The assignment of 150 participants to conditions (control or treatment) was done randomly to assign them into 2 groups of 75 students each for both a CG) and TG. The 75 students in each group were further shared into 2 groups to reduce their numbers and ease the conducting of a proper experiment. Thus, intact classes were not used for the study. The TG was manipulated for three weeks by using GIS as an instructional resource (ArcGIS software). The topic taught was "The world and its continents". Each session lasted 90 minutes, twice a week, and was held in an ICT laboratory with about 45 computers for three weeks.

The lesson always started with creating data through hyperlinks, tracing each continent, and labeling it on a world map. Class activities were normally given to the group at the end of each lesson, before the lesson was concluded for the week. Class attendance of the CG and TG was 100 percent, as the participants demonstrated interest and excitement to participate. The only activity that the students had some form of difficulty with during treatment was creating hyperlinks while tracing the world continents.

Teaching of the CG was done in a normal class with a physical wall map, with 90 minutes allotted to each period for 3 weeks, twice a week. The sequence was that both groups were first pre-tested, followed by teaching then treatment, and finally post-treatment- tests were administered. The mean scores of both groups were then analyzed, compared, and correlated. For the qualitative research, a phenomenological research design was adopted to collect in-depth data from participants with the use of open-ended questions, as depicted in the result section. Ten students were randomly selected from both groups; this gave a total of 20 students; this number was chosen because a phenomenological study does not require too many participants.

3.5. Data analysis

The pre-test and post-test results were multiplied by 4 and converted to percentages to make a total of 100 marks; this determined each student's academic performance. Quantitative data was analyzed with mean, standard deviation, and analysis of variance (ANOVA) using the statistical package for the social sciences (SPSS) software, and the results were presented in tables with accompanying explanations. ANOVA was chosen for testing hypotheses in order to control the confounding in the study. The qualitative data was analyzed with content analysis because of the open-ended nature of the questions. Content analysis was adopted to analyze the presence of the research question themes from the answers given by the participants in the phenomenological study.

4. RESULTS

The effect of GIS as an educational technology on the teaching of social studies was investigated in this study, the results and findings from this research are presented here under four tables and followed by those of the qualitative research.

4.1. Research question 1: how does GIS as an educational technology affect the teaching of social studies students?

Table 1 showed that in the TG, a recorded post-test mean score was far higher than the pre-test mean score. This implies that GIS has a positive effect on teaching social studies to students, as it caused an improvement in the academic performance of participants.

4.2. Research question 2: what will be the difference in the mean score of students taught with GIS and those taught without GIS?

In a similar vein, the mean for post-test obtained from the CG and TG as seen in Table 2 signifies a higher post-test mean score for the TG as compared to the CG. These results indicate that GIS is a positive technology, and it could cause an enhancement in social studies education and improve the academic performance of students in social studies.

4.3. Ho1: there is no significant effect of GIS system as an educational technology on the teaching of social studies students.

Table 3 one-way ANOVA analysis shows the effect of GIS as the level of significance at a p-value of 0.00. This implies that there was a significant effect of GIS on the teaching of social studies. Hence, we reject the null hypothesis and conclude that the alternate hypothesis is correct. Thus, the study submitted that there is a compelling effect of GIS on teaching of social studies, as it can help enhance the academic performance of its students.

4.4. Ho2: there is no significant difference in the mean score of students taught with GIS and those taught without GIS.

Table 4, ANOVA analysis shows the significance of the difference between the mean score of students treated with of GIS and those taught without the use of GIS. Since the level of significance p-value was between 0.00-0.001. It therefore means that there is a substantial difference in the mean scores of the 2 groups. Therefore, the null hypothesis is null and void, while the alternate hypothesis is adopted. The findings conclude that there is a significant difference in the mean score of both groups in favor of the CG group treated with GIS as educational technology.

