Interdisciplinary Journal of the African Alliance for Research, Advocacy & Innovation

ISSN (O): 3093-4664

Vol.1, Issue 3 | Oct–Dec 2025

www.ijaarai.com

Socio-Educational Demographics and Variations in Pedagogical Content Knowledge of Mathematics Education Teachers at C. K. Tedam University of Technology and Applied Sciences, Ghana

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Abstract

This study investigated the influence of socio-educational demographics on the pedagogical content knowledge (PCK) of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences (CKTUTAS), Ghana. Using a descriptive survey design, data were collected from 98 undergraduate and postgraduate mathematics education students through a structured questionnaire. The study examined differences in PCK levels across gender, age, and educational level, focusing on both generic and topic-specific dimensions. Data were analyzed using descriptive statistics, independent-samples t-tests, and chi-square tests of association. The findings revealed no statistically significant differences in PCK across gender, age, or educational level, indicating that challenges in pedagogical development were widespread among teacher trainees. These results suggest that pedagogical weaknesses are systemic rather than demographic-specific. The study concludes that teacher education programs should adopt holistic interventions that strengthen PCK across all trainee groups. Policy implications highlight the importance of curriculum reforms and nationwide professional development programs that target the enhancement of pedagogical knowledge in mathematics education.

Keywords: pedagogical content knowledge, demographics, mathematics education, teacher education, Ghana

Introduction

The development of effective mathematics teachers depends not only on their mastery of content knowledge but also on their pedagogical content knowledge (PCK), which enables them to make mathematical concepts accessible to learners (Shulman, 1986). PCK encompasses both generic aspects, such as understanding how students learn and the strategies used to teach, and topic-specific elements, such as curricular saliency and representations (Grossman, 1990). Research in mathematics education has increasingly emphasized the role of PCK as a determinant of instructional quality and student achievement (Hill, Ball, & Schilling, 2008).

Corresponding email: abert551@gmail.com.
https://doi.org/10.64261/ijaarai.v1n3.005.

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ISSN (O): 3093-4664

Vol.1, Issue 3 | Oct–Dec 2025

www.ijaarai.com

A key question in teacher education research is whether PCK varies across demographic categories such as gender, age, or educational level. Some studies suggest that demographic factors may influence the development of teacher knowledge. For example, gender has been associated with different patterns of engagement in mathematics teaching and learning (Forgasz, 2010), while age and educational level may affect the accumulation of teaching experiences and pedagogical skills (Baumert et al., 2010). Other studies, however, have reported little to no demographic influence on teacher knowledge, concluding that variations in PCK are more strongly related to the structure of teacher preparation programs than to individual characteristics (Depaepe, Verschaffel, & Kelchtermans, 2013).

In Ghana, mathematics education continues to face challenges in student achievement, and improving teacher preparation is a central policy concern (Anamuah-Mensah, 2020). Yet, there is limited empirical evidence on how demographic factors influence PCK among pre-service mathematics teachers. Understanding whether PCK variations exist across socio-educational demographics is essential for designing equitable and effective teacher education programs.

This study therefore examined the influence of gender, age, and educational level on the PCK of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences. By addressing this gap, the study contributes to knowledge on the systemic and contextual factors that shape pedagogical preparation in Ghana.

Methods

Research Design

The study employed a descriptive survey design to examine demographic variations in PCK among mathematics education teachers. This design was appropriate for analyzing differences in teacher knowledge across categorical variables such as gender, age, and educational level (Creswell & Creswell, 2018).

Participants

The population comprised mathematics education students enrolled at C. K. Tedam University of Technology and Applied Sciences. A total of 98 respondents participated, including both undergraduate and postgraduate students. The sample consisted of 62 males (63.3%) and 36 females (36.7%), with ages ranging from 20 years to above 31 years. This composition allowed for comparisons across socio-educational subgroups.

