



TEACHERS' TECHNOLOGICAL PEDAGOGY, TECHNOLOGICAL CONTENT KNOWLEDGE AND LEARNERS' MATHEMATICAL PERFORMANCE IN ELEMENTARY SCHOOLS

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ABSTRACT

This study examined the relationship between teachers' Technological Pedagogical and Content Knowledge (TPACK) and students' mathematical performance using a descriptive-correlational research design. The study was conducted in selected private elementary schools in Davao City during the Academic Year 2024–2025. Participants included 80 elementary mathematics teachers and 133 Grade 6 learners, selected through purposive sampling. An adapted and validated questionnaire was utilized to assess the teachers' level of TPACK across its different dimensions, while the students' mathematical performance was determined through their mathematics grades. The findings revealed that teachers demonstrated a high level of technological, pedagogical, and content knowledge, indicating their capability to integrate technology effectively into mathematics instruction. Moreover, the Grade 6 learners obtained a very satisfactory level of mathematical performance. Statistical analysis further revealed a significant relationship between teachers' TPACK and students' mathematical performance, suggesting that effective integration of technology, pedagogy, and content knowledge contributes positively to learners' academic achievement in mathematics. All TPACK indicators were found to significantly influence students' performance. Based on the findings, the study recommends that school administrators and academic leaders strengthen professional development initiatives and training programs focused on technology integration to further improve mathematics instruction and enhance student learning outcomes.

KEYWORDS: *Technological Pedagogical and Content Knowledge, mathematical performance, mathematics instruction*

I. INTRODUCTION

The Problem and Its Setting

Mathematics continues to be one of the most challenging subjects for elementary learners, often characterized by low academic performance, limited confidence, and difficulty understanding abstract concepts. These challenges are frequently associated with learners' mathematical anxiety, low motivation, and inability to apply mathematical knowledge to real-life situations. International studies have consistently shown that student performance in Mathematics is influenced not only by learner-related factors but also by the quality of instruction and the teacher's ability to present concepts in meaningful and accessible ways. Effective teaching practices are therefore essential in helping learners develop both competence and confidence in Mathematics.

Evidence from various countries highlights the importance of instructional quality in shaping Mathematics achievement. Studies conducted in Tanzania, Turkey, and the United States revealed that poor learning outcomes are often linked to ineffective instructional environments, student anxiety, and difficulties in conceptual understanding. Conversely, targeted and well-structured instructional interventions have been shown to improve learners' mathematical performance significantly. These findings suggest that teachers play a critical role in addressing both the cognitive and affective dimensions of Mathematics learning, emphasizing the need for strong pedagogical and content-related competencies.

Within the Philippine context, several studies have reported persistent challenges in Mathematics achievement among elementary learners. Research conducted in Cebu, Ifugao, Guihulngan City, and Davao City found that while teachers commonly employ various instructional strategies and assessment practices, student performance remains inconsistent. Findings indicate that factors such as teacher experience, subject specialization, student engagement, availability of learning resources, and parental involvement may significantly influence learning outcomes. These studies suggest that effective Mathematics instruction requires more than the application of teaching strategies; it also depends on teachers' capacity to adapt instruction to learners' needs and learning contexts.

Despite growing research on Mathematics education, limited attention has been given to the direct influence of teachers' Technological Pedagogical Content Knowledge (TPCK) on elementary learners' Mathematics performance, particularly in the Philippine setting. Existing studies have largely focused on instructional strategies, learner motivation, and contextual factors, leaving a gap in understanding how teachers' integration of content knowledge, pedagogy, and technology contributes to student achievement. Addressing this gap is important because TPCK provides a framework for understanding how teachers can effectively deliver mathematical concepts through learner-centered and technology-enhanced approaches. Consequently, this study examines the relationship between teachers' TPCK and students' Mathematics performance to provide evidence that may inform instructional improvement, curriculum development, and educational policy.

**Statement of the Problem**

This study sought to determine the significant relationship between teachers' pedagogical content knowledge and students' achievement in Mathematics. Specifically, it aimed to address the following research questions:

1. What is the level of teachers' technological pedagogy in terms of:

- 1.1 technological knowledge (TK)
- 1.2 content knowledge (CK);
- 1.3 pedagogical knowledge (PK);
- 1.4 pedagogical content knowledge (PCK);
- 1.5 technological pedagogical knowledge (TPK);
- 1.6 technological content knowledge (TCK); and

2. What is the level of students' performance in Mathematics in terms of grade?

3. Is there a significant relationship between the teachers' technological pedagogical content knowledge and learners' performance in Mathematics?

