Utilisation of Generative Artificial Intelligence Tools as Correlates of Physics Student-Teachers' Pedagogical Content Knowledge and Perceived Teaching Practice Performance During Secondary School Teaching Practice

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Abstract- This study investigated the relationships among the use of Generative Artificial Intelligence (AI) tools, physics student-teachers' pedagogical content knowledge (PCK), and their perceived teaching performance during teaching practice in secondary schools. Specifically, the study examined the interrelationships among these variables, explored the relationship between pedagogical content knowledge and perceived teaching practice performance, and determined the predictive roles of Generative AI tool usage and pedagogical content knowledge on perceived teaching practice performance. The study adopted a correlational survey research design. The population comprised physics student-teachers in the Department of Science and Technology Education, Lagos State University, who were undertaking their teaching practice. A sample of 50 student-teachers was selected using a simple random sampling technique. Data were collected using a researcher-developed questionnaire containing 30 items on the use of Generative AI tools, pedagogical content knowledge, and perceived teaching practice performance. The instrument was validated by experts, and its reliability was established using Cronbach's alpha coefficient. Data were analysed using mean, standard deviation, Pearson Product-Moment Correlation, and multiple linear regression at the 0.05 level of significance. The findings revealed significant positive relationships among the study variables. The use of Generative AI tools was positively correlated with pedagogical content knowledge ($r = .367$, $p = .010$) and perceived teaching practice performance ($r = .314$, $p = .028$). A strong positive relationship was also found between pedagogical content knowledge and perceived teaching practice performance ($r = .783$, $p < .001$). Furthermore, the multiple regression analysis showed that 61.4% of the variance in perceived teaching practice performance was jointly explained by the use of Generative AI tools and pedagogical content knowledge ($R^2 = .614$, $F(2, 46) = 36.509$, $p < .001$). The study concluded that although the use of Generative AI tools was positively associated with both pedagogical content knowledge and perceived teaching practice performance, pedagogical content knowledge emerged as the stronger predictor of teaching practice performance. The study recommends the integration of Generative AI tools into teacher education programmes, particularly in physics teacher training, and the continuous enhancement of student-teachers' pedagogical content knowledge to improve teaching effectiveness.

Keywords: Generative Artificial Intelligence, Pedagogical Content Knowledge, Perceived Teaching Practice Performance, Physics Student-Teachers, Teacher Education.

I. INTRODUCTION

Digital technologies have become increasingly integrated into education, influencing both the design and delivery of teaching and learning. One of the most recent innovations in educational technology is Generative Artificial Intelligence (GenAI), which has the potential to significantly transform educational practice. Unlike traditional Artificial Intelligence systems that primarily analyse data and make predictions, GenAI tools are capable of generating new content based on user prompts. These tools can produce lesson plans, instructional materials, assessment items, explanations, visual resources, and personalised feedback. As a result, they have gained considerable attention in teacher education and professional development due to their potential to support instructional planning, content development, and reflective practice (Chaitidou, 2026).

The emergence of GenAI represents a continuation of efforts to enhance the integration of technology into education. Earlier frameworks emphasised the importance of combining technological knowledge, pedagogical knowledge, and content knowledge to improve teaching effectiveness. Generative AI extends this approach by providing tailored support to teachers, enabling them to explore diverse instructional strategies, develop learning resources, and address individual learners' needs. However, the educational value of these tools depends largely on educators' ability to critically evaluate the accuracy, relevance, and appropriateness of AI-generated content before integrating it into classroom instruction (Akanzire, 2025).

In physics education, the application of GenAI is particularly relevant because many physics concepts are abstract and difficult for students to understand. Topics such as electricity, electromagnetic fields, thermodynamics, and quantum mechanics often require multiple representations, meaningful analogies, and carefully selected instructional strategies to facilitate comprehension. GenAI tools can assist student-teachers in generating explanations, examples, learning activities, instructional materials, and teaching aids that simplify complex concepts. Consequently, these tools have the potential to enhance pedagogical content knowledge (PCK), which refers to the integration of content knowledge and pedagogical knowledge necessary for effective teaching (Shulman, 1986; Chaitidou, 2026).

Pedagogical content knowledge remains one of the most important competencies expected of student-teachers. According to Shulman (1986), it involves understanding how to organise and present subject matter in ways that promote student learning. It also includes identifying learners' misconceptions, selecting appropriate teaching strategies, adapting instruction to meet learners' needs, and effectively assessing learning outcomes. Research has shown that pedagogical content knowledge develops through coursework, teaching practice experiences, and the application of theoretical knowledge in classroom settings. Furthermore, strong pedagogical content knowledge has been associated with effective lesson delivery, increased teaching confidence, and improved classroom instruction (Shulman, 1986; Chaitidou, 2026).

