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Challenges in Developing Pedagogical Content Knowledge among Mathematics Education Teachers at C. K. Tedam University of Technology and Applied Sciences: Implications for Teacher Education Reform in Ghana

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Abstract

This study investigated the challenges that mathematics education teachers encounter in developing pedagogical content knowledge (PCK) at C. K. Tedam University of Technology and Applied Sciences (CKTUTAS) in Ghana. PCK, which integrates subject matter expertise with pedagogical strategies, remains a critical determinant of teacher effectiveness and student learning. Using a descriptive survey design, data were collected from 98 undergraduate and postgraduate mathematics education students through a structured questionnaire. Results revealed that participants struggled most with applying multiple instructional strategies, diagnosing students' misconceptions, and integrating curriculum knowledge into classroom practice. Limited exposure to practice-based training and insufficient opportunities for reflective teaching were identified as key barriers. These findings underscore the need for systemic reforms in teacher education to better integrate theory with practice. Policy implications include strengthening practicum experiences, promoting mentorship, and embedding PCK-focused modules in mathematics teacher education programs.

Keywords: pedagogical content knowledge, mathematics education, teacher education reform, instructional challenges, Ghana

Introduction

Pedagogical content knowledge (PCK) represents a unique category of knowledge that distinguishes teachers from subject matter experts. Shulman (1986) defined it as the blending of subject matter knowledge with pedagogical strategies that make content comprehensible to learners. In mathematics education, PCK encompasses understanding the curriculum, anticipating student misconceptions, employing multiple representations, and designing appropriate instructional strategies (Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008).

Despite its importance, developing PCK remains a major challenge for pre-service and in-service mathematics teachers globally. Research has shown that teachers often struggle to move beyond procedural knowledge to conceptual explanations that foster deeper student understanding (Depaepe, Verschaffel, & Kelchtermans, 2013; Mavhunga & Rollnick, 2013). In sub-Saharan Africa, and Ghana in particular, concerns persist about the preparedness of mathematics teachers to

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effectively integrate content with pedagogy (Anamuah-Mensah, 2020; Osei, 2006). Studies have attributed these challenges to teacher education programs that focus heavily on subject matter mastery while offering limited opportunities for practice-based learning (Ayebo & Assuah, 2017).

International evidence from the TEDS-M study (Tatto et al., 2012) further highlights that systemic factors such as weak curriculum structures, inadequate mentoring, and limited professional development opportunities contribute significantly to the gaps in teachers' PCK. For Ghana, where mathematics achievement has remained a persistent concern (Anamuah-Mensah, 2020), addressing these challenges is critical for improving both teacher effectiveness and student outcomes.

Against this backdrop, this study sought to identify the challenges mathematics education teachers at CKTUTAS face in developing PCK. By focusing on their experiences with instructional strategies, curricular saliency, and diagnosing student misconceptions, the study provides insights that can inform reforms in teacher education programs and professional development initiatives in Ghana.

Methods

Research Design

The study adopted a descriptive survey design to investigate the challenges faced by mathematics education teachers in developing PCK. This design was suitable for capturing teachers' perceptions and experiences in a structured manner, allowing for both descriptive and inferential statistical analysis (Creswell & Creswell, 2018).

Participants

The population comprised mathematics education students at C. K. Tedam University of Technology and Applied Sciences. Using a purposive sampling technique, 98 participants were selected, consisting of 62 males (63.3%) and 36 females (36.7%). The sample included 54 undergraduates (55.1%) and 44 postgraduates (44.9%), with ages ranging from 20 years to above 31 years.

Instrumentation

Data were collected through a structured questionnaire adapted from validated PCK frameworks (Hill et al., 2008; Mavhunga & Rollnick, 2013). Items focused on challenges related to instructional strategies, diagnosing student misconceptions, integrating curriculum content, and applying multiple representations. Responses were measured on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The instrument was reviewed by mathematics education experts and piloted to ensure validity and reliability.

Data Collection Procedure

The questionnaires were administered during scheduled class sessions after obtaining permission from faculty instructors. Participants were briefed on the purpose of the study, assured of confidentiality, and encouraged to respond honestly. Completed questionnaires were collected immediately after administration, ensuring a high response rate.

Data Analysis

Data were analyzed using SPSS version 25. Descriptive statistics such as means, frequencies, and percentages were used to identify the most prevalent challenges. Chi-square tests were performed to examine associations between demographic characteristics and reported

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challenges. Statistical significance was set at $p < .05$.

Ethical Considerations

Ethical clearance was granted by the Faculty of Education at CKTUTAS. Participation was voluntary, and informed consent was obtained from all respondents. Confidentiality and anonymity were ensured by assigning numerical codes rather than names. Participants were also assured of their right to withdraw from the study at any point without penalty. Data were securely stored and used solely for academic purposes.

