

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) AND MATHEMATICS TEACHING ANXIETY AMONG PUBLIC ELEMENTARY MATHEMATICS TEACHERS IN LOON, BOHOL

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ABSTRACT

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This study examined the relationship between Technological Pedagogical and Content Knowledge (TPACK) and mathematics teaching anxiety among public elementary school mathematics teachers in Loon, Bohol during the School Year 2024–2025. Using a quantitative–correlational research design, data were collected from 89 mathematics teachers through standardized survey instruments, namely the TPACK.xs questionnaire and the Mathematics Teaching Anxiety Scale. Descriptive statistics, weighted mean, and Spearman Rank-Order Correlation were employed in analyzing the data. Findings revealed that the respondents demonstrated a very high level of TPACK, particularly in pedagogical knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. Meanwhile, respondents exhibited a moderately low level of mathematics teaching anxiety. Correlation analysis showed no significant relationship between overall



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TPACK and mathematics teaching anxiety. However, pedagogical knowledge demonstrated a significant inverse relationship with mathematics teaching anxiety, indicating that teachers with stronger pedagogical competence tend to experience lower instructional anxiety. The findings underscore the importance of strengthening pedagogical competencies alongside technology integration initiatives to enhance teachers' instructional confidence and emotional preparedness in mathematics education. The study recommends sustained professional development programs focusing on pedagogical enhancement, technology integration, and anxiety management strategies among mathematics teachers.

INTRODUCTION

Mathematics education in the 21st century has become increasingly complex due to the simultaneous demands of content mastery, pedagogical innovation, and technology integration. Despite advances in educational technology, many teachers continue to struggle to integrate digital tools effectively into mathematics instruction while maintaining confidence in their ability to teach mathematical concepts. Teachers are expected not only to deliver mathematical concepts effectively but also to create engaging, learner-centered, and technology-enhanced instructional environments that respond to the needs of diverse learners. In current education, technology integration has become an essential aspect of effective teaching and learning, especially in facilitating active engagement, collaboration, critical thinking, and lifelong learning among students (Vooigt et al., 2013). Consequently, educational systems require teachers to develop competencies that enable them to integrate technology meaningfully into classroom instruction.

TPACK asserts that for successful technology integration, teachers need not only technical expertise but also pedagogical and content knowledge, as well as the ability to synthesize these domains in instructional practice. In contemporary classrooms, effective teaching is achieved when teachers integrate technology, pedagogy, and subject-matter expertise to improve student learning and engagement (Koehler et al., 2013). Consequently, TPACK has become a major framework for understanding teacher preparation for 21st-century teaching. The framework was originally developed by Koehler and Mishra (2006) as an extension of Shulman's Pedagogical Content Knowledge model. TPACK emphasizes that effective teaching occurs not through isolated competencies but through the dynamic interaction among technology, pedagogy, and content knowledge within specific instructional contexts.

TPACK is especially important in mathematics education, where complex concepts and problem-solving procedures often require innovative teaching methods and technological support. In technology-enhanced instruction, interactive apps, simulations, visualization tools, and multimedia resources are used to increase conceptual comprehension and learner engagement in

mathematics education (Kholid et al., 2023). Teachers with excellent TPACK competences exhibit greater instructional confidence and adaptability when using digital resources in mathematics education, thereby improving teaching quality and student engagement (Khine et al., 2019; Plantado, 2023).

However, with the growing emphasis on technological integration, mathematics teaching anxiety (MTA) remains a concern for teachers. Mathematics teaching anxiety is defined as the sensations of worry, stress, trepidation, or discomfort that teachers experience when teaching mathematics concepts or engaging in mathematics learning activities (Peker & Ertekin, 2011). Alkan et al. (2019) found that teachers who perceive a deficiency in mathematical or pedagogical skills are more prone to mathematics anxiety in instruction. Such worry can significantly affect the quality of instruction, classroom interaction, teacher confidence, and student achievement.

Prior research has shown that anxiety in teaching mathematics is influenced by several interrelated factors, including limited content mastery, inadequate pedagogical preparation, low self-efficacy, negative prior experiences in mathematics, and poor technological competence (Akinsola, 2014; Haciomeroglu, 2014). High levels of anxiety in teachers are generally associated with difficulties in lesson planning, classroom facilitation, and responding adequately to the mathematical demands of the pupils (Aydin, 2021). Moreover, teachers' worry can be communicated to the learners, which might influence students' attitudes towards mathematics and their academic achievement (Ramirez et al., 2018).