4. What indicators of teachers' technological pedagogical content knowledge significantly influence students' performance in Mathematics?

Significance of the Study

The findings of this study provide valuable insights for educational stakeholders seeking to improve Mathematics instruction and student achievement. For the Department of Education and school administrators, the results may serve as a basis for developing targeted professional development programs that strengthen teachers' pedagogical content knowledge (PCK) and instructional practices. The study also highlights the importance of school-based professional learning opportunities, such as collaborative learning sessions and reflective teaching practices, that support teachers in making mathematical concepts more accessible and meaningful to learners.

The study likewise benefits teachers, students, and future researchers. For teachers, it offers an opportunity to reflect on and enhance their instructional approaches to better address learners' needs. For students, the findings emphasize the value of having teachers who possess strong content knowledge and effective pedagogical skills, thereby fostering greater understanding, confidence, and success in Mathematics. Furthermore, the study contributes to the existing body of knowledge by providing evidence on the role of teacher knowledge in student performance and may serve as a reference for future investigations on pedagogical content knowledge, teacher development, and Mathematics education.

II. METHODOLOGY**Research Design**

This study utilized a quantitative, non-experimental research design employing the descriptive-correlational approach. It is classified as non-experimental because the independent variable will not be manipulated, and participants will not be randomly assigned to groups. As noted by McMillan and Schumacher (2020), non-experimental designs are appropriate when variables are examined as they naturally occur, without the introduction of interventions or treatments. In this case, the study explored the level of teachers' PCK and examined how it may relate to students' performance in mathematics.

Participants

The respondents consisted of 80 elementary mathematics teachers and 133 Grade 6 learners from selected private schools in Davao City for the Academic Year 2026–2027. These sample sizes were determined using Slovin's Formula based on an estimated population of 100 teachers which yielded a required sample of approximately 80, and an estimated population of 200 Grade 6 learners which produced a required sample of approximately 133. The resulting sample sizes aligned with the recommendation of Fraenkel, et al., (2022), who noted that correlational research requires at least 30 to 50 participants to detect moderate relationships with sufficient statistical power. These revised sample sizes therefore strengthen the representativeness of the study while maintaining feasibility within time and resource constraints.

Sampling Design

The study utilized purposive sampling to ensure that the participants meet clearly defined criteria. The inclusion criteria for teacher-respondents are: (1) currently teaching mathematics in Grades 6 in a private elementary school in Davao City, and (2) with at least two years of teaching experience in mathematics at the elementary level. For the student-respondents, they must: (1) be enrolled in Grades 6 during the current school year, and (2) have received final grades in mathematics for the previous academic year. The exclusion criteria included: (1) teachers not currently teaching math, (2) teachers or students who decline to participate or withdraw consent at any stage, and (3) students with incomplete or missing math grades.



Data Gathering Procedures

In gathering the data for this study, the following steps was carefully carried out:

The researcher first obtained formal approval from the Dean of the Graduate School to conduct the study. Upon approval, an endorsement letter was issued and addressed to the administrators of the selected private elementary schools in Davao City. This endorsement served as the official request to conduct the research among Grade 6 Mathematics teachers and learners in the participating schools.

After obtaining the necessary permissions, the researcher coordinated directly with the school administrators to ensure that the study is carried out without disrupting classes or official school operations. With the principals' approval, the researcher then proceeded to administer the survey questionnaires. Each participating Mathematics teacher and learner was provided with the appropriate research instrument, along with a clear explanation of the study's objectives, procedures, and ethical considerations.

The data collection took place in a respectful and non-intrusive manner, ensuring that all participants are comfortable and fully informed. Once all the completed questionnaires have been retrieved, the responses was tallied, organized, and analyzed with strict confidentiality. The findings was then interpreted according to the research objectives while upholding ethical and academic standards.

Data Analysis

The following statistical tools were utilized to analyze and interpret the data gathered in this study:

Weighted Mean and *Standard Deviation* were used to determine the level of teachers' TPACK and the academic performance of learners in Mathematics. According to Hayes (2022), the *mean* is a measure of central tendency that provides the mathematical average of a set of values, while the standard deviation measures the variability or dispersion of scores from the mean. In this study, the weighted mean was used to determine the average level of teachers' Technological Pedagogical Content Knowledge (TPACK) and the average performance of learners in Mathematics based on their grades, while the *standard deviation* was used to assess the consistency or variation of the responses and performance scores.