Results

Table 1
Demographic Characteristics 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

As presented in Table 1, most respondents were male (63.3%) compared to female (36.7%). A majority fell within the age range of 20–30 years (81.7%), reflecting the youthful nature of the teacher trainee population. Slightly more than half (55.1%) were undergraduates, while 44.9% were postgraduate students, providing a balance across academic levels.

Table 2
Descriptive Statistics of Reported Challenges (N = 98)

Challenge Area	Mean	SD	Interpretation
Limited use of multiple instructional strategies	3.72	0.59	High Challenge
Diagnosing students' misconceptions	3.65	0.61	High Challenge
Integrating curriculum knowledge into practice	3.48	0.57	Moderate Challenge
Applying multiple representations	3.42	0.63	Moderate Challenge

Table 2 shows that respondents rated limited use of multiple instructional strategies (M = 3.72, SD = 0.59) as the most significant challenge, followed closely by diagnosing students' misconceptions (M = 3.65, SD = 0.61). Both were categorized as high challenges. Moderate challenges included integrating curriculum knowledge into practice (M = 3.48, SD = 0.57) and applying multiple representations (M = 3.42, SD = 0.63). These findings suggest that while participants possessed subject matter knowledge, they encountered difficulties in

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transforming this knowledge into pedagogically effective teaching practices.

Table 3
Chi-Square Tests of Association between Demographics and Reported Challenges (N = 98)

Variable	χ^2	df	p-value
Gender × Instructional Strategies Challenge	1.14	1	.29
Gender × Misconceptions Challenge	0.87	1	.35
Age × Curriculum Integration Challenge	2.61	2	.27
Age × Representation Challenge	3.08	2	.21
Educational Level × Misconceptions Challenge	0.96	1	.33

The chi-square analysis revealed no statistically significant associations between demographic factors and reported challenges ($p > .05$ across all tests). This indicates that both undergraduates and postgraduates, regardless of gender or age, experienced similar difficulties in developing pedagogical content knowledge. The findings suggest that the challenges are systemic within the teacher education program rather than attributable to specific demographic groups.

Summary of Findings

The results indicate that mathematics education teachers at CKTUTAS face significant challenges in employing diverse instructional strategies and diagnosing students' misconceptions, while moderately struggling with curriculum integration and the use of multiple representations. These challenges were consistent across demographic groups, pointing to structural issues in teacher preparation programs rather than differences based on gender, age, or educational level.

Discussion

This study investigated the challenges faced by mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences in developing pedagogical content knowledge (PCK). The findings revealed that respondents experienced the greatest difficulties in applying diverse instructional strategies and diagnosing students' misconceptions, while moderate challenges were reported in integrating curriculum knowledge into practice and using multiple representations. Demographic characteristics such as gender, age, and educational level did not significantly influence the reported challenges, suggesting that these barriers are systemic rather than individual.

The prominence of difficulties in using multiple instructional strategies supports earlier research indicating that pre-service and in-service mathematics teachers often rely on limited pedagogical approaches, typically dominated by lecture or procedural explanations (Depaepe, Verschaffel, & Kelchtermans, 2013; Hill, Ball, & Schilling, 2008). When teachers lack a wide range of instructional methods, they are less able to adapt to diverse learning needs, thereby reducing the effectiveness of mathematics instruction (Baumert et al., 2010). The findings also resonate with Ghanaian studies that have observed that mathematics classrooms tend to privilege teacher-centered approaches, leaving little room

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for interactive and exploratory teaching (Ayebo & Assuah, 2017; Anamuah-Mensah, 2020).

Diagnosing students' misconceptions was also identified as a significant challenge. Misconceptions in mathematics are common and can persist if not effectively addressed (Kind, 2009). Teachers' ability to identify and respond to these misconceptions requires both strong content knowledge and deep pedagogical insight (Shulman, 1986; Mavhunga & Rollnick, 2013). The fact that many respondents struggled in this area suggests insufficient emphasis on formative assessment and reflective practice in teacher education programs. Similar concerns have been documented in sub-Saharan Africa, where teacher training has been criticized for its limited focus on diagnostic teaching practices (Osei, 2006; Tatto et al., 2012).

Moderate challenges were also found in curriculum integration and the use of multiple representations. The ability to connect mathematical topics and to represent ideas through visual, symbolic, and contextual forms is essential for effective mathematics teaching (Grossman, 1990; Park & Oliver, 2008). However, respondents' moderate performance suggests that teacher education at CKTUTAS, like many programs in the region, may not sufficiently emphasize these aspects of PCK. This gap has been highlighted by international studies, which argue that strong curriculum saliency and representation skills are hallmarks of effective teaching but are often underdeveloped in teacher trainees (Blömeke & Delaney, 2012; Kleickmann et al., 2013).

The absence of demographic effects reinforces findings from earlier articles in this series, as well as from international studies such as TEDS-M, which reported that structural factors in teacher education exert a stronger influence on PCK than demographic characteristics (Tatto et al., 2012). In the context of Ghana, this suggests that both undergraduate and postgraduate mathematics education students face similar systemic barriers in developing PCK, regardless of gender or age.