Teaching practice provides student-teachers with an opportunity to demonstrate the competencies acquired during their teacher education programmes. During this period, they are expected to plan and deliver lessons, manage classrooms, engage learners, assess learning outcomes, and exhibit professional conduct under the supervision of experienced educators. Teaching practice therefore serves as a bridge between university-based preparation and actual classroom teaching. In physics education, effective teaching practice requires the integration of content knowledge, pedagogical skills, and appropriate instructional strategies to facilitate meaningful learning. Previous studies have shown that supportive teaching practice experiences contribute positively to the instructional competence and professional development of pre-service teachers (Onyefulu, 2018; Moosa, 2026; Alreiahi, 2025).

Within the Nigerian educational context, physics student-teachers often encounter challenges during teaching practice, including limited instructional resources, large class sizes, and diverse learner needs. These challenges can influence both the development of pedagogical content knowledge and teaching performance. Consequently, educators are increasingly exploring innovative technologies that can support student-teachers during this critical stage of professional development. The growing interest in GenAI tools in teacher education is also driven by national and international efforts to promote digital transformation in education, while emphasising responsible and ethical technology use and equitable access to digital resources (Akanzire, 2025; UNESCO, n.d.).

Although GenAI tools have the potential to support lesson planning, instructional content development, assessment design, and reflective practice, empirical evidence regarding their relationship with pedagogical content knowledge and teaching practice performance remains limited, particularly among physics student-teachers in Nigeria. Existing research on Artificial Intelligence in education has largely focused on general applications of AI, with relatively little attention given to its relationship with professional learning outcomes achieved during teaching practice. This gap in the literature highlights the need for further investigation.

II. STATEMENT OF THE PROBLEM

The preparation of physics teachers involves several stages, one of the most important being teaching practice. Success during teaching practice depends not only on a thorough understanding of physics concepts but also on the ability to select appropriate teaching strategies, identify learners' misconceptions, design effective learning activities, and assess students' understanding. These competencies are reflected in pedagogical content knowledge and are essential for effective teaching practice performance.

The emergence of Generative Artificial Intelligence (GenAI) has introduced a new generation of instructional tools capable of supporting the development of these professional competencies. Student-teachers can now utilise GenAI tools to generate lesson plans, instructional explanations, classroom activities, assessment items, and immediate feedback. These capabilities suggest that GenAI may enhance lesson planning, pedagogical decision-making, and reflective practice. However, the educational value of these tools depends largely on how effectively student-teachers utilise them in support of their professional development.

Recent studies on Artificial Intelligence in education have primarily focused on awareness, acceptance, attitudes, adoption, and perceptions of AI technologies among teachers and students. While these studies provide valuable insights into technology use, they offer limited evidence regarding the relationship between the use of GenAI tools and the pedagogical knowledge and teaching competencies expected of student-teachers during teaching practice. This gap is particularly evident in physics teacher education, where strong pedagogical content knowledge and effective classroom practice are critical for teaching abstract scientific concepts.

Despite the increasing use of GenAI tools in Nigerian universities, empirical studies examining the relationships among the use of GenAI tools, pedagogical content knowledge, and teaching practice performance among physics student-teachers remain scarce. Consequently, there is insufficient evidence to guide teacher education programmes in evaluating how GenAI tools contribute to the development of professional competence during school-based teaching practice. There is also limited information to inform the effective integration of these tools into teacher preparation programmes. Therefore, there is a need for empirical research that investigates the relationships among these variables within the context of physics teacher education.

III. PURPOSE OF THE STUDY

The purpose of this study was to examine the relationships among the utilisation of Generative Artificial Intelligence (GenAI) tools, pedagogical content knowledge, and perceived teaching practice performance of physics student-teachers during teaching practice in secondary schools. Specifically, the study sought to:

1. examine the relationships among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance of physics student-teachers;
2. determine the relationship between pedagogical content knowledge and perceived teaching practice performance of physics student-teachers; and
3. determine the extent to which the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge predict perceived teaching practice performance among physics student-teachers.

IV. RESEARCH QUESTIONS

The following research questions guided the study:

1. What relationships exist among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance of physics student-teachers?
2. What relationship exists between pedagogical content knowledge and perceived teaching practice performance of physics student-teachers?

3. To what extent do the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge predict perceived teaching practice performance among physics student-teachers?

Significance of the Study

The findings of this study could provide empirical evidence on the relationship between the utilisation of Generative Artificial Intelligence tools and the professional preparation of physics student-teachers. The results may assist teacher educators in understanding how GenAI tools can be effectively integrated into teacher education programmes to enhance pedagogical content knowledge and improve teaching practice experiences.

The study could also benefit curriculum developers by providing evidence-based insights to guide the integration of GenAI competencies into physics teacher education curricula. Such evidence may support the design of learning experiences that promote the responsible and effective use of emerging technologies in lesson planning, instruction, assessment, and reflective practice.

