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Examining the Generic Pedagogical Content Knowledge of Mathematics Education Teachers at C. K. Tedam University of Technology and Applied Sciences, Ghana

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Abstract

The study examined the generic pedagogical content knowledge (GPCK) of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences (CKTUTAS). Using a descriptive survey design, data were collected from 98 undergraduate and postgraduate mathematics education students through a structured questionnaire. Descriptive statistics were employed to assess participants' levels of GPCK, while correlation and independent t-tests were used to analyze relationships and demographic variations. The results showed that teachers demonstrated moderate knowledge of students' understanding but low knowledge of instructional practices. A significant positive correlation was found between the two components of GPCK, indicating their interdependent nature. No significant differences in GPCK were observed across gender or educational level. These findings suggest that weaknesses in pedagogical knowledge are widespread and not tied to demographic factors. The study recommends that teacher education programs integrate more practice-based learning to strengthen instructional skills. Policy initiatives by the Ministry of Education and the Ghana Education Service should prioritize professional development programs that enhance teachers' instructional competence. Limitations of the study include its reliance on self-reported data from a single university, suggesting the need for larger and mixed-methods studies. The study contributes to the discourse on mathematics teacher preparation and provides evidence to guide reforms in mathematics education in Ghana.

Keywords: pedagogical content knowledge, mathematics education, teacher education, instructional practices, student understanding

Introduction

The effectiveness of mathematics teaching is strongly influenced by teachers' ability to connect subject matter knowledge with appropriate instructional strategies. Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) highlights this integration, noting that effective teaching requires not only mastery of the content but also an understanding of how students learn and how concepts can be represented. In mathematics education, this blend of knowledge is particularly important because abstract ideas often challenge learners, requiring teachers to transform content into forms that are accessible and meaningful (Ball, Thames, & Phelps, 2008).

Generic Pedagogical Content Knowledge (GPCK) represents teachers' general capacity to organize instruction,

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interpret students' difficulties, and select appropriate strategies across mathematics topics (Grossman, 1990). Unlike topic-specific PCK, which focuses on teaching particular concepts, GPCK provides a broad foundation for instructional decision-making. Research suggests that teachers with strong GPCK are better able to identify misconceptions, adapt their methods to learners' needs, and create supportive learning environments (Depaepe, Verschaffel, & Kelchtermans, 2013).

Despite the significance of GPCK, evidence from sub-Saharan Africa shows that pre-service and in-service teachers often display weaknesses in instructional knowledge and in recognizing student thinking (Tatto et al., 2012; Ayebo & Assuah, 2017). In Ghana, studies have primarily emphasized content knowledge or general teaching practices, with relatively little empirical attention on GPCK in mathematics education programs. This creates a gap, as teacher preparation programs are expected to develop future educators with both sound content knowledge and effective pedagogy.

This paper draws on data from C. K. Tedam University of Technology and Applied Sciences (CKTUTAS) to examine the GPCK of mathematics education students and teachers-in-training. The analysis focuses on their knowledge of instructional practices and understanding of students' learning processes, providing insights into their preparedness to teach mathematics effectively.

Methods

Research Design

This study employed a descriptive survey design, which is suitable for capturing and analysing the current status of teachers' pedagogical content knowledge (Creswell & Creswell, 2018). The approach enabled the researcher to quantify participants' levels of GPCK and explore relationships among its components.

Participants

The study involved 98 mathematics education students from CKTUTAS, comprising both undergraduate and postgraduate cohorts. Participants were selected using purposive and simple random sampling techniques to ensure representation across levels of study. The group included individuals at different stages of teacher education, thereby reflecting the variation in exposure to pedagogical training and classroom practice.

Instrumentation

A structured questionnaire was developed to assess the respondents' GPCK. The instrument focused on two dimensions: knowledge of instructional strategies and knowledge of students' understanding in mathematics. Items were adapted from existing frameworks on PCK (Hill, Ball, & Schilling, 2008; Mavhunga & Rollnick, 2013) and contextualized for the Ghanaian educational setting. Respondents rated their agreement with statements on a Likert scale, which allowed for

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quantitative analysis of their pedagogical knowledge.

