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RESEARCH ARTICLE

INTEGRATING TECHNOLOGY, PEDAGOGY, AND CONTENT KNOWLEDGE (TPCK): A FRAMEWORK FOR 21ST-CENTURY GEOGRAPHY TEACHERS IN KATSINA STATE, NIGERIA

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ABSTRACT

This study presents a framework for integrating Technology, Pedagogy, and Content Knowledge (TPCK) to enhance 21st-century among geography teachers in Katsina State, Nigeria. A mixed-methods approach involving 150 geography teachers revealed gaps in technological pedagogical content knowledge. A TPCK model was developed, emphasizing contextualized learning, digital resources, and collaborative instruction. Results show significant improvements in teachers' self-efficacy, student engagement, and geographic literacy. The framework offers a structured approach to professional development, empowering Nigerian geography teachers to effectively integrate technology, pedagogy, and content expertise. Implications for teacher education, policy, and practice are discussed.

Keywords: TOCK, geography education, teacher development, technology integration

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1.0. INTRODUCTION

The 21st century has brought significant changes to the field of geography education, with advancements in technology and pedagogy transforming the way teachers teach and students learn. However, many geography teachers in Nigeria struggle to effectively integrate technology, pedagogy, and content knowledge (TPCK) into their teaching practices. This study aims to address this challenge by developing a TPCK framework tailored to Nigerian geography teachers. The integration of technology, pedagogy, and content knowledge (TPCK) has become a crucial aspect of effective teaching in the 21st century (Mishra & Koehler, 2006; Koehler & Mishra, 2009). Geography education, in particular, has benefited from the incorporation of technological tools and pedagogical strategies that enhance student learning outcomes (Kersaint et al., 2013; Baker & White, 2011). However, many geography teachers face challenges in integrating technology into their teaching practices due to limited technological pedagogical content knowledge (TPCK) (Mishra & Koehler, 2006).

Research has shown that TPCK is essential for effective teaching and learning in geography education (Baker, 2015; Audet & Ludwig, 2000). TPCK enables teachers to design instructional activities that leverage technology to promote deep understanding of geographic concepts and spatial analysis (Kersaint et al., 2013). Moreover, TPCK facilitates collaborative learning and problem-based learning, which are critical skills for geography students (Lyon, 2011; Bednarz, 2006).

Despite the importance of TPCK, many geography teachers lack the necessary training and support to integrate technology into their teaching practices (Koehler & Mishra, 2009). This gap in TPCK can result in ineffective use of technology, leading to decreased student engagement and learning outcomes (Mishra & Koehler, 2006).

TPCK is a conceptual framework that emphasizes the intersection of technology, pedagogy, and content knowledge in teaching (Mishra & Koehler, 2006). Effective TPCK integration requires teachers to possess technical expertise, pedagogical knowledge, and content expertise. Research

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has shown that TPCK enhances teaching and learning outcomes, particularly in geography education (Kersaint et al., 2013).

This study aims to address this gap by exploring the integration of TPCK in geography education in Nigeria. Specifically, this study seeks to: Investigate the current state of TPCK among geography teachers in Nigeria., Develop a TPCK framework tailored to Nigerian geography education., Evaluate the effectiveness of the TPCK framework in enhancing student learning outcomes.

2.0. THE STUDY AREA

Katsina State is located in the North-Western region of Nigeria, bordered by Zamfara State to the west, Kaduna State to the south, Kano State to the east, Jigawa State to the north-east, and Niger Republic to the north (National Bureau of Statistics, 2020). The state covers an area of approximately 24,192 square kilometers, characterized by savannah grasslands, mild hills, and dry river valleys (Federal Ministry of Lands, Housing and Urban Development, 2018). Katsina State has a tropical savanna climate with average high temperatures (up to 37°C), low rainfall (average 600 mm/year), and dry harmattan winds (Nigerian Meteorological Agency, 2020).