Furthermore, the findings could inform university administrators and educational policymakers in making decisions regarding investments in digital infrastructure, teacher training, and institutional policies that support the effective integration of Generative Artificial Intelligence into teacher preparation programmes. The study may also contribute to the development of guidelines for the ethical and responsible use of GenAI tools in educational settings.

For physics student-teachers, the insights gained from this study could enhance lesson preparation, instructional decision-making, classroom practice, and overall professional development. The findings may encourage student-teachers to utilise GenAI tools more purposefully, critically, and reflectively during teaching practice.

Finally, the study could serve as a valuable resource for researchers in the fields of Artificial Intelligence, teacher education, physics education, and educational technology. It would contribute to the growing body of knowledge on the relationships among GenAI utilisation, pedagogical content knowledge, and teaching practice performance within the Nigerian educational context.

V. LITERATURE REVIEW

Concept of Generative Artificial Intelligence

Generative Artificial Intelligence (GenAI) represents a significant advancement in Artificial Intelligence technologies, shifting the focus from analysing existing information to generating new content. Unlike traditional AI systems that are primarily designed for prediction, classification, or information retrieval, GenAI systems generate original outputs such as text, images, computer code, audio, and other digital content by identifying complex patterns within large datasets. Powered by advances in deep learning, natural language processing, and transformer architectures, these systems can interpret context, follow instructions, and produce coherent, human-like responses that closely resemble human-generated content (Henriksen, 2025).

GenAI has transformed the way individuals interact with intelligent technologies. Earlier educational technologies primarily functioned as repositories of information or automated support systems. In contrast, contemporary GenAI tools serve as dynamic collaborators that assist users in brainstorming ideas, solving problems, organising information, and refining written content or instructional materials. Consequently, technology has evolved from being merely a source of information to becoming an active partner in knowledge creation and professional practice. The increasing accessibility of these tools through user-friendly interfaces has further expanded their use among teachers, students, researchers, and professionals across diverse fields (Kolhatin, 2025).

Within education, GenAI has attracted significant attention because of its potential to support teaching, learning, and assessment. Teachers increasingly utilise these tools to develop lesson plans, instructional materials, classroom activities, assessment tasks, and personalised feedback. These applications can reduce the time spent on routine instructional tasks, allowing teachers to devote more attention to instruction, learner engagement, and educational improvement. Furthermore, Artificial Intelligence literacy is gradually being incorporated into teacher education programmes to prepare future teachers for technology-rich learning environments. These developments highlight the need for teacher preparation programmes to integrate the educational applications of GenAI as an emerging professional competency (Brandão, 2024; Tuncel, 2025).

The relevance of GenAI is particularly evident in science education, where effective teaching often requires multiple representations of complex concepts. Physics student-teachers frequently encounter subject matter that learners perceive as abstract and difficult to understand. GenAI tools can assist in generating alternative explanations, relevant analogies, classroom activities, and predictions of potential learner misconceptions. Such support enables student-teachers to explore different instructional approaches and continuously refine lesson preparation through interaction with AI-generated resources. Consequently, GenAI has the potential to enhance instructional planning and teaching practice experiences (Kolhatin, 2025).

However, the educational value of GenAI depends not only on its availability but also on the quality of its application. AI-generated outputs may contain inaccuracies, misinformation, bias, or content that is unsuitable for specific learning contexts. Therefore, teachers must critically evaluate, validate, and adapt AI-generated content before incorporating it into instruction. Responsibility for instructional decisions remains with the teacher rather than the technology. As a result, critical judgment remains an essential professional competency. Contemporary scholarship therefore views GenAI as a tool that supports and augments professional expertise rather than replacing it (Park, 2025).

Another important consideration is the broader implication of GenAI for education. Beyond enhancing instructional efficiency, GenAI has implications for learner engagement, teacher–student interaction, and professional competence. Consequently, integrating GenAI into teacher education requires more than technical proficiency; it also demands ethical awareness, responsible use, and sound pedagogical judgment. Preparing future teachers for effective GenAI use therefore requires the development of both digital competence and professional dispositions that enable technology to enhance rather than diminish meaningful learning experiences (Henriksen, 2025).

Although research continues to explore the instructional value of GenAI, relatively few studies have examined its relationship with professional learning outcomes among pre-service teachers. Existing studies have largely focused on the capabilities, opportunities, and challenges associated with the technology, while limited attention has been given to how patterns of GenAI use relate to pedagogical knowledge and classroom practice during teaching practice. This gap is particularly evident in physics teacher education within developing contexts, where the adoption of emerging technologies is increasing despite persistent inequalities in access to digital resources and structured AI training.