Table 1. Effect of GIS on social studies

Test type	N	Mean	Std. deviation	Std. error mean	Mean difference
Pre-test	75	18.0701	6.2284	1.4495	30.0935
Post-test	75	48.1636	4.3022	1.3300	

Table 2. Difference in mean score for control and TGs

Test type	Group	N	Mean	Std. deviation	Std. error mean	Mean difference
Pre-test	Control	75	17.0339	6.15980	1.40195	1.0362
	GIS	75	18.0701	6.22844	1.40105	
Post-test	Control	75	19.3757	5.47456	-1.33006	28.7879
	GIS	75	48.1636	4.30216	1.33000	

Table 3. ANOVA summary on GIS effect on teaching social studies

Source	Sum of squares	df	Mean square	F	p-value	Decision
GIS group	666.29	2	333.145	26.40	0.000	Rejected
Error	988.00	72	13.722			
Total	1654.29	74				

Table 4. Summary of ANOVA on difference between GIS and CGs

TG and CG	Sum of squares	df	Mean of squares	F	p-value	Decision
Pre-test:						
Between groups	649.533	2	324.7665	2.066	0.000	Rejected
Within groups	23246.222	147	157.4572			
Total	23795.755	149				
Post-test:						
Between groups	2897.198	2	1448.599	24.500	0.001	Rejected
Within groups	8691.594	147	59.126			
Total	11588.792	149				

4.5. Findings from the qualitative study

In the second part of the research, qualitative analysis began with the selection of twenty students, 10, of whom were randomly selected from each group to take part in the interview. From the TG (Rukewe, Tega, Ifeoma, Edna, Alfred, Ben, Ofejiro, Collins, Jeffia, and Beauty) and the CG (Anita, John, Reke, Tome, Promise, Victory, Igho, Kevwe, Obinna, and Dominic) were selected. Qualitative data was analyzed with content analysis.

4.6. Effect of GIS on social studies teaching

Rukewe explained that, *"From my experience with GIS, I believe that GIS is an effective educational technology because I understood better as the lesson was detailed."* Tega: *"I feel positive learning with GIS software, although learning with it wasn't as easy as I thought."* Ifeoma: *"I was highly motivated, interested, and excited to explore a positive way of learning my favorite subject, "social studies."* Edna: *"I perceived that I can learn a whole new lot with GIS."* Alfred: *"I loved exploring new things with GIS."* Ben, Ofejiro, and Beauty: *"GIS broadened their social studies knowledge."* Collins: *"GIS enhanced my spatial skills and understanding."* Jeffia: *"GIS helped me to understand the topic better and pass the GAT."*

4.7. Difference in perception between the CG and TG on learning with GIS

All ten students in the TG were in the affirmative that their goal of learning the topic with the software was achieved. However, they expressed difficulties in tracing the continents using GIS. Collins and Ofejiro revealed that they experienced some difficulty in processing the topic but managed to score a good grade in the post-test. Thus, they concluded that they did not achieve one hundred percent academic performance as expected. This is an indication integration of educational technology is needed in boosting academic performance of social studies students in certain topics. In the second phase of the qualitative research, the researcher used post-test achievement to investigate if there is any improvement with the GIS group as compared to the CG. Participants were asked three straight questions on the "content of the lesson" taught during the experiment "the world and its continents."

4.7.1. Question 1: what is a continent?

The expected answer is *"A continent is one of the largest landmasses on earth surrounded by oceans."* In the CG, four students found it a bit difficult to get the correct answer but gave responses not too close to the answer. Nevertheless, Kevwe almost got it correct. The students said they have forgotten; this

could be attributed to teaching without any educational technology or resources. As the method of teaching used for them did not involve any educational technology, this may have made them forget the exact definition of a continent.

Meanwhile, the students from TG gave correct and very close answers. For example, Ifeoma defined *"Continent as the largest landmass in the world."* While Ben said *"A landmass that is made up of many countries,"* and Alfred said *"A continent is the largest expanse of land surrounded by water/oceans."* The above responses showed that each of them understood what the term "continent" means and goes on to imply that students taught the topic using ArcGIS software understood and retained the content of the topic better than those taught the same topic without the software.

4.7.2. Question 2: how many continents are there in the world?

The question was designed to test students' ability to reproduce facts; the participants in the study are expected to state correctly the total number of continents in the world. The correct answer is 7, and the 5 participants from the TG (GIS) group gave correct answers. On the contrary, only three-Kevwe, Victory, and Obinna from the CG-got it right. Igho answered 5, while Dominic said 6.

