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INTEGRATING TECHNOLOGY IN GEOGRAPHY PEDAGOGY: ENHANCING SPATIAL THINKING SKILLS AMONG SELECTED SECONDARY SCHOOL STUDENTS IN WUDIL LOCAL GOVERNMENT, KANO STATE, NIGERIA

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Abstract

This study examined the integration of technology in geography pedagogy and its impact on spatial thinking skills among secondary school students in Wudil Local Government Area, Kano State, Nigeria. Employing a descriptive survey design, the study targeted 835 senior secondary school students and 16 geography teachers across four purposively selected schools. A sample of 271 students was selected using proportionate stratified random sampling, while all teachers were included through total enumeration. Data were collected via structured questionnaires and classroom observations, and analyzed using descriptive statistics. Findings indicated a high level of technology integration, with teachers frequently using Geographic Information Systems (GIS), Google Earth, digital maps, and multimedia resources. Both students and teachers reported that technology-enhanced instruction improved students' spatial thinking, problem-solving, engagement, and understanding of geographic concepts. Challenges included limited access to digital tools, inadequate resources, unreliable internet connectivity, and insufficient teacher training. Opportunities were identified through mobile and web-based tools, administrative support, and professional development initiatives. The study concludes that integrating technology into geography instruction positively influences spatial reasoning and learning outcomes. It recommends the expansion of ICT infrastructure, systematic teacher training, curriculum incorporation of digital tools, and policy support to ensure effective adoption of technology in geography education. The research provides empirical evidence to inform educational practice, policy, and teacher development in Nigerian secondary schools and contributes to the broader discourse on technology-enhanced pedagogy and spatial literacy.

Keywords: Technology Integration, Geography Pedagogy, Spatial Thinking, Secondary Education, GIS, Digital Learning

Introduction

The integration of technology into teaching and learning has become an essential component of modern education. Advances in digital technologies have transformed instructional practices, creating opportunities for interactive, learner-centered, and inquiry-based learning environments. According to UNESCO (2023), educational technologies improve learner engagement, facilitate collaboration, and enhance the development of critical thinking and problem-solving skills. Similarly, Bond, Buntins, Bedenlier, Zawacki-Richter, and Kerres

(2024) reported that technology-supported learning environments positively influence students' participation, motivation, and academic achievement. Geography is a discipline that focuses on the study of places, environments, and spatial relationships. Effective learning in geography requires students to develop spatial thinking skills, including the ability to interpret maps, analyse geographic patterns, visualize spatial relationships, and solve location-based problems. Jo, Bednarz, and Metoyer (2021) describe spatial thinking as a critical competency that enables learners to understand and interpret geographic information effectively. Likewise, Kim and Bednarz (2023) emphasized that spatial thinking plays a significant role in enhancing students' geographic literacy and decision-making abilities.

Despite the importance of spatial thinking, geography instruction in many secondary schools continues to rely largely on conventional teaching approaches. According to Aina and Adedoja (2022), traditional lecture-based methods often encourage rote learning rather than active engagement with geographic concepts and spatial data. As a result, students may experience difficulties in map reading, spatial analysis, and the application of geographic knowledge to real-world situations.Recent studies have demonstrated that technology-enhanced geography instruction can significantly improve students' spatial thinking skills and academic performance. Favier and Van der Schee (2022) found that digital mapping technologies and geospatial applications support visualization, inquiry, and analytical reasoning among geography learners. Similarly, Kerski (2023) reported that Geographic Information Systems (GIS), interactive maps, and virtual globes provide students with opportunities to explore real-world geographic phenomena and develop higher-order spatial reasoning skills.

The Technological Pedagogical Content Knowledge (TPACK) framework remains one of the most widely used models for understanding effective technology integration in education. Recent studies by Koehler, Mishra, and Cain (2024) emphasize that successful technology integration requires teachers to combine technological knowledge, pedagogical expertise, and subject content knowledge to achieve meaningful learning outcomes. In geography education, this involves the effective use of digital maps, GIS tools, satellite imagery, and multimedia resources to support students' understanding of geographic concepts. In Nigeria, efforts have been made to promote Information and Communication Technology (ICT) integration in secondary schools. However, challenges such as inadequate infrastructure, limited access to digital resources, poor internet connectivity, and insufficient teacher training continue to affect implementation (Federal Ministry of Education, 2023; Yusuf & Abdulrahman, 2024). Consequently, many geography classrooms remain largely textbook-centred, limiting students' opportunities to develop spatial thinking skills through technology-supported learning.