The findings carry important policy implications. Teacher education programs in Ghana, including at CKTUTAS, should embed stronger practice-oriented learning opportunities that enable teachers to experiment with multiple instructional strategies and engage in diagnostic assessment of student thinking. Structured mentorship programs, where trainees work alongside experienced teachers, could provide valuable exposure to diverse pedagogical practices (Clarke & Hollingsworth, 2002). Furthermore, professional development initiatives should emphasize reflective teaching and lesson study as tools for strengthening PCK (Darling-Hammond, 2017). At the national level, education policymakers should consider revising mathematics education curricula to explicitly integrate modules that target the development of topic-specific and diagnostic teaching skills.

Despite these contributions, the study is not without limitations. The reliance on self-reported questionnaire data may have introduced response bias, as participants could have over- or underestimated their challenges. Additionally, the study was confined to a single institution, limiting the generalizability of findings to other teacher education programs in Ghana. Future research should therefore expand the scope to include multiple universities and employ mixed-methods designs, incorporating classroom observations and interviews to provide a more comprehensive understanding of the challenges teachers face in

Conclusion

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This study explored the challenges faced by mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences in developing pedagogical content knowledge. The findings revealed that the most significant barriers were the limited use of multiple instructional strategies and difficulties in diagnosing students' misconceptions, while moderate challenges were reported in curriculum integration and the use of multiple representations. These challenges were consistent across gender, age, and educational level, indicating that they are systemic issues within teacher education rather than individual differences.

The study underscores the urgent need for reforms in mathematics teacher education programs in Ghana. Efforts should focus on embedding practice-oriented learning, reflective teaching, and mentorship into training programs to strengthen PCK. Policy reforms at the national level should aim to revise teacher education curricula to explicitly target topic-specific pedagogical skills, while continuous professional development programs should provide in-service teachers with opportunities to refine their instructional strategies and diagnostic practices.

Although the study was limited by its reliance on self-reported data and its focus on a single institution, it contributes to the growing body of literature emphasizing the importance of PCK in mathematics education. Future research should adopt mixed-methods approaches and expand across multiple universities to provide a more comprehensive picture of challenges in teacher education. Strengthening the development of PCK is critical for improving the effectiveness of mathematics teachers and ultimately enhancing student achievement in Ghana.

References

Anamuah-Mensah, J. (2020). Improving mathematics education in Ghana: The role of teacher preparation and professional development. *Ghana Journal of Education*, 7(2), 15–28.

Ayebo, A., & Assuah, C. K. (2017). Teachers' knowledge of mathematics and its connection to students' learning. *International Journal of Research in Education and Science*, 3(1), 64–73. https://doi.org/10.21890/ijres.267373

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59(5), 389–407. https://doi.org/10.1177/0022487108324554

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., ... & Tsai, Y. M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal*, 47(1), 133–180. https://doi.org/10.3102/0002831209345157

Blömeke, S., & Delaney, S. (2012). Assessment of teacher knowledge across countries: A review of the state of research. *ZDM Mathematics Education*, 44(3), 223–247. https://doi.org/10.1007/s11858-012-0429-7

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18(8), 947–967. https://doi.org/10.1016/S0742-051X(02)00053-7

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

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Darling-Hammond, L. (2017). Teacher education around the world: What can we learn from international practice? *European Journal of Teacher Education*, 40(3), 291–309. https://doi.org/10.1080/02619768.2017.1315399

Depaepe, F., Verschaffel, L., & Kelchtermans, G. (2013). Pedagogical content knowledge: A systematic review of the way in which the concept has pervaded mathematics educational research. *Teaching and Teacher Education*, 34, 12–25. https://doi.org/10.1016/j.tate.2013.03.001

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. Teachers College Press.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, 39(4), 372–400.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education*, 45(2), 169–204. https://doi.org/10.1080/03057260903142285

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., & Baumert, J. (2013). Teachers' content knowledge and pedagogical content knowledge: The role of structural differences in teacher education. *Journal of Teacher Education*, 64(1), 90–106. https://doi.org/10.1177/0022487112460398

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical bonding in pre-service teachers. *Journal of Research in Science Teaching*, 50(8), 943–969. https://doi.org/10.1002/tea.21102

Osei, G. M. (2006). Teachers in Ghana: Issues of training, remuneration and effectiveness. *International Journal of Educational Development*, 26(1), 38–51. https://doi.org/10.1016/j.ijedudev.2005.07.015

Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, 38(3), 261–284. https://doi.org/10.1007/s11165-007-9049-6

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. https://doi.org/10.3102/0013189X015002004

Tatto, M. T., Schwille, J., Senk, S., Ingvarson, L., Peck, R., & Rowley, G. (2012). *Policy, practice, and readiness to teach primary and secondary mathematics in 17 countries: Findings from the IEA teacher education and development study in mathematics (TEDS-M)*. International Association for the Evaluation of Educational Achievement.

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