Pedagogical Content Knowledge

Pedagogical Content Knowledge (PCK) is widely recognised as one of the most important attributes of effective teaching because it enables teachers to make subject matter understandable to learners. The concept was introduced by Shulman (1986), who argued that mastery of subject content alone or general pedagogical knowledge alone is insufficient for effective teaching. Rather, teachers require a specialised form of knowledge that allows them to organise, represent, and communicate subject matter in ways that address students' prior knowledge, misconceptions, and learning needs. PCK therefore integrates content knowledge and pedagogical knowledge, enabling teachers to make informed instructional decisions that promote meaningful learning (Shulman, 1986; Melo, 2020).

In science education, PCK is particularly important because scientific concepts often involve abstract ideas that students find difficult to understand. Concepts such as force, electricity, motion, waves, and energy frequently conflict with learners' everyday experiences and intuitive beliefs. Effective teaching therefore requires knowledge of common misconceptions, the ability to select appropriate demonstrations and analogies, the logical sequencing of learning activities, and the use of suitable representations to communicate scientific ideas effectively. Teachers with strong pedagogical content knowledge are better able to anticipate learning difficulties and adapt their instruction to enhance student engagement and understanding (Hlaela, 2025; Marake, 2025).

Research suggests that the development of PCK is a gradual process that occurs through both formal instruction and classroom experience. While pre-service teachers acquire disciplinary knowledge through academic coursework, the transformation of this knowledge into effective classroom practice is often achieved through teaching practice, observation, reflection, and mentorship. Studies have shown that lesson study, video-based reflection, and structured metacognitive activities contribute significantly to the development of PCK by encouraging student-teachers to critically examine their instructional decisions and improve their teaching practices. These experiences help bridge the gap between theoretical preparation and classroom realities (Hlaela, 2025).

The educational context within which teachers are trained also influences the development of PCK. In many African countries, including Nigeria, teacher education often occurs within environments characterised by limited resources, overcrowded classrooms, and diverse learner populations. Under such conditions, teachers must adapt instructional approaches to local realities and curriculum expectations. Consequently, PCK extends beyond theoretical understanding to include contextual knowledge of teaching and learning. Developing pedagogical approaches that are responsive to local classroom realities has therefore become a major focus of science education research.

The increasing integration of technology into education has further expanded discussions surrounding PCK. Contemporary perspectives recognise that teachers must be able to incorporate digital tools into instructional planning and decision-making while maintaining instructional quality. One emerging technology supporting this process is Generative Artificial Intelligence. GenAI tools can assist teachers in generating lesson plans, alternative explanations, instructional materials, and potential learner misconceptions. These capabilities may broaden instructional possibilities and support reflective lesson preparation among student-teachers. Nevertheless, the effectiveness of such tools depends on teachers' ability to evaluate and adapt AI-generated content to align with curriculum objectives and learners' needs. Technology should therefore serve as a support for pedagogy rather than a substitute for it (Melo, 2020).

The relationship between GenAI utilisation and pedagogical content knowledge is particularly relevant for physics student-teachers during teaching practice. Effective classroom instruction requires continuous instructional decision-making regarding content representation, questioning techniques, demonstrations, learner engagement, and formative assessment. GenAI tools may provide access to diverse instructional resources and alternative explanations that support these decisions. However, successful integration requires professional judgment in selecting, adapting, and applying AI-generated content appropriately within classroom contexts. While technology can support instructional preparation, it cannot replace the specialised pedagogical knowledge required for effective physics teaching.

Despite extensive research on pedagogical content knowledge in teacher education, relatively little attention has been given to the relationship between emerging AI technologies and PCK development among physics student-teachers. Existing studies have largely focused on traditional approaches to PCK development, including mentoring, reflective practice, and classroom experience. Consequently, there remains limited evidence regarding the contribution of GenAI to pedagogical content knowledge development, particularly within the Nigerian context where AI integration into teacher education is still emerging. This gap highlights the need for further research into how GenAI may contribute to the professional competence of future physics teachers.

Teaching Practice Performance

Teaching practice is a critical component of teacher education programmes because it provides an opportunity for student-teachers to apply theoretical knowledge in authentic classroom settings. It involves demonstrating the professional competencies acquired during teacher preparation and is typically evaluated through lesson planning, instructional delivery, learner engagement, assessment practices, classroom management, and professional conduct. Teaching practice therefore serves as the point at which prospective teachers integrate subject matter knowledge, pedagogical skills, and classroom experiences under the guidance of teacher educators and cooperating teachers (Onyefulu, 2018).

Teaching practice performance serves as an important indicator of a student-teacher's readiness for professional teaching. Performance is typically assessed using structured observation instruments completed by university supervisors and cooperating teachers during school visits. These evaluations focus on lesson organisation, instructional clarity, learner interaction, use of teaching resources, classroom management, assessment strategies, and professional attitudes. High levels of teaching practice performance have been associated with greater instructional confidence, improved classroom effectiveness, and smoother transitions into the teaching profession (Adebola, 2022).