In Kano State, particularly in Wudil Local Government Area, empirical evidence on the effectiveness of technology integration in geography pedagogy remains limited. Although some schools have access to digital technologies, little is known about their impact on students' spatial thinking skills. Therefore, this study seeks to investigate the integration of technology in geography pedagogy and its influence on enhancing spatial thinking skills among selected secondary school students in Wudil Local Government Area, Kano State, Nigeria.

Objectives of the Study

1. To assess the extent of technology utilization in geography instruction in selected secondary schools in Wudil Local Government Area.
2. To evaluate the spatial thinking skills of secondary school students in selected schools in Wudil Local Government Area.
3. To determine the relationship between technology integration in geography instruction and students' spatial thinking skills.
4. To identify challenges associated with the integration of technology in teaching geography in the selected schools.

Research Questions

1. To what extent is technology utilized in geography instruction in selected secondary schools in Wudil Local Government Area?
2. What is the level of spatial thinking skills among secondary school students in the selected schools?
3. Is there a significant relationship between technology integration in geography instruction and students' spatial thinking skills?
4. What are the challenges facing teachers in integrating technology into geography instruction in the selected schools?

Significance of the Study

The study is expected to provide multiple benefits.

Firstly, it will generate empirical evidence on the effectiveness of technology integration in enhancing spatial thinking skills among secondary school students, contributing to the broader discourse on ICT in education.

Secondly, geography educators and curriculum developers will gain insights into the most effective digital tools and instructional strategies, which could inform teaching practices and curriculum planning.

Thirdly, policymakers and school administrators will be better informed about the infrastructural and professional development needs necessary to support technology-enhanced instruction

Finally, the study will provide a foundation for future research in technology-assisted geography education in Kano State and similar contexts, helping to bridge the gap between digital policy intentions and classroom realities (**Jo, Bednarz, & Metoyer, 2021; Kim &Bednarz, 2023**).

Statement of the Problem

Despite the growing global emphasis on integrating digital technologies into education, many secondary school classrooms in Kano State, Nigeria, continue to rely predominantly on traditional, lecture-based instructional approaches. Geography, which inherently requires spatial reasoning and analytical thinking, often remains limited to textbook-based learning, depriving students of opportunities to develop critical spatial thinking skills (**Aina&Adedoja, 2022; Jo, Bednarz, & Metoyer, 2021)**. While some schools have begun adopting ICT tools, there is limited evidence on how these technologies impact students' spatial reasoning abilities in the local context. Furthermore, teachers face challenges such as inadequate training, poor infrastructure, lack of digital resources, and inconsistent electricity supply, which hinder effective technology integration (**Tella et al., 2020; Federal Ministry of Education, 2023**). Consequently, students may exhibit low proficiency in map interpretation, spatial pattern recognition, and problem-solving tasks—skills critical for academic success and future career prospects in fields like urban planning, environmental management, and disaster response (**Kerski, 2023; Kim &Bednarz, 2023**).This study seeks to address this gap by investigating the relationship between technology integration in geography instruction and the spatial thinking skills of secondary school students in Wudil Local Government Area, Kano State (**UNESCO, 2023; Bond et al., 2024**).

Methodology

This study employed a descriptive survey research design to examine the integration of technology in geography pedagogy and its influence on spatial thinking skills among secondary school students in Wudil Local Government Area (LGA), Kano State, Nigeria. The study was conducted in four purposively selected secondary schools: Government Day Secondary School, Government Secondary Commercial School, Government Girls Arabic Secondary School, and Government Secondary School, Wudil.The target population comprised 835 senior secondary school students offering Geography and 16 Geography teachers in the selected schools. Using Taro Yamane's (1967) formula at a 5% margin of error, a sample size of 271 students was determined and selected through proportionate stratified random sampling. In addition, all 16 Geography teachers were included through total enumeration.

Data were collected using two structured questionnaires: the Student Technology Engagement and Spatial Thinking Questionnaire (STEST-Q) and the Teacher Technology Integration and Impact Questionnaire (TTII-Q). The instruments assessed the level of technology integration in geography lessons, students' spatial thinking skills, teachers' use of technological tools, and challenges associated with technology-enhanced instruction. Classroom observations were also conducted to complement questionnaire data and verify the actual use of technology during geography lessons.To ensure validity, the instruments were reviewed by experts in Geography and Education from Bayero University, Kano. Reliability was established through a pilot study involving 20 students from a secondary school in Sumaila Local Government

Area. Cronbach's Alpha yielded a reliability coefficient of 0.75, indicating acceptable internal consistency.