4.7.3. Question 3: why is the climate of some continents colder than others?

Answer *"Continents farther from the equator are cold, while those close to the equator are hot."* The response from all 5 students from the TG was correct, and surprisingly Tega said, *"The equator divides the earth into two equal halves."* When asked how she knew this, she said that in the GIS software that was used to teach them, you can clearly see the equator in the middle of the globe. She asked the researcher, who acted as the teacher for the study, was told the answer. In contrast, all ten students from the CG could not get the answer correctly as they were guessing. In summary, the interview (qualitative research) shows that the TG demonstrated a higher knowledge of the topic than the CG; this was the same finding from the quantitative research. Furthermore, the answers given by students in the TG suggested that the students have the ability to analyze, explain, and elaborate; they also displayed a high level of confidence. In contrast, the level of these qualities in CG was lower.

5. DISCUSSION

The primary goal of the research was to investigate if GIS could be an educational technology to improve social studies teaching through examining students' academic performance in the subject. The results obtained from data analysis signified that GIS-based teaching has the potential to raise students' academic performance in social studies, because the GIS group recorded a greater academic performance for students than the CG. Similarly, the results from qualitative (interview) research were consistent with those of the quantitative study, implying that GIS can be used as an educational technology to help students achieve improved teaching of social studies. This finding is consistent with the findings of other studies such as Güneş *et al*. [12] Wilson *et al*. [13] and Jo and Hong [32]. The studies have attempted to integrate GIS into social studies education, and the results showed improvement in students' academic performance. For example, Yang *et al*. [27] discovered that GIS, when adopted in social studies education, gave a better result in students' academic performance compared to abstract teaching of the subject.

The significance of the study's findings implied that GIS has the potential to promote students' interest/readiness to learn, curiosity, excitement, and learning autonomy. These advantages should encourage teachers to always incorporate educational technology such as GIS into social studies lessons to boost the academic performance of students. Secondly, the findings from the phenomenological study confirmed that GIS encouraged students to generate new knowledge, which could boost their academic performance in the long run. This is in consonance with Šiljeg *et al*. [14], Redican *et al*. [16], Mzuza and Westhuizen [29] and Jo and Hong [32] This study's findings can help solve the problem of poor pedagogy and underperformance of social studies students through the adoption of GIS technology because it is an interactive tutor. This study revealed the need for GIS integration as an educational technology and to apply it in social studies education for optimal academic performance of its learners. Hence the results from this research affirmed the positive role that GIS technology could play in social studies education.

5.1. Limitation

The study used a mixed-method research approach, which is a significant advantage because it allows for a more in-depth investigation. However, a few limitations remain; the first is the study's sample is small, which limits the generalizability of the results. However, the authors observed that in previous phenomenological studies on GIS, a small number of participants were used; hence, a small size was chosen in this particular study.

Furthermore, the researcher conducted a quantitative evaluation of the participants based on multi-choice questions on the topic from previous Delta State Ministry of Education Basic Certificate Examinations. It would have been preferable to use more diverse sources for data collection, such as theory or fill-in-the-gap- type tests. This means that a student who has challenges understanding multi-choice questions may not perform well; this could have had a negative impact on their overall performance and the final results. Finally, financial constraints and the lack of electricity, computers, and internet connectivity in most schools can limit the scope of the study.

5.2. Implications of future research

First, social studies researchers should make critical efforts to incorporate GIS technology into the educational research of social studies. Secondly, the needed resources for integrating GIS into social studies education should be provided through the ministries of education. The results of the study could inspire social studies researchers become more innovative and resourceful in GIS technology for teaching social studies. Finally, the study will encourage the educational usage of GIS, especially in social studies education.

6. CONCLUSION

The findings from this study concluded that using GIS as educational technology could have advantageous effect on social studies and boost the academic performance of students. If social studies teachers incorporate GIS, it can improve students' assimilation, as well as excite social studies students' learning in the long run. This research demonstrated that GIS can be integrated and used to address the issue of poor pedagogy and students' academic underperformance in social studies. As a result, the researchers believe that these findings can prompt GIS usage by inspiring social studies teachers to integrate and incorporate GIS technology into social studies teaching. Since the findings have confirmed that it could promote social studies education and the academic performance of students in the subject.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors unequivocally state no conflict of interest of the study.

DATA AVAILABILITY

The authors made evidence available as a supplementary file.

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