In physics education, effective teaching practice extends beyond mastery of subject content. Physics student-teachers are expected to communicate scientific concepts in ways that promote scientific reasoning, inquiry, and meaningful understanding among learners. This responsibility includes selecting appropriate instructional methods, designing practical activities, utilising instructional materials effectively, and addressing learners' misconceptions. Consequently, effective teaching practice in physics requires the integration of pedagogical content knowledge and practical classroom skills. Student-teachers who possess these competencies are more likely to promote learner engagement and improve students' understanding of scientific concepts (Onyefulu, 2018).

Several contextual and institutional factors influence teaching practice performance. Across many teacher education programmes in Africa and Nigeria, student-teachers often complete their school placements in environments characterised by large class sizes, inadequate instructional resources, limited laboratory facilities, and varying levels of supervisory support. These conditions can affect lesson planning, classroom interactions, instructional flexibility, and overall teaching effectiveness. Research has shown that factors such as supervision quality, opportunities for professional reflection, and alignment between university training and school experiences significantly influence teaching practice outcomes. Continuous mentoring and constructive feedback have been found to enhance instructional competence during teaching practice (Moosa, 2026; Adebola, 2022).

Research further indicates that structured preparation before school placement contributes positively to teaching practice performance. Activities such as microteaching, simulated classroom experiences, peer feedback, and reflective practice enable student-teachers to develop instructional skills before engaging with actual learners. These experiences strengthen lesson planning, classroom management, communication skills, and teaching confidence, thereby improving overall teaching effectiveness. Consequently, teacher education programmes increasingly emphasise experiential learning approaches that encourage ongoing reflection and professional growth.

The emergence of Generative Artificial Intelligence presents new opportunities for supporting teaching practice. GenAI tools can assist student-teachers in lesson planning, instructional material development, assessment design, and reflective evaluation of classroom experiences. These capabilities may enhance lesson quality, instructional organisation, and responsiveness to learners' needs. However, these benefits can only be realised when student-teachers critically evaluate AI-generated content and adapt it to specific subject matter, classroom contexts, and learning objectives. Thus, GenAI functions as a support tool rather than a substitute for pedagogical expertise.

Although the use of GenAI in education is expanding rapidly, empirical studies examining its relationship with teaching practice performance remain limited. Existing research has primarily focused on AI-supported lesson preparation, instructional innovation, and teacher development, with comparatively little attention given to how GenAI influences performance during school-based teaching practice. Within the context of physics teacher education in Nigeria, this gap underscores the need to investigate the relationship between GenAI utilisation and teaching practice performance. Such research can provide valuable insights into how emerging technologies contribute to the professional preparation and classroom effectiveness of future physics teachers.

VI. THEORETICAL FRAMEWORK

This study is anchored on the Technological Pedagogical Content Knowledge (TPACK) framework and supported by Social Cognitive Theory (SCT). Together, these theories provide a comprehensive framework for understanding the relationships among the utilisation of Generative Artificial Intelligence (GenAI) tools, pedagogical content knowledge, and teaching practice performance among physics student-teachers.

The TPACK framework, developed by Mishra and Koehler (2006), extends Shulman's concept of Pedagogical Content Knowledge (PCK) by incorporating technology as a critical component of effective teaching. The framework posits that successful technology integration requires the interaction of three forms of knowledge: content knowledge, pedagogical knowledge, and technological knowledge. At the centre of the framework is Technological Pedagogical Content Knowledge (TPACK), which represents the specialised knowledge required to effectively integrate technology into teaching and learning within a specific subject area. In the context of this study, the technological component is represented by the utilisation of Generative Artificial Intelligence tools, which have the potential to support physics student-teachers in developing their pedagogical content knowledge and enhancing their teaching practice performance (Mishra & Koehler, 2006).

Social Cognitive Theory (Bandura, 1986) complements the TPACK framework by explaining the psychological and environmental factors that influence learning and behaviour. The theory emphasises concepts such as self-efficacy, observational learning, and reciprocal determinism, which describe the dynamic interaction among personal factors, behaviour, and the environment. The use of Generative Artificial Intelligence tools during lesson preparation and classroom instruction may enhance student-teachers' self-efficacy by providing instructional support, feedback, and opportunities for reflection. Through positive learning experiences and exposure to AI-assisted instructional strategies, student-teachers may develop greater confidence in their teaching abilities, which can contribute to the development of pedagogical content knowledge and improved teaching practice performance.