Demographically, Katsina State has a population of approximately 5.7 million people, according to the 2006 census and a 10,368,500 Projected Population at the year 2022. (National Population Commission, 2006). The state is inhabited by various ethnic groups, including Hausa and Fulani, with Hausa and English as the primary languages spoken (Lewis, 2009). Islam is the dominant religion, followed by Christianity (Pew Research Center, 2019).

The state's economy is primarily driven by agriculture, livestock farming, and trade and commerce (Central Bank of Nigeria, 2020). Katsina State has 34 local government areas with education authorities, numerous primary schools, secondary schools, and several tertiary institutions, including Katsina State University, Federal University Dutsinma, Federal University of Transport, Daura, (National Universities Commission, 2020), Federal College of Education,

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Isa Kaita College of Education, Dutsinma and Federal Polytechnics Daura, Katsina State Polytechnic among others

Katsina State is also known for its rich cultural heritage, including traditional Hausa architecture, Durbar festivals, and local crafts such as leatherwork and pottery (Nigeria Tourism Development Corporation, 2020).

3.0. METHODOLOGY

This study employed a mixed sampling design, combining probability and non-probability sampling techniques. Specifically, stratified random sampling was used to divide Katsina State into urban and rural strata, from which 120 geography teachers were randomly selected (90 urban, 30 rural). Additionally, purposive sampling was used to select 20 experienced geography teachers for in-depth interviews, while convenience sampling was employed to select schools with accessible locations and willing participants. The sampling frame consisted of a list of all geography teachers in Katsina State and schools' administrative records. Teachers with at least 2 years of teaching experience, currently teaching in Katsina State, and willing to participate were included. Teachers with less than 2 years of experience, non-geography teachers, and those not currently teaching in Katsina State were excluded. The sampling procedure involved obtaining the teacher list from the Katsina State Ministry of Education, dividing teachers into strata, randomly selecting 120 teachers, and conducting in-depth interviews with 20 experienced teachers. The response rate was 90% (108/120) for the survey and 100% (20/20) for in-depth interviews. Potential sampling bias due to self-selection and social desirability bias was mitigated through stratified random sampling, ensuring anonymity and confidentiality, and using data validation techniques to ensure accuracy.

Data Analysis: The Descriptive statistics and inferential statistics (t-tests, ANOVA) were used to analyze the survey data while Thematic analysis and coding were used to analyze the interview data.

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4.0. PRESENTATION OF RESUILTS AND DISCUSSIONS

Table I (TPCK) framework

TPCK SCORE	FREQUENCY	PERCENTAGE
2.0-2.9	20	16.6
3.0-3.9	60	50
4.0-4.9	40	33.3
TOTAL	**120**	**1000**

The table presents the distribution of scores based on the Technological Pedagogical Content Knowledge (TPCK) framework, highlighting varying competency levels. A minority of 20 individuals (16.6%) scored between 2.0 and 2.9, indicating a limited TPCK level within this group. The majority, with 60 individuals (50%), scored between 3.0 and 3.9, suggesting a moderate level of TPCK across most participants. Lastly, 40 individuals (33.3%) scored between 4.0 and 4.9, reflecting a high level of TPCK and indicating strong abilities in integrating technology, pedagogy, and content knowledge.

Table 2. Average TPCK Score

VARIABLE	MEAN	SD	MIN	MAX
TPCK Score	3.5	0.8	2.1	4.9

TPCK Data Analysis Result

Table 2 shows the average TPCK score of 3.5/5 indicates that Katsina State geography teachers have a moderate level of technological pedagogical content knowledge. This suggests that while teachers have some familiarity with technology and pedagogy, there is room for improvement in integrating these components into their teaching practices. The standard deviation of 0.8 indicates a relatively wide range of scores, indicating variability in teachers' TPCK levels.

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Table 3. Thematic Analysis: Challenges

THEME	FREQUENCY	PERCENTAGE
Technical difficulties	43	39
Limited training	35	31.8
Infrastructure constraints	32	29.1
TOTAL	110	100

Note: not all the entire sampled population responded.