Research also indicates that the teachers' TPACK competencies might reduce instructional anxiety by increasing confidence and efficacy in teaching. Teachers with higher levels of technological and pedagogical competencies are more likely to be adaptable and creative in delivering instruction and confident in addressing classroom problems (Joo et al., 2018; Sojanah et al., 2021). On the other hand, teachers who lack sufficient technical knowledge or teach outside their field may experience greater tension and anxiety when teaching mathematics. Uçar and Ertekin (2019) showed that preservice teachers with higher levels of TPACK had reduced levels of mathematics teaching anxiety. Similarly, Aksu and Kul (2019) found that pedagogical content knowledge had a significant role in reducing mathematics teaching anxiety by improving instructional efficacy.

There is a growing amount of literature on TPACK and mathematics teaching anxiety. However, few studies have examined their relationship among in-service elementary mathematics instructors in the Philippine context. Previous studies have mostly focused on preservice teachers or on general technology integration, without sufficiently probing the emotional components of mathematics teaching. This gap is especially noteworthy in public elementary schools, since many mathematics teachers are non-specialists and belong to the generation often called "digital immigrants" (Prensky, 2001). These teachers were trained in an era when educational technology was less prominent, and

they may struggle to adapt to the rapid changes in digital learning environments.

In the municipality of Loon, Bohol, many elementary mathematics teachers are assigned to teach mathematics with insufficient specialization in the discipline. At the same time, these teachers are expected to use digital tools in instruction to meet the requirements of the MATATAG Curriculum and 21st-century learning standards. Rural public schools in Bohol may face challenges related to internet access, limited digital infrastructure, and insufficient ICT training opportunities, which may further undermine teachers' confidence in integrating technology into mathematics instruction.

These conditions might create contradictions between what is expected of instructors in terms of instruction and their perceived competencies, contributing to anxiety about teaching mathematics. Therefore, understanding the association between TPACK and mathematics teaching anxiety is important in informing responsive professional development programs and institutional measures that enhance effective mathematics instruction.

The present study draws on numerous theoretical perspectives on the relationships among teacher competence, technology integration, and emotional responses in teaching. The first is the Engagement Theory by Kearsley and Shneiderman (1998), which states that when technology is effectively integrated into classroom instruction, it encourages active, collaborative, and meaningful learning experiences (Relator, 2022). This idea suggests that student engagement is contingent upon teachers' technological and pedagogical competencies. Second, Appraisal Theory holds that emotional reactions are products not only of conditions but also of individuals' cognitive appraisals of situations (Lazarus, 1991). Thus, teachers' worry in this study could be related to their self-evaluation of TPACK competencies. Third, the Cognitive Dissonance Theory states that psychological discomfort arises when there are inconsistencies among beliefs, competencies, and instructional needs (Harmon-Jones & Mills, 2019). Therefore, teachers with good content expertise who feel unprepared to integrate technology may experience dissonance and discomfort in their education. Collectively, these theories explain how teachers' technological and pedagogical competencies, self-appraisal processes, and perceived instructional preparedness interact in shaping emotional responses toward mathematics teaching.

The study is further supported by international and national educational policies advocating quality education and technology integration. Sustainable Development Goal 4 emphasizes inclusive and equitable quality education through competent and well-supported teachers. In the Philippine context, the 1987 Philippine Constitution guarantees every citizen's right to quality education. Republic Act No. 10533, or the Enhanced Basic Education Act of 2013, promotes learner-centered and globally competitive education. Likewise, the Philippine Professional Standards for Teachers (PPST) and the MATATAG Curriculum emphasize teachers' competencies in technology integration, innovative pedagogy, and responsive instructional practices

(Department of Education [DepEd], 2017, 2024).

Despite the rising international literature on TPACK and mathematics teaching anxiety, actual research on in-service elementary mathematics instructors in localized Philippine contexts is lacking. Existing research focuses mostly on preservice teachers' or general technology integration competencies, without sufficiently investigating the emotional dimensions of mathematics instruction among professional teachers. Furthermore, there is little research on how digital immigrant instructors who teach outside their field of study negotiate the dual demands of integrating technology and mathematics instruction in rural