Data Collection Procedure

Data were collected through in-person administration of the questionnaires at the university. Participation was voluntary, and respondents were assured of confidentiality. The researcher sought approval from the relevant university authorities and obtained informed consent from participants before data collection.

Data Analysis

Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics such as means and standard deviations were used to summarize the overall levels of GPCK. Inferential analyses, including correlation tests, were conducted to examine the interaction between teachers' knowledge of instructional practices and their knowledge of student understanding. These analyses helped establish the strength and direction of relationships among the GPCK components.

Results

Demographic Characteristics of Respondents

Table 1

Demographic Distribution of Respondents (N = 98)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	62	63.3
	Female	36	36.7
Age	20–25 years	42	42.9
	26–30 years	38	38.8
	31 years & above	18	18.3
Educational Level	Undergraduate	54	55.1
	Postgraduate	44	44.9

Analysis of Demographic Data

As shown in Table 1, the study sample comprised 98 mathematics education students. Male respondents (63.3%) were more represented than females (36.7%). This distribution reflects the broader gender imbalance often reported in mathematics-related programs in Ghana (Anamuah-Mensah, 2020).

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The majority of participants were within the age groups of 20–25 years (42.9%) and 26–30 years (38.8%). Only 18.3% were 31 years and above, suggesting that most respondents were young adults in the early stages of their teaching careers.

With respect to educational level, slightly more than half (55.1%) were undergraduates, while 44.9% were postgraduate students. This balance provided the opportunity to compare pre-service teachers at different stages of professional development.

Table 2

Generic Pedagogical Content Knowledge of Teachers (N = 98)

GPCK Dimension	**Mean (M)**	**Std. Dev. (SD)**	**Interpretation**
Knowledge of Students' Understanding	3.12	0.78	Moderate
Knowledge of Instructional Practices	2.48	0.65	Low
Overall GPCK	2.80	0.72	Moderate

The results in Table 2 indicate that participants demonstrated a moderate level of knowledge regarding students' understanding (M = 3.12, SD = 0.78). This suggests that most respondents could recognize common student errors and misconceptions in mathematics. However, their knowledge of instructional practices (M = 2.48, SD = 0.65) was rated low, highlighting challenges in selecting effective strategies to enhance learning. The overall GPCK mean of 2.80 reflects a moderate level of pedagogical competence. These findings imply that while student teachers are relatively aware of how learners process mathematics, they may struggle to design and implement effective instructional methods, a weakness also reported in previous studies (Hill et al., 2008; Tatto et al., 2012).

Table 3

Correlation between Teachers' Knowledge of Students' Understanding and Instructional Practices

Variable	**1**	**2**
1. Knowledge of Students' Understanding	1	
2. Knowledge of Instructional Practices	.42**	1

Note. p < .01

As presented in Table 3, there was a significant positive correlation (r = .42, p < .01) between teachers' knowledge of students' understanding and their knowledge of instructional practices. This finding indicates that the more teachers understood students' learning processes, the better they were at applying suitable instructional

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approaches. The relationship emphasizes the interdependence of the two GPCK components, suggesting that strengthening one area could positively influence the other.

Table 4
Independent t-Test of Differences in GPCK by Gender and Educational Level

Variable	Category	Mean (M)	t-value	p-value
Gender	Male	2.81	0.62	.54
	Female	2.78		
Educational Level	Undergraduate	2.77	0.84	.40
	Postgraduate	2.83		

The results in Table 4 show no statistically significant difference in GPCK based on gender ($t = 0.62$, $p = .54$) or educational level ($t = 0.84$, $p = .40$). Both male and female teachers, as well as undergraduates and postgraduates, demonstrated similar levels of generic pedagogical content knowledge. This suggests that GPCK development is not strongly influenced by demographic factors but may instead depend more on the quality of instructional training and teaching practice opportunities available to students.