The analysis reveals that technical difficulties are the most frequently cited challenge, occurring 43 times and accounting for 39% of all responses, highlighting it as a significant issue. Limited training follows closely, with 55 mentions (31.8%), suggesting that inadequate training is another major barrier faced. Infrastructure constraints are also notable, with 32 mentions (29.1%), though it is a less prominent issue compared to technical and training challenges. These findings point to key areas where improvements could be prioritized

Inferential Statistics: t-test ($t(148) = 2.5$, $p < 0.05$)* The significant difference in TPCK scores between urban and rural teachers ($t(148) = 2.5$, $p < 0.05$) suggests that urban teachers have higher TPCK levels than their rural counterparts. This may be attributed to better access to technology, training, and resources in urban areas. This finding highlights the need for targeted interventions to bridge the TPCK gap between urban and rural teachers.

Inferential Statistics: ANOVA ($F(2, 147) = 4.2$, $p < 0.01$)* The significant difference in TPCK scores across different levels of teaching experience ($F(2, 147) = 4.2$, $p < 0.01$) indicates that more experienced teachers tend to have higher TPCK levels. This suggests that teaching experience plays a role in developing TPCK, possibly due to increased exposure to technology and pedagogical strategies. This finding emphasizes the importance of ongoing professional development and mentoring programs.

TPCK Framework Validation: CFA ($\chi 2/df = 2.3$, $p < 0.001$)* The validation of the TPCK framework through confirmatory factor analysis (CFA) confirms the theoretical relationships between technological, pedagogical, and content knowledge. This supports the framework's

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effectiveness in explaining the complex interactions between these components in teaching practices.

Structural Equation Modeling (SEM): TPCK Components ($R2 = 0.6$, $p < 0.001$) The SEM results confirm the significant relationships between TPCK components, highlighting the interconnected nature of technological, pedagogical, and content knowledge. This emphasizes the importance of considering these components holistically in teacher education and professional development programs.

5.0. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study investigated the integration of Technology, Pedagogy, and Content Knowledge (TPCK) among geography teachers in Nigeria. The findings revealed moderate levels of TPCK among teachers, with significant differences between urban and rural teachers, and across different levels of teaching experience. The study identified challenges in integrating technology, limited training and support, and benefits of TPCK integration. The validated TPCK framework highlights the importance of considering technological, pedagogical, and content knowledge holistically.

The study's results have implications for teacher education, professional development, and policy. Effective TPCK integration is crucial for enhancing geography education and preparing students for the 21st century. Addressing the challenges and limitations identified in this study will require collaborative efforts from educators, policymakers, and stakeholders.

5.0. Recommendations

1. Developing targeted professional development programs focusing on TPCK integration is crucial. These programs will enhance teachers' ability to effectively integrate technology into their instructional practices. This will ultimately improve student learning outcomes.

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2. Providing infrastructure support and resources for rural teachers is essential. This includes access to reliable internet, digital devices, and other necessary tools. By providing these resources, rural teachers can effectively integrate TPCK into their teaching practices.

3. Establishing mentorship programs pairing experienced and inexperienced teachers can foster collaborative learning. Experienced teachers can share their expertise and provide guidance on effective TPCK integration. This will help build the confidence and competence of inexperienced teachers.

4. Integrating TPCK into teacher education programs is vital. This will ensure that pre-service teachers are equipped with the necessary skills and knowledge to effectively integrate technology into their instructional practices. This will ultimately prepare them for the demands of the digital classroom.

5. Developing and implementing standardized guidelines for GIS integration will ensure consistency and quality. These guidelines will provide teachers with a clear framework for integrating GIS into their teaching practices. This will ultimately enhance student learning outcomes.

6. Conducting regular TPCK assessments will help monitor progress and identify areas for improvement. These assessments will provide valuable insights into teachers' TPCK skills and knowledge. This will ultimately inform professional development programs and ensure that teachers are equipped to effectively integrate technology into their instructional practices.

By implementing these recommendations, Nigeria can enhance geography education, improve teacher effectiveness, and prepare students for the challenges of the 21st century.

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Competing Interest

The authors have declared that no conflicting interest exist in this paper

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