Meanwhile, the *Pearson Product-Moment Correlation Coefficient (Pearson's r)* was employed to determine the relationship between teachers' TPACK and students' Mathematics performance. This statistical tool was used to identify the strength and direction of the relationship between the two variables and to determine whether higher levels of TPACK are associated with better academic performance among learners.

Lastly, *Multiple Linear Regression Analysis* was applied to assess which specific indicators of pedagogical content knowledge significantly influence students' academic performance. By using multiple predictors such as content knowledge, pedagogical strategies, and knowledge of learners this statistical method helped identify which components of TPCK are most strongly linked to learner success in mathematics.

III. RESULTS AND DISCUSSION

Level of Teachers' Technological Pedagogical and Content Knowledge

The study revealed that teachers in selected private elementary schools in Davao City demonstrated a high level of Technological Pedagogical and Content Knowledge (TPACK), with an overall mean score of 3.86 (SD = 0.69). The TPACK construct was examined through six indicators: Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK). The results indicate that teachers generally possess the knowledge and competencies needed to integrate technology, pedagogy, and subject matter effectively within their instructional practices.

Table 1.

Summary Data on the Level of Teachers' Technological Pedagogical and Content Knowledge

No.	Indicators of Instructional Leadership of School Heads in Kindergarten	Mean	SD	Descriptive Equivalent
1.	Technological Knowledge (TK)	3.33	0.79	High
2.	Content Knowledge (CK)	3.87	0.70	High
3.	Pedagogical Knowledge (PK)	4.11	0.63	High
4.	Pedagogical Content Knowledge (PCK)	3.90	0.70	High
5.	Technological Pedagogical Knowledge (TPK)	4.00	.67	High
6.	Technological Content Knowledge (TCK)	.00	0.65	High
Overall		3.86	0.69	High

The high overall level of TPACK suggests that teachers have a strong foundation in both subject matter and instructional delivery. Specifically, they demonstrated competence in understanding the content they teach (CK), applying effective teaching methods (PK), and selecting appropriate subject-specific instructional strategies (PCK). These competencies enable teachers to present concepts



in ways that are meaningful and accessible to learners, thereby supporting deeper understanding and more effective classroom learning experiences.

The findings further indicate that teachers possess the capacity to integrate technology into teaching and learning processes. Through their Technological Knowledge (TK), teachers demonstrate familiarity with technological tools and resources, while their Technological Pedagogical Knowledge (TPK) reflects their ability to select and use technologies that enhance instructional approaches. Similarly, their Technological Content Knowledge (TCK) suggests an ability to utilize technology to represent and explain subject matter more effectively, allowing learners to engage with content in diverse and meaningful ways.

Overall, the results highlight that teachers possess a well-developed and integrated knowledge base that combines technology, pedagogy, and content. Such competence is essential in contemporary education, particularly in Mathematics instruction, where effective teaching requires not only mastery of subject matter but also the ability to employ appropriate pedagogical approaches and technological resources. The findings underscore the importance of sustaining this high level of TPACK through continuous professional development, reflective practice, and technology-enhanced instructional training to further strengthen teaching effectiveness and student learning outcomes.

The high level of TPACK observed in this study supports the view that effective teaching is achieved when teachers successfully integrate Technological Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Pedagogical Knowledge, and Technological Content Knowledge into a cohesive instructional framework. This integrated competence enables teachers to make informed instructional decisions, adapt to diverse learner needs, and create engaging learning environments that promote meaningful and lasting student learning.

Students' Mathematical Performance

The study found that students demonstrated a very satisfactory level of mathematical performance, with an overall mean grade of 85. This result indicates that learners generally achieved the expected learning competencies and curricular standards in Mathematics. The finding suggests that students possess an adequate understanding of mathematical concepts and are able to perform satisfactorily in assessed learning tasks and academic requirements.

Table 2.
Students' Mathematical Performance in Terms Grade

No.	Items	Mean	Descriptive Equivalent
1.	Grade in Mathematics	85	Very Satisfactory
Overall		85	Very Satisfactory

The very satisfactory performance of students may reflect the presence of instructional and learning conditions that support mathematical understanding and achievement. Research has consistently shown that students' success in Mathematics is influenced not only by their individual abilities but also by the quality of instruction, teacher preparedness, classroom environment, and opportunities for meaningful engagement with mathematical concepts. A supportive learning environment can help learners develop confidence, reduce anxiety, and strengthen their problem-solving skills.