The integration of TPACK and Social Cognitive Theory provides a holistic foundation for this study. While TPACK explains the knowledge domains required for effective technology integration in teaching, Social Cognitive Theory explains the personal and contextual processes through which student-teachers acquire and apply this knowledge during teaching practice. Together, these frameworks provide a basis for examining the relationships among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and teaching practice performance among physics student-teachers at Lagos State University.

VII. METHODOLOGY

This study adopted a correlational survey research design to examine the relationships among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance among physics student-teachers in secondary schools. The design was considered appropriate because it enabled the researcher to investigate the relationships among the study variables without manipulating them.

The study was conducted among physics student-teachers in the Department of Science and Technology Education, Lagos State University, Nigeria, who were undertaking their teaching practice programme. A simple random sampling technique was employed to select a sample of 50 student-teachers, thereby ensuring that every member of the population had an equal chance of being selected.

Data were collected using a researcher-developed questionnaire consisting of four sections. Section A collected demographic information from the respondents. Section B contained 10 items measuring the utilisation of Generative Artificial Intelligence tools across the domains of lesson planning and preparation, instructional content development, assessment and feedback, and professional learning and reflective practice. Section C comprised 10 items designed to assess pedagogical content knowledge across dimensions such as physics content knowledge, knowledge of learners, instructional strategies, curriculum knowledge, and assessment knowledge. Section D contained 10 items measuring perceived teaching practice performance in the areas of lesson planning, lesson delivery, classroom management, student engagement, assessment, and reflective practice. All items in Sections B, C, and D were rated on a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1).

The instrument was subjected to face and content validation by experts in Physics Education, Educational Technology, and Measurement and Evaluation to ensure that the items adequately measured the intended constructs. A pilot study was conducted among physics student-teachers in a university outside the study area to establish the reliability of the instrument. Internal consistency was determined using Cronbach's alpha coefficient. The reliability coefficients obtained were 0.79 for the Utilisation of Generative Artificial Intelligence Tools Scale, 0.81 for the Pedagogical Content Knowledge Scale, and 0.84 for the Perceived Teaching Practice Performance Scale, indicating that the instrument was reliable for data collection.

Prior to data collection, ethical approval and the necessary institutional permissions were obtained. The researcher personally administered the questionnaires to the selected respondents and retrieved them immediately after completion. The completed questionnaires were checked for completeness, coded, and analysed using the Statistical Package for the Social Sciences (SPSS) Version 27.

Both descriptive and inferential statistics were used to analyse the data. Mean and standard deviation were used to answer the research questions relating to the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance. Pearson Product-Moment Correlation was used to determine the relationships among the study variables. Multiple linear regression analysis was employed to determine the extent to which the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge predicted perceived teaching practice performance. All statistical analyses were conducted at the 0.05 level of significance.

VIII. RESULTS

Demographic Characteristics of the Respondents

The demographic characteristics of the respondents were analysed using frequency counts and percentages to provide an overview of the participants' profile. The variables considered were gender, previous training in Generative Artificial Intelligence, and the Generative Artificial Intelligence tool most frequently used by the respondents.

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Table 1: Demographic Characteristics of the Respondents (N = 50)

Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	14	28.0
	Female	36	72.0
Generative Artificial Intelligence Training	Yes	36	72.0
	No	14	28.0
Most Frequently Used Generative Artificial Intelligence Tool	ChatGPT	29	58.0
	Claude	9	18.0
	Gemini	5	10.0
	Microsoft Copilot	4	8.0
	Grok	3	6.0

As seen in Table 1, the majority of respondents were female (36, 72.0%) and the other 14 (28.0%) were male. With respect to previous training in Generative Artificial Intelligence, 36 (72.0%) of the respondents indicated that they had received training, whereas 14 (28.0%) had not. As far as the most commonly used GPTs are concerned, ChatGPT was the most widely used one, with 29 (58.0%) respondents using it. Claude was used by 9 (18.0%) respondents, Gemini by 5 (10.0%), Microsoft Copilot by 4 (8.0%), and Grok by 3 (6.0%) respondents. The results show that most of the physics student teachers were introduced to Generative Artificial Intelligence before their teaching practice and mainly utilized ChatGPT in their teaching practice.

Research Question One

What relationships exist among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance of physics student-teachers?

Pearson Product-Moment Correlation was used to examine the relationships among the three study variables. The results are presented in Table 2.

Table 2: Pearson Product-Moment Correlation Matrix Showing the Relationships among the Study Variables

Variables	Mean	SD	1	2	3
Utilisation of Generative Artificial Intelligence Tools	31.24	7.93	1		
Pedagogical Content Knowledge	28.04	6.16	.367**	1	
Perceived Teaching Practice Performance	35.55	5.86	.314*	.783**	1

As shown in Table 2, there was a positive relationship between the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge which was statistically significant ($r = .367$, $p < .005$). The results also showed a statistically significant correlation between the use of Generative Artificial Intelligence tools and the teacher's sense of competence in teaching practice ($r = .314$, $p < .005$). Moreover, the positive and strong correlation between pedagogical content knowledge and perceived teaching practice performance ($r = .783$, $p < .005$) could be seen as another support of the study. The findings indicated that they obtained higher scores in pedagogical content knowledge and in perceived teaching practice performance with increased use of tools of Generative Artificial Intelligence, and higher scores in pedagogical content knowledge were related to higher scores in perceived teaching practice performance.