Discussion

The purpose of this study was to examine the generic pedagogical content knowledge (GPCK) of mathematics education teachers at CKTUTAS. The findings provide important insights into the strengths and weaknesses of pre-service teachers as they prepare to enter the teaching profession. Results showed that respondents demonstrated a moderate level of knowledge in understanding students' learning processes but a low level of knowledge of instructional practices. This outcome is consistent with earlier research suggesting that teacher trainees often recognize student misconceptions more easily than they are able to design and implement strategies to address them effectively (Hill, Ball, & Schilling, 2008; Tatto et al., 2012). Such results may indicate that teacher education programs emphasize diagnosing learning difficulties but give less practical preparation in classroom delivery.

The positive correlation between knowledge of students' understanding and knowledge of instructional practices underscores the interdependence of the two GPCK components. Teachers who have a deeper grasp of how learners construct mathematical knowledge are better positioned to adopt instructional methods that foster comprehension. This aligns with Shulman's (1986) original conception of pedagogical content knowledge as the blending of content knowledge with pedagogy in ways that make concepts accessible. It also resonates with Grossman's (1990) argument that PCK is not compartmentalized but consists of interacting domains that collectively shape teaching practice. Strengthening

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one dimension, such as knowledge of student thinking, may therefore have positive spillover effects on the development of instructional practices.

The absence of significant differences in GPCK based on gender and educational level suggests that weaknesses in pedagogical knowledge are not unique to specific groups but are widespread among mathematics teacher trainees. Similar findings have been reported in other contexts, where socio-demographic characteristics have not consistently explained variations in PCK (Depaepe, Verschaffel, & Kelchtermans, 2013). This outcome suggests that interventions to strengthen GPCK should be systemic rather than targeted. Both undergraduate and postgraduate programs should be restructured to ensure that pre-service teachers engage in more practice-based and reflective experiences that enhance their instructional competence. As Ball, Thames, and Phelps (2008) emphasized, teacher education needs to move beyond content mastery to deliberate cultivation of mathematical knowledge for teaching, including the practical dimension of instructional decision-making.

From a policy perspective, the findings highlight the need for the Ministry of Education and the Ghana Education Service to design professional development initiatives that specifically focus on instructional practices in mathematics. In-service workshops, mentoring schemes, and closer university-school partnerships could help teacher trainees translate theoretical insights into classroom practice. Sustained training programs of this nature have been shown to improve teachers' ability to integrate knowledge of content and pedagogy in mathematics education (Mavhunga & Rollnick, 2013). Such initiatives will not only support teacher readiness but also contribute to improving students' achievement in mathematics at the national level.

This study, however, is not without limitations. Data were collected from a single university, which restricts the generalizability of the results. The exclusive reliance on quantitative self-report questionnaires may also limit the depth of insights into participants' actual classroom practices, as responses may be influenced by social desirability bias. Future research could adopt a mixed-methods approach, incorporating interviews and lesson observations to triangulate findings. Finally, while the sample size of 98 was sufficient for the analysis conducted, larger and more diverse samples across institutions would strengthen the external validity of the conclusions.

Conclusion

This study examined the generic pedagogical content knowledge of mathematics education teachers at CKTUTAS, focusing on their knowledge of students' understanding and instructional practices. The findings revealed that while respondents demonstrated a moderate ability to identify learners' misconceptions, their knowledge of instructional practices was limited. The significant correlation between these two components highlights the importance of developing them in tandem, as awareness of student

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learning processes directly informs the selection of effective teaching strategies.

The lack of significant variation in GPCK across gender and educational level indicates that deficiencies in pedagogical knowledge are common among teacher trainees, regardless of their demographic background. This underscores the need for systemic improvements in mathematics teacher education rather than isolated interventions. Teacher preparation programs should therefore integrate more practice-based training and reflective experiences that explicitly link student thinking with instructional strategies.

At the policy level, professional development efforts by the Ministry of Education and the Ghana Education Service should prioritize enhancing instructional competence among both pre-service and in-service teachers. Collaborative initiatives between universities and schools, as well as continuous mentorship, can provide sustained support in bridging the gap between theoretical knowledge and classroom practice. Addressing these gaps is essential not only for improving teacher readiness but also for raising the overall quality of mathematics education and student outcomes in Ghana.

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