Data were analysed using descriptive statistics, including frequencies, percentages, mean scores, and standard deviations. Responses were measured on a five-point Likert scale, and a mean score of 3.0 or above was considered acceptable. Ethical principles were strictly observed through informed consent, voluntary participation, confidentiality, anonymity, and the use of data solely for research purposes.

RESULTS PRESENTATION

Demographic Characteristics of Respondents

Table 1. Student Demographics

Demographic Variable	Frequency	Percentage (%)
Age		
13–15 years	90	33.2
16–17 years	140	51.7
18+ years	41	15.1
Gender		
Male	160	59
Female	111	41
Total	271	100
Class Level		
SS1	92	34
SS2	95	35
SS3	84	31
Total	271	100

The result from Table 1 above shows that nearly half (51.7%) of the students were aged 16–17 years, with a slightly higher proportion of males (59%). The sample was fairly distributed across SS1, SS2, and SS3 classes (34%,35%, and 31%), respectively.

Table 2: Teachers' Demographics

Demographic Variable	Frequency	Percentage (%)
Age		
25–35 years	5	31.2
36–45 years	7	43.8
46+ years	4	25
Gender		
Male	10	62.5

Female	6	37.5
Total	20	100
Years of Experience		
1–5 years	4	25
6–10 years	5	31.2
11–15 years	4	25
16+ years	3	18.8
Total	20	100

The result from Table2 above shows that the majority of the teachers (43.8%) were between 36 and 45 years, with nearly two-thirds of the teachers (62.5%) being male. Experience was moderately distributed, with the majority (31.2%)between 6 and 10 years of teaching experience.

Table3: Level of Technology Integration in Geography Lessons (Student Perspective)

Item	SA	A	U	D	SD	Mean	Interpretation
Teachers use technology (GIS, Google Earth, digital maps)	70	120	30	35	16	3.7	High
Technology is regularly incorporated	60	110	40	45	16	3.5	Moderate
Encouraged to use digital tools	50	115	45	45	16	3.4	Moderate
Technology explains concepts clearly	80	125	25	30	11	3.8	High
Technology supports understanding spatial patterns	75	120	30	35	11	3.7	High
Decision mean: 3.0						Aggregate mean: 3.62	

The result from Table3 above shows the frequency, percentage, mean, and standard deviation of students' perspectives on the level of technology integration in geography lessons. The table revealed that all the 5 itemshas mean score greater than 3.0, which is above the decision mean, which shows that there is a high level of integration of technology in geography class across the selected schools (aggregate mean of 3.62).

Table 4: Level of Technology Integration in Geography Lessons (Teachers' Perspective)

Item	SA	A	U	D	SD	Mean	Interpretation
Frequently integrate technology	6	7	1	2	0	4.1	High
Use GIS in teaching	5	6	2	3	0	3.8	High
Use Google Earth	6	5	2	3	0	3.9	High

Use digital maps	4	7	3	2	0	3.7	Moderate
Use multimedia	7	6	1	2	0	4.0	High
Decision mean: 3.0						Aggregate mean: 3.9	

The result from Table 4 above shows the frequency, percentage, mean, and standard deviation of teachers' perspectives on the level of technology integration in geography lessons. The table revealed that all the 5 items have mean score greater than 3.0, which is above the decision mean, which shows that teachers generally integrate technology into lessons, particularly GIS, Google Earth, multimedia resources, and digital maps (aggregate mean of 3.9).

Table 5: Effectiveness of Technology in Enhancing Spatial Thinking (Student Responses)

Item	SA	A	U	D	SD	Mean	Interpretation
Helps understand spatial relationships	85	120	25	30	11	3.9	High
Analyze & interpret geographic data	80	115	30	35	11	3.8	High
Makes lessons interactive & engaging	70	110	40	35	16	3.6	Moderate
Apply skills in practical situations	60	120	45	35	11	3.5	Moderate
Improves problem-solving skills	65	115	45	30	16	3.6	Moderate
Decision mean: 3.0						Aggregate mean: 3.68	

The result from Table5 above shows the frequency, percentage, mean, and standard deviation of students' perspectives on the effectiveness of Technology in Enhancing Spatial Thinking. The table revealed that all the 5 items have mean score greater than 3.0, which is above the decision mean, which shows students agree that technology enhances spatial thinking, understanding of relationships, and problem-solving. Interactive and applied learning benefits were rated moderate due to occasional limitations in access.