Research Question Two

What relationship exists between pedagogical content knowledge and perceived teaching practice performance of physics student-teachers?

Pearson Product-Moment Correlation was employed to determine the relationship between pedagogical content knowledge and perceived teaching practice performance. The results are presented in Table 3.

Table 3: Pearson Product-Moment Correlation Showing the Relationship between Pedagogical Content Knowledge and Perceived Teaching Practice Performance

Variables	Mean	SD	1	2
Pedagogical Content Knowledge	28.04	6.16	1.000	
Perceived Teaching Practice Performance	35.55	5.86	.783**	1.000

Table 3 shows that there was a strong positive correlation between pedagogical content knowledge and perceived teaching practice performance ($r = .783$, $p < .001$). This probability value was less than 0.05 level of significance, which means that the relationship was statistically significant. The results suggest that among the physics student-teachers, the more developed ones in terms of PCK also had higher level of perceived teaching-practice performance.

Research Question Three
To what extent do the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge predict perceived teaching practice performance of physics student-teachers?

Multiple linear regression analysis was conducted to determine the joint predictive contributions of the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge to perceived teaching practice performance. The results are presented in Tables 4 and 5.

Table 4: Model Summary for the Prediction of Perceived Teaching Practice Performance

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change
.783[a]	.614	.597	3.72350	.614	36.509

Table 5: Regression Coefficients Showing the Contributions of the Predictor Variables to Perceived Teaching Practice Performance

SUMMARY REGRESSION ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1012.357	2	506.179	36.509	.000[b]
Residual	637.765	46	13.864		
Total	1650.122	48			

Table 4 revealed that the multiple correlation coefficient was .783 which indicated the teaching practice performance to be in a strong relationship with the predictor variables. The coefficient of determination ($R^2 = .614$) shows that the combination of the use of Generative Artificial Intelligence tools and pedagogical content knowledge led to an explanation of 61.4% of the variance of the performance of the teaching practices perceived by the participants. The overall effect of the regression model was statistically significant ($F(2, 46) = 36.509$, $p < .001$) such that the predictor variables as a group accounted for a significant amount of the variation in perceived teaching practice performance.

The analysis of variance for the regression model is given in Table 5. This result indicates that the regression model is statistically significant ($F(2, 46) = 36.509$, $p < .001$). Together the use of Generative Artificial Intelligence tools and pedagogical content knowledge had a strong impact on predicting perceived physics student-teacher performance in teaching. The regression model also seemed to predict perceived teaching practice performance significantly better than a model lacking the predictor variables.

IX. DISCUSSION

This study examined the relationships among the utilisation of Generative Artificial Intelligence (GenAI) tools, pedagogical content knowledge (PCK), and perceived teaching practice performance among physics student-teachers in secondary schools. The findings revealed significant positive relationships among the three variables, although the strength of the relationships varied. Specifically, the utilisation of GenAI tools was positively associated with both pedagogical content knowledge and perceived teaching practice performance, while pedagogical content knowledge demonstrated the strongest relationship with perceived teaching practice performance.

The findings revealed a significant positive relationship between the utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge. This suggests that physics student-teachers who reported greater use of GenAI tools also reported higher levels of pedagogical content knowledge. The finding supports the view that GenAI can serve as an instructional support tool by assisting student-teachers in lesson planning, instructional material development, explanation of complex concepts, and the exploration of alternative teaching strategies. Through these functions, GenAI may provide opportunities for student-teachers to strengthen the pedagogical knowledge required for effective classroom instruction. This finding is consistent with previous studies that reported positive associations between the use of GenAI tools and improvements in instructional preparation, professional learning, and teaching competence (Brandão, 2024; Tuncel, 2025; Henriksen, 2025).

The study also found a significant positive relationship between the utilisation of Generative Artificial Intelligence tools and perceived teaching practice performance. This result indicates that student-teachers who made greater use of GenAI tools tended to report better teaching practice performance. The use of AI applications for lesson preparation, instructional activities, assessment design, and reflective practice may have enhanced their confidence, preparedness, and effectiveness in the classroom. However, the relatively modest strength of the relationship suggests that GenAI utilisation alone cannot fully explain variations in teaching practice performance. Teaching practice performance is a multidimensional construct influenced by several factors, including pedagogical competence, teaching experience, institutional support, and classroom conditions.