Overall, the findings indicate that students are performing well in Mathematics and are generally meeting the academic expectations established by the curriculum. The results further suggest that effective instructional practices and positive learning experiences may contribute to sustaining learners' achievement in the subject. Maintaining and further enhancing these supportive educational conditions can help ensure continued improvement in students' mathematical performance and learning outcomes.

Significant Relationship Between Teachers' Technological Pedagogical and Content Knowledge and Students' Mathematical Performance

The study revealed a statistically significant and very strong positive relationship between teachers' Technological Pedagogical Content Knowledge (TPACK) and students' Mathematics performance ($r = 0.900$, $p = 0.00$). The result indicates that higher levels of teachers' ability to integrate technology, pedagogy, and content knowledge are associated with higher levels of student achievement in Mathematics. Since the p-value was lower than the 0.05 level of significance, the null hypothesis was rejected, confirming that teachers' TPACK is significantly related to students' mathematical performance.

**Table 3.****Significant Relationship Between Teachers' Technological Pedagogical and Content Knowledge and Students' Mathematical Performance**

Variables	Computed Value	r	p value	Equivalent Decision on Ho
(X) <i>Teachers' Technological Pedagogical and Content Knowledge</i>	0.900s		0.00	Positive High Correlation Reject Ho
(Y) <i>Students' Mathematical Performance</i>				

The findings suggest that teachers who effectively combine subject matter expertise, appropriate instructional strategies, and technology integration are better positioned to create meaningful learning experiences that enhance student achievement. This result underscores the important role of teachers' integrated professional knowledge in supporting Mathematics learning and aligns with existing literature emphasizing teacher quality as a key determinant of student success. Overall, the study highlights the value of strengthening teachers' TPACK through continuous professional development as a means of improving instructional effectiveness and promoting higher levels of student performance in Mathematics.

Domains of TPACK that Significantly Affects Students Mathematics Performance

The study examined the domains of teachers' Technological Pedagogical Content Knowledge (TPACK) that significantly influence students' Mathematics performance using multiple regression analysis. The results revealed that all six TPACK domains—Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK)—significantly affected students' Mathematics performance, as evidenced by p-values below the 0.05 level of significance. This finding indicates that each component of TPACK contributes meaningfully to student achievement in Mathematics.

Table 4.**Domains of Teachers' Technological Pedagogical and Content Knowledge that Significantly Influence Students' Mathematical Performance**

Indicators	Unstandardized Coefficients		Standardized Coefficients	t-ratio	Sig
	B	Std. Error	Beta		
<i>Constant</i>	β_0	3.37	0.44	21.00	0.03
Technological Knowledge (TK)	β_1	0.56	0.94	29.09	0.02
Content Knowledge (CK)	β_2	0.58	0.47	6.20	0.01
Pedagogical Knowledge (PK)	β_3	0.23	0.68	12.07	0.02
Pedagogical Content Knowledge (PCK)	β_4	0.56	0.65	6.10	0.02
Technological Pedagogical Knowledge (TPK)	β_5	0.50	0.68	12.07	0.01
Technological Content Knowledge (TCK)	β_6	0.23	0.68	12.07	0.01

The results suggest that effective Mathematics instruction depends on more than content expertise alone. Teachers' ability to understand and use technology, apply appropriate pedagogical strategies, and integrate these competencies with subject matter knowledge plays a crucial role in supporting student learning. The significant influence of Pedagogical Content Knowledge, Technological Pedagogical Knowledge, and Technological Content Knowledge further highlights the importance of transforming mathematical concepts into meaningful learning experiences through appropriate instructional approaches and technology-enhanced teaching practices.

Overall, the findings demonstrate that students' Mathematics performance is strongly influenced by the integrated application of technology, pedagogy, and content knowledge. Teachers who exhibit competence across all TPACK domains are better equipped to design engaging lessons, address student misconceptions, facilitate conceptual understanding, and create effective learning



environments. These results underscore the importance of continuous professional development programs that holistically strengthen all dimensions of teachers' TPACK to further improve instructional quality and student achievement in Mathematics.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study yielded the following conclusions:

1. Teachers in the selected private elementary schools in Davao City demonstrate a high level of Technological Pedagogical and Content Knowledge (TPACK) across all its domains, namely Technological Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Pedagogical Knowledge, and Technological Content Knowledge. Among these domains, pedagogical knowledge emerged as the strongest, indicating teachers' competence in managing instruction, adapting teaching strategies, and addressing learners' needs.