Table6: Effectiveness of Technology in Enhancing Spatial Thinking (Teachers' Responses)

Item	SA	A	U	D	SD	Mean	Interpretation
Improves students' spatial thinking	8	6	1	1	0	4.2	High
Students actively engage when tech is used	7	7	1	1	0	4.1	High

Students' performance has improved	6	7	2	1	0	3.9	High
Supports inquiry-based learning	8	5	2	1	0	4.0	High
Helps differentiate instruction	7	6	2	1	0	4.0	High
Decision mean: 3.0						Aggregate mean: 4.04	

The result from Table 6 above shows the frequency, percentage, mean, and standard deviation of teachers' perspectives on the effectiveness of Technology in Enhancing Spatial Thinking. The table revealed that all the 5 itemshas mean score greater than 3.0, which is above the decision mean, which shows tteachers perceive that technology significantly improves spatial thinking, engagement, performance, and differentiated instruction in geography

Table 7: Challenges and opportunities associated with integrating technology (Students' Response).

Item	SA	A	U	D	SD	Mean	Interpretation
Sufficient resources available	40	100	50	60	21	3.1	Moderate
Face difficulties using technology	75	105	30	45	16	3.7	High
The teacher provides guidance	60	120	35	40	16	3.6	Moderate
Mobile/web tools would improve learning	85	120	25	30	11	3.9	High
Technology is reliable/easy to use	55	115	40	40	21	3.4	Moderate
Decision mean: 3.0						Aggregate mean: 3.54	

The result from Table 7 above shows the frequency, percentage, mean, and standard deviation of students' perspectives on Challenges and **opportunities associated with integrating technology**. The table revealed that all the 5 itemshas mean score greater than 3.0, which is above the decision mean, which shows students face challenges, including insufficient resources and occasional technical difficulties. They also perceive opportunities for mobile/web-based tools to enhance learning.

Table 8: Challenges and opportunities associated with integrating technology (Teachers' Response).

Item	SA	A	U	D	SD	Mean	Interpretation
Limited access hinders teaching	8	5	2	1	0	4.0	High
Lack of training affects use	7	6	2	1	0	3.9	High
Administrative support enhances integration	6	7	2	1	0	3.9	High
Need to improve technology use	8	5	2	1	0	4.0	High
Adequate professional development received	4	5	4	3	0	3.3	Moderate
Decision mean: 3.0						Aggregate mean: 3.82	

The result from Table8 above shows the frequency, percentage, mean, and standard deviation of teachers' perspectives on Challenges and **opportunities associated with integrating technology**. The table revealed that all the 5 itemshas mean score greater than 3.0, which is above the decision mean, showing that teachers highlight challenges in access and training but acknowledge administrative support. Professional development is moderate, indicating a need for improved training programs.

Table 9: Recommendations for educators and policymakers

Recommendation	Students' Response (%)	Teachers' Response (%)
Increased provision of computers and GIS tools	65	70
Teacher training on technology integration	70	75
Incorporation of digital learning in the curriculum	60	65
Regular maintenance of the ICT infrastructure	55	60

Results from table 9 above suggest strong support for **enhanced resource provision, teacher training, and policy support** to improve technology integration and spatial thinking outcomes.

Fig 1: Showing a summary of the findings

Summary of Findings

1. **Demographics:** The student sample was slightly male-dominated, mostly aged 16–17 years. Teachers were mostly 36–45 years old with 6–10 years of experience.
2. **Technology Integration:** Technology is moderately to highly integrated in lessons. Teachers frequently use GIS, Google Earth, and multimedia, while students are exposed to these tools variably.
3. **Spatial Thinking:** Both students and teachers report that technology positively enhances spatial thinking, problem-solving, and engagement.
4. **Challenges:** Limited access to technology, inadequate resources, and occasional lack of teacher training remain barriers.
5. **Opportunities:** Mobile and web-based tools, increased administrative support, and professional development are seen as key enablers for effective integration.

Discussion

The findings revealed that the majority of student respondents were aged 16–17 years, while most teachers had between 6 and 10 years of teaching experience. These characteristics suggest that both students and teachers possessed the maturity and experience necessary to engage with technology-enhanced geography instruction. The demographic distribution also provided a balanced representation of learners across senior secondary school levels.