One of the most significant findings of the study was the strong positive relationship between pedagogical content knowledge and perceived teaching practice performance. The results indicate that student-teachers with higher levels of pedagogical content knowledge tended to report higher levels of teaching practice performance. This finding supports Shulman's (1986) proposition that effective teaching requires the integration of subject matter knowledge and pedagogical expertise. During teaching practice, student-teachers are required to translate theoretical knowledge into classroom instruction, address learners' misconceptions, select appropriate teaching strategies, and assess learners' understanding. Consequently, stronger pedagogical content knowledge is likely to translate into improved classroom performance. This finding aligns with previous studies that identified pedagogical content knowledge as a key determinant of teaching quality and professional competence (Shulman, 1986; Melo, 2020; Hlaela, 2025).

The regression analysis further revealed that the combined effects of Generative Artificial Intelligence tool utilisation and pedagogical content knowledge accounted for a significant proportion of the variance in perceived teaching practice performance. However, when the individual contributions of the predictor variables were examined, only pedagogical content knowledge emerged as a statistically significant predictor. Although GenAI utilisation was positively associated with teaching practice performance, its independent contribution was not significant when pedagogical content knowledge was considered. This finding suggests that the educational benefits of GenAI are largely dependent on the pedagogical competence of the user. Student-teachers with strong pedagogical content knowledge may be better positioned to evaluate, adapt, and integrate AI-generated content into effective classroom instruction.

Overall, the findings suggest that the integration of Generative Artificial Intelligence into teacher education should complement rather than replace the development of pedagogical knowledge and professional teaching skills. The educational potential of GenAI is likely to be maximised when it is embedded within teacher preparation programmes that emphasise instructional design, critical evaluation of AI-generated outputs, and reflective teaching practice.

X. CONCLUSION

This study investigated the relationships among the utilisation of Generative Artificial Intelligence tools, pedagogical content knowledge, and perceived teaching practice performance among physics student-teachers during teaching practice in secondary schools. The findings revealed significant positive relationships between the utilisation of Generative Artificial Intelligence tools and both pedagogical content knowledge and perceived teaching practice performance. The study also found a strong positive relationship between pedagogical content knowledge and perceived teaching practice performance.

Furthermore, the combined utilisation of Generative Artificial Intelligence tools and pedagogical content knowledge accounted for a significant proportion of the variance in perceived teaching practice performance. However, pedagogical content knowledge emerged as the only significant predictor of teaching practice performance. This finding highlights the central role of pedagogical competence in effective teaching and learning.

The study therefore concludes that while Generative Artificial Intelligence has considerable potential to support lesson planning, instructional delivery, assessment, and reflective practice, its effectiveness depends largely on the pedagogical expertise of the teacher. Consequently, efforts to integrate GenAI into teacher education should be accompanied by deliberate strategies aimed at strengthening the pedagogical content knowledge of physics student-teachers. Such an approach would ensure that emerging technologies are used effectively to enhance teaching and learning outcomes.

XI. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Teacher education institutions should integrate the educational applications of Generative Artificial Intelligence tools into physics teacher education programmes through structured training that promotes responsible, ethical, and pedagogically appropriate use.
2. Physics teacher education programmes should strengthen learning experiences that enhance pedagogical content knowledge, enabling student-teachers to effectively utilise Generative Artificial Intelligence tools for lesson planning, instructional delivery, assessment, and reflective practice.
3. Universities should organise regular workshops, seminars, and professional development programmes to improve student-teachers' ability to critically evaluate, adapt, and effectively utilise AI-generated instructional materials.
4. Student-teachers should be encouraged to use Generative Artificial Intelligence tools as instructional support resources rather than substitutes for professional judgment, critical thinking, and pedagogical decision-making.
5. Curriculum developers and educational policymakers should establish institutional guidelines and policies that promote the ethical, responsible, and effective integration of Generative Artificial Intelligence into teacher preparation programmes.

XII. LIMITATIONS OF THE STUDY

This study was conducted among physics student-teachers in the Department of Science and Technology Education, Lagos State University. Consequently, the findings may not be generalisable to student-teachers in other universities or teacher education programmes operating under different institutional contexts.

The study adopted a correlational survey research design, which examined relationships among variables without establishing causal relationships. Therefore, the findings should be interpreted as evidence of association rather than causation.
Data were collected through self-reported questionnaires, which may be subject to response biases such as social desirability bias and variations in respondents' perceptions of their pedagogical competence and teaching practice performance.

Finally, the sample size of 50 participants was relatively small, which may have limited the statistical power of the analyses and the generalisability of the findings. Future studies should involve larger and more diverse samples drawn from multiple institutions to provide stronger evidence regarding the role of Generative Artificial Intelligence in physics teacher education.

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