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Instrumentation

Data were gathered using a structured questionnaire adapted from established PCK frameworks (Hill et al., 2008; Mavhunga & Rollnick, 2013). The instrument included items measuring both generic and topic-specific aspects of PCK, with responses rated on a Likert scale. Items were contextualized to reflect mathematics teaching in Ghana.

Data Collection Procedure

Questionnaires were administered directly to students after ethical clearance was obtained from the university. Respondents were assured of anonymity and confidentiality, and informed consent was obtained before participation.

Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics were used to summarize demographic characteristics. Independent-samples t-tests and chi-square tests were conducted to examine differences in PCK across gender, age, and educational level. Statistical significance was set at $p < .05$.

Results

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

The demographic data in Table 1 show that the majority of participants were male (63.3%) compared to female (36.7%). Most respondents fell between 20–30 years (81.7%), reflecting the youthful profile of mathematics education students. In terms of academic level, undergraduates (55.1%) slightly outnumbered postgraduates (44.9%), providing a

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fair basis for comparison of pedagogical content knowledge across academic backgrounds.

Table 2

Independent-Samples t-Test of Gender Differences in PCK (N = 98)

Gender	N	Mean PCK Score	SD	t	df	p-value
Male	62	3.42	0.56			
Female	36	3.38	0.61	0.34	96	.73

The independent-samples t-test (Table 2) revealed no statistically significant difference in PCK between male (M = 3.42, SD = 0.56) and female respondents (M = 3.38, SD = 0.61), t(96) = 0.34, p = .73. This indicates that gender did not significantly influence the pedagogical content knowledge of mathematics education teachers. Both male and female participants demonstrated comparable levels of PCK.

Table 3

Independent-Samples t-Test of Educational Level Differences in PCK (N = 98)

Educational Level	N	Mean PCK Score	SD	t	df	p-value
Undergraduate	54	3.39	0.59			
Postgraduate	44	3.45	0.55	-0.52	96	.60

As shown in Table 3, no statistically significant difference was found in PCK between undergraduate (M = 3.39, SD = 0.59) and postgraduate students (M = 3.45, SD = 0.55), t(96) = -0.52, p = .60. This finding suggests that advancing to postgraduate level did not necessarily result in higher pedagogical content knowledge scores among mathematics education teachers in this context.

Table 4

Chi-Square Test of Association between Age and PCK Levels (N = 98)

Variable	χ^2	df	p-value
Age × PCK Level	2.18	2	.34

The chi-square test (Table 4) indicated no significant association between age and PCK levels, $\chi^2(2, N = 98) = 2.18$, p = .34. This suggests that PCK did not differ systematically across the age categories of 20–25 years, 26–30 years, and 31 years and above.

Summary of Findings

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Across gender, educational level, and age, no statistically significant differences or associations were found in PCK. These results suggest that demographic factors did not play a determining role in shaping the pedagogical knowledge of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences. Instead, weaknesses in PCK appeared to be systemic across groups.

Discussion

This study examined whether socio-educational demographics such as gender, age, and educational level influenced the pedagogical content knowledge (PCK) of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences in Ghana. The findings showed no statistically significant differences in PCK across gender, age, or educational level, suggesting that pedagogical challenges are systemic across teacher trainees rather than attributable to demographic variations.

The absence of significant gender differences in PCK is consistent with research that has found minimal impact of gender on teacher knowledge in mathematics education (Depaepe, Verschaffel, & Kelchtermans, 2013; Hill, Rowan, & Ball, 2005). While studies such as Forgasz (2010) and Leder, Forgasz, and Solar (1996) have reported gender-related variations in teachers' mathematical beliefs and classroom practices, this study found comparable levels of PCK among male and female respondents. This reinforces arguments that gender disparities in mathematics education are more pronounced at the student level rather than the teacher level (Else-Quest, Hyde, & Linn, 2010). In contexts like Ghana, where gendered differences in teacher preparation are less institutionalized, access to similar teacher education curricula likely accounts for the parity observed.

Similarly, the finding that educational level did not significantly influence PCK aligns with Baumert et al. (2010), who demonstrated that teacher effectiveness is more strongly linked to opportunities for practice-based learning than to formal academic progression. Postgraduate students in this study did not show significantly stronger PCK than their undergraduate peers, a result that mirrors international findings that advanced academic training alone does not guarantee improved instructional competence (Blömeke & Delaney, 2012; Tatto et al., 2012). Effective teacher education must therefore embed structured opportunities for reflection, microteaching, and supervised practicum experiences that explicitly target both generic and topic-specific

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PCK (Mavhunga & Rollnick, 2013; Kleickmann et al., 2013).

The chi-square results further indicated no significant relationship between age and PCK, suggesting that older students were not necessarily better prepared pedagogically than their younger counterparts. This is in line with findings from TEDS-M, which showed that age was a weak predictor of teacher knowledge when compared to the quality of teacher preparation programs (Tatto et al., 2012). PCK development appears to be influenced more by exposure to effective instructional frameworks and opportunities for practical application rather than by chronological age (Grossman, 1990; Kind, 2009).

These results carry important implications for policy and practice. First, the lack of demographic effects underscores the systemic nature of weaknesses in mathematics PCK in Ghana. This suggests that reforms should not target specific groups of trainees but should instead focus on strengthening teacher education curricula for all students (Anamuah-Mensah, 2020; Osei, 2006). Institutions such as C. K. Tedam University of Technology and Applied Sciences should consider embedding diagnostic tasks that require trainees to anticipate student misconceptions and plan targeted instructional strategies, as recommended by Hill, Ball, and Schilling (2008). Nationally, professional development programs organized by the Ministry of Education and Ghana Education Service should emphasize sustained mentorship and collaborative lesson study models that support continuous growth in PCK (Clarke & Hollingsworth, 2002; Darling-Hammond, 2017).

Despite its contributions, the study is not without limitations. The reliance on self-reported questionnaires may have introduced social desirability bias, as noted in similar PCK studies (Kind, 2009; Gess-Newsome, 2015). Additionally, the single-institution sample limits the generalizability of the findings, as teacher education structures may vary across universities in Ghana. The cross-sectional design also does not account for how PCK evolves over time, an area where longitudinal studies could provide deeper insights (Kleickmann et al., 2013). Future research should adopt mixed-methods approaches, combining quantitative measures with classroom observations, interviews, and analysis of lesson artifacts, to capture the dynamic and situated nature of PCK (Park & Oliver, 2008). Expanding studies across multiple teacher education institutions would further strengthen the evidence base and provide a more comprehensive view of demographic influences on mathematics PCK in Ghana.

Conclusion

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This study explored the influence of socio-educational demographics on the pedagogical content knowledge of mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences in Ghana. The findings revealed no statistically significant differences in PCK across gender, age, or educational level, indicating that pedagogical challenges are systemic and not confined to particular demographic subgroups. This suggests that weaknesses in teacher knowledge are rooted in structural issues within teacher preparation rather than demographic variation.

The results highlight the importance of comprehensive reforms in teacher education programs that focus on strengthening pedagogical content knowledge across all trainee groups. Rather than designing interventions for specific categories of teachers, policymakers and institutions should invest in practice-based learning, mentorship, and professional development initiatives that deliberately integrate content knowledge with pedagogy. Such efforts would better equip future mathematics teachers to address learner difficulties and improve mathematics outcomes nationally.

While the study provides valuable insights, it was limited by its reliance on self-reported data and its focus on a single institution. Broader studies across multiple universities and with classroom-based evidence would provide a more robust understanding of demographic and systemic influences on PCK. Nonetheless, the findings underscore the urgency of adopting holistic, inclusive approaches to mathematics teacher preparation in Ghana.

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https://doi.org/10.64261/ijaarai.v1n3.005.

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Vol.1, Issue 3 | Oct–Dec 2025

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