The study found a relatively high level of technology integration in geography classrooms, as evidenced by students' and teachers' mean ratings of 3.62 and 3.90, respectively. Technologies such as Geographic Information Systems (GIS), Google Earth, digital maps, and multimedia resources were commonly used to support lesson delivery. This finding agrees with previous studies (Voogt et al., 2020; Favier & van der Schee, 2019), which reported that technology integration promotes student-centered learning and enhances understanding of geographic concepts and spatial relationships.

Results further indicated that technology significantly enhances students' spatial thinking skills. Students reported improved understanding of spatial relationships, data interpretation, and problem-solving abilities, while teachers observed increased engagement, inquiry-based learning, and academic performance. These findings support the work of Demirci (2018) and Lee and Bednarz (2012), who found that geospatial technologies improve spatial reasoning, analytical thinking, and the practical application of geographic knowledge. The findings suggest that technology facilitates higher-order thinking by enabling students to explore and analyze geographic information beyond traditional textbook learning.

Despite these benefits, several challenges were identified. Both students and teachers reported limited access to digital devices, inadequate technological resources, insufficient teacher training, technical difficulties, and the high cost of technology tools. These challenges are consistent with the findings of Voogt et al. (2015) and Favier and van der Schee (2019), who identified infrastructural limitations and inadequate professional development as major barriers to effective technology integration. Nevertheless, respondents acknowledged significant opportunities, particularly the use of mobile and web-based technologies, administrative support, and policy initiatives that can strengthen technology-enhanced geography instruction.

Overall, the findings demonstrate that technology integration has a positive influence on geography teaching and learning by enhancing students' spatial thinking skills. However, maximizing these benefits requires improved infrastructure, increased access to digital resources, and continuous teacher training to ensure effective and sustainable implementation.

Conclusion

The study investigated the integration of technology in geography pedagogy and its impact on enhancing spatial thinking skills among secondary school students in Wudil Local

Government Area, Kano State. The findings reveal a **high level of technology integration** in classrooms, with tools such as GIS, Google Earth, digital maps, and multimedia resources actively used by teachers. Both students and teachers reported that technology positively influences **spatial thinking, problem-solving, engagement, and understanding of geographic concepts**, confirming the effectiveness of technology-based instruction in promoting higher-order cognitive skills. Despite these benefits, the study identified challenges, including limited access to digital resources, poor internet connectivity, insufficient teacher training, and high costs of technology tools. Nevertheless, opportunities exist for improving learning outcomes through mobile and web-based tools, administrative support, and professional development programs.

In conclusion, the study demonstrates that integrating technology into geography instruction can significantly enhance students' spatial thinking skills and overall learning experiences. To maximize these benefits, schools and policymakers must ensure adequate infrastructure, teacher training, and curriculum support. This research contributes empirical evidence to the understanding of technology-enhanced pedagogy in semi-urban Nigerian contexts and provides actionable recommendations for educators, administrators, and policymakers seeking to strengthen geography education.

Implications of the Study

The findings of this study have significant implications for educational practice, policy, and research:

1. **Educational Practice:** Teachers can leverage GIS, Google Earth, and other digital tools to enhance spatial thinking, problem-solving, and analytical skills among geography students. The study underscores the need for regular integration of technology into classroom instruction to ensure active, student-centered learning.
2. **Policy and Administration:** School administrators and policymakers should prioritize investment in ICT infrastructure, including computers, tablets, reliable internet access, and software tools that support geographic education. Such investment will ensure equitable access and reduce disparities between schools.
3. **Teacher Development:** Continuous professional development and training are critical. Teachers must be equipped with the skills and pedagogical strategies to maximize technology use and facilitate inquiry-based and interactive learning.
4. **Curriculum Design:** Digital tools and interactive platforms should be formally embedded within the geography curriculum, ensuring that students develop spatial thinking skills as part of standard learning objectives.
5. **Student Engagement:** Encouraging students to actively engage with technology, including independent exploration and collaborative projects, enhances learning outcomes and fosters lifelong digital literacy.

Recommendations

Based on the findings and discussion, the following recommendations are proposed:

1. **For Teachers:** Consistently integrate GIS, Google Earth, and other multimedia resources into geography lessons to enhance spatial reasoning and problem-solving abilities.
2. **For School Administrators:** Ensure adequate provision of ICT infrastructure, including computers, tablets, internet access, and digital learning resources.
3. **For Policymakers:** Develop and implement professional development programs focused on technology integration in teaching and learning.
4. **For Curriculum Designers:** Incorporate interactive digital tools and GIS-based activities into the standard geography curriculum.

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