2. Students' mathematical performance was assessed as very satisfactory, as reflected by the overall mean grade of 85. This result suggests that students are generally able to meet the expected learning competencies in mathematics and perform adequately in the subject.

3. There is a significant and high positive relationship between teachers' Technological Pedagogical and Content Knowledge and students' mathematical performance. This implies that higher levels of teachers' integrated knowledge of technology, pedagogy, and content are associated with improved student achievement in mathematics. Moreover, the multiple regression analysis revealed that all domains of TPACK significantly influence students' mathematical performance, indicating that effective mathematics instruction is not driven by a single dimension of teacher knowledge but by the synergistic integration of content mastery, pedagogical expertise, and purposeful use of technology. These findings highlight that teachers who are capable of aligning instructional strategies, subject matter, and technological tools are better positioned to support meaningful learning and enhance students' academic outcomes in mathematics.

The conclusions of this study are strongly supported by Shulman's Theory of Pedagogical Content Knowledge (1986), which emphasizes that effective teaching arises from the integration of subject matter knowledge and pedagogical skill. The significant influence of Pedagogical Content Knowledge on students' mathematical performance affirms Shulman's assertion that knowing how to teach specific content is as critical as knowing the content itself. Likewise, Piaget's Constructivist Learning Theory (1952) is reflected in the findings, as teachers with strong pedagogical and technological competencies are more capable of designing learning experiences that allow students to actively construct mathematical understanding through exploration, problem-solving, and engagement.

Furthermore, the findings are consistent with Vygotsky's Sociocultural Theory (1978), particularly the concept of the Zone of Proximal Development, which emphasizes the role of guided learning in student development. Teachers with strong TPACK are better positioned to scaffold learning, provide appropriate feedback, and utilize technological tools that support students in progressing from assisted learning to independent mathematical reasoning. The results also strongly support the TPACK framework of Mishra and Koehler (2006), which asserts that effective teaching requires the integration of technology, pedagogy, and content knowledge. The significant influence of all TPACK domains found in this study confirms that effective technology integration, when combined with sound pedagogical practices and strong content knowledge, contributes positively to students' Mathematics performance. Overall, the study concludes that enhancing teachers' TPACK is essential for improving Mathematics instruction and promoting higher levels of student achievement.

Recommendations

Based on these findings, the study offered the following recommendations:

1. School administrators and academic leaders are encouraged to continuously support the professional growth of teachers by prioritizing programs that strengthen Technological Pedagogical and Content Knowledge (TPACK). Professional development initiatives should focus on the integrated use of content knowledge, pedagogical strategies, and technology, particularly in mathematics instruction. School leaders may encourage sustained participation in workshops, seminars, and in-service training that emphasize instructional design, technology-enhanced pedagogy, and subject-specific teaching strategies to further improve students' mathematical performance.

2. Teachers are encouraged to actively engage in continuous professional learning through structured platforms such as Learning Action Cells (LACs), professional learning communities, and peer mentoring. These collaborative spaces may be used to share effective mathematics teaching practices, explore innovative uses of technology, and reflect on instructional strategies that support conceptual understanding and problem-solving skills. Teachers are also encouraged to engage in reflective practice and seek constructive feedback to further refine their pedagogical, technological, and content-related competencies.

3. Education officials and school administrators are encouraged to allocate sufficient resources to support technology integration in mathematics instruction. This includes providing access to appropriate digital tools, instructional software, and learning platforms that align with curricular goals. Institutional support for targeted professional development programs that enhance teachers'



TPACK particularly Technological Pedagogical Knowledge and Technological Content Knowledge may contribute to more meaningful learning experiences and improved student outcomes in mathematics.

4. Future researchers may conduct further studies using experimental, longitudinal, or mixed-methods designs to examine the causal impact of teachers' TPACK on students' mathematical performance over time. Similar studies may also be conducted across different grade levels, subject areas, or educational contexts to validate and extend the findings of the present study. Exploring additional variables such as teacher beliefs, instructional practices, and student engagement may provide deeper insights into how integrated teacher knowledge influences academic achievement.

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