



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

Robert Asichab Yaw Avaniwen, Mathematics Tutor, Azantilow Senior High Technical School, Ghana, West Africa.

Abstract

This study explored the interaction between components of generic pedagogical content knowledge (GPCK) among mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences (CKTUTAS), Ghana. A descriptive survey design was adopted, and data were collected from 98 undergraduate and postgraduate mathematics education students through a structured questionnaire. The instrument measured two GPCK dimensions: knowledge of students' understanding and knowledge of instructional practices. Data were analyzed using descriptive statistics and Pearson correlation tests with SPSS version 25. Findings indicated a significant positive correlation between the two GPCK components, suggesting that teachers who had greater awareness of students' mathematical thinking also demonstrated stronger instructional practices. The results reinforce the interconnected nature of GPCK, showing that improvement in one area can enhance the other. The study recommends that teacher education programs integrate student cognition and instructional practices in a unified approach to better prepare mathematics teachers. Policy implications include the need for structured professional development that emphasizes the alignment of instructional strategies with students' learning processes.

Keywords: pedagogical content knowledge, generic PCK, mathematics education, instructional practices, student understanding, Ghana

Introduction

Effective mathematics teaching requires more than mastery of subject matter knowledge; it also involves the ability to transform this knowledge into meaningful learning experiences for students. Shulman (1986) conceptualized this as pedagogical content knowledge (PCK), which integrates content with pedagogy to support teaching and learning. Within this framework, generic pedagogical content knowledge (GPCK) refers to broad pedagogical skills applicable across topics, such as diagnosing student

understanding and applying appropriate instructional strategies (Grossman, 1990).

The interaction between components of GPCK has received considerable attention in mathematics education research. Knowledge of students' understanding, which includes recognizing misconceptions and anticipating learning difficulties, is closely linked to knowledge of instructional practices, which concerns selecting methods and representations to



support learning (Hill, Ball, & Schilling, 2008). Studies have shown that teachers with greater awareness of how students think are more likely to adopt strategies that foster comprehension (Mavhunga & Rollnick, 2013). Conversely, weak understanding of student cognition often results in limited instructional adaptability (Depaepe, Verschaffel, & Kelchtermans, 2013).

In Ghana, however, empirical studies on how components of GPCK interact among mathematics teachers remain scarce. While research has explored teacher preparedness and general pedagogy, few studies have systematically investigated how teachers'

Methods

Research Design

The study employed a descriptive survey design, which was suitable for analyzing the relationships between GPCK components among the respondents. This approach allowed for the quantification of levels of knowledge and the statistical testing of associations between variables (Creswell & Creswell, 2018).

Participants

The population consisted of undergraduate and postgraduate mathematics education students enrolled at C. K. Tedam University of Technology and Applied Sciences in Ghana. A total of 98 participants were selected using purposive and simple random sampling techniques to ensure representation across levels of study. This sample included both pre-service

knowledge of student understanding informs their instructional practices. This gap is significant, as teacher education programs are expected to produce graduates who can seamlessly connect these knowledge domains to enhance mathematics learning outcomes (Ayebo & Assuah, 2017).

The present study therefore examined the interaction between components of GPCK among mathematics education students at C. K. Tedam University of Technology and Applied Sciences. Specifically, it explored the relationship between knowledge of students' understanding and knowledge of instructional practices.

teachers and postgraduate students who were engaged in advanced teacher education, making it possible to capture variations in pedagogical preparation.

Instrumentation

Data were collected using a structured questionnaire designed to assess the two main components of GPCK: knowledge of students' understanding and knowledge of instructional practices. Items were adapted from established frameworks on teacher knowledge (Hill et al., 2008; Mavhunga & Rollnick, 2013) and contextualized to reflect mathematics teaching in the Ghanaian setting. Responses were captured on a Likert scale ranging from strongly disagree to strongly agree, enabling the measurement of participants' perceived competence in each area.



Data Collection Procedure

The questionnaires were administered in person to participants at the university. Respondents were informed of the study's purpose and assured of confidentiality. Participation was voluntary, and informed consent was obtained before the commencement of data collection.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics were used to summarize participants' levels of knowledge in the two GPCCK dimensions. Pearson correlation analysis was conducted to examine the strength and significance of the relationship between knowledge of students' understanding and knowledge of instructional practices. A significance level of $p < .05$ was adopted.

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 sample comprised 98 mathematics education students, with a majority being male (63.3%) and the remaining female (36.7%). Most respondents were aged 20–30 years (81.7%), reflecting the youthful profile of pre-service teachers. A fairly balanced distribution was recorded across educational levels, with 55.1% undergraduates and 44.9% postgraduates. This demographic diversity provided a useful basis for comparing variations in GPCCK.



Table

2

Correlation between Knowledge of Students' Understanding and Knowledge of Instructional Practices (N = 98)

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

Note. $p < .01$

As shown in Table 2, there was a significant positive correlation ($r = .42$, $p < .01$) between knowledge of students' understanding and knowledge of instructional practices. This implies that teachers who were better at identifying learners' mathematical difficulties also tended to employ stronger instructional practices. The moderate strength of the correlation reflects the interconnected but distinct nature of these two GPCK dimensions.

Table

3

Chi-Square Test of Association between Demographic Variables and GPCK (N = 98)

Variable	χ^2	df	p-value
Gender $\times$ GPCK	1.25	1	.26
Age $\times$ GPCK	3.42	2	.18
Educational Level $\times$ GPCK	0.84	1	.36

Analysis of Chi-Square Results

The Chi-square analysis in Table 3 indicates that there were no statistically significant associations between GPCK levels and gender ($\chi^2 = 1.25$, $p = .26$), age ($\chi^2 = 3.42$, $p = .18$), or educational level ($\chi^2 = 0.84$, $p = .36$). This suggests that the interaction between GPCK components is not dependent on demographic characteristics. In other words, both male and female respondents, younger and older groups, as well as undergraduates and postgraduates, displayed similar relationships between their knowledge of students' understanding and instructional practices. This finding reinforces the idea that GPCK development challenges are systemic and not confined to specific demographic subgroups.

Discussion

This study examined the interaction between components of generic pedagogical content knowledge (GPCK) of mathematics education teachers at C. K. Tedam University of Technology and

Applied Sciences in Ghana. The results revealed a significant positive correlation between teachers' knowledge of students' understanding and their knowledge of instructional practices. This finding reinforces Shulman's (1986) foundational assertion that pedagogical



content knowledge is integrative in nature, blending content knowledge with pedagogy in ways that are sensitive to students' learning processes. Teachers who demonstrated higher awareness of how students conceptualize mathematics also reported stronger instructional practices, echoing previous findings that knowledge of student cognition informs instructional decision-making (Hill, Ball, & Schilling, 2008; Ball, Thames, & Phelps, 2008).

The moderate strength of the correlation suggests that while these two components are related, they are not interchangeable. Teachers may recognize student difficulties yet still lack the pedagogical repertoire to address them effectively. This resonates with the work of Mavhunga and Rollnick (2013), who observed that knowledge of learners' difficulties does not automatically translate into effective instructional practice unless teacher education deliberately integrates the two domains. The implication is that teacher preparation programs should emphasize not only diagnosing misconceptions but also designing instructional interventions that are directly informed by such diagnoses.

The chi-square results showed no significant associations between GPCCK and demographic factors such as gender, age, and educational level. This suggests that the challenges of developing GPCCK cut across categories of mathematics teacher trainees, a trend that has been observed in other studies where demographic differences explained little variation in PCK (Depaepe, Verschaffel, & Kelchtermans, 2013; Ayebo & Assuah,

2017). The absence of demographic effects emphasizes the need for systemic interventions in mathematics teacher education rather than targeted strategies for specific groups. Whether undergraduate or postgraduate, male or female, young or older, teacher trainees require structured opportunities to build connections between understanding student thinking and developing instructional practices.

The findings carry important implications for policy and practice in Ghana. Teacher education institutions such as C. K. Tedam University of Technology and Applied Sciences should integrate coursework and practicum experiences that deliberately link student learning processes to instructional decision-making. For example, lesson planning activities could require trainees to identify potential misconceptions and then propose strategies to address them. The Ministry of Education and the Ghana Education Service should also prioritize continuous professional development programs that enhance both awareness of student cognition and the application of evidence-based instructional strategies. Sustained training and mentoring partnerships between universities and schools could provide teachers with ongoing support to strengthen these interrelated aspects of GPCCK (Grossman, 1990; Tatto et al., 2012).

Despite the contributions of this study, limitations should be noted. The sample was drawn from a single university, which restricts the generalizability of the findings to other teacher education contexts in Ghana. The reliance on self-



reported data may also have introduced bias, as participants could have over- or under-estimated their competence. Additionally, the study employed a quantitative approach, which limited the depth of insights into how GPCCK components interact in actual classroom practice. Future studies could employ mixed-methods designs incorporating classroom observations and interviews to capture the dynamic ways in which teachers connect student understanding with instructional practices. Expanding the sample to multiple institutions would also enhance the external validity of the findings.

Conclusion

This study investigated the interaction between components of generic pedagogical content knowledge among mathematics education teachers at C. K. Tedam University of Technology and Applied Sciences in Ghana. The results showed that knowledge of students' understanding and knowledge of instructional practices are significantly and positively related, confirming that teachers' ability to anticipate learners' misconceptions enhances their capacity to employ effective teaching strategies. The absence of significant associations between demographic variables and GPCCK further indicates that the development of pedagogical knowledge is a shared challenge among teacher trainees, irrespective of gender, age, or educational level.

The findings underscore the need for teacher education programs to adopt integrative approaches that simultaneously develop awareness of

student thinking and the instructional practices required to address it. For policymakers, the study highlights the importance of professional development initiatives that prioritize the alignment of instructional decision-making with insights into student learning processes. Addressing these areas is essential for preparing mathematics teachers who can deliver more effective and responsive classroom instruction, ultimately contributing to improved mathematics achievement in Ghana.

References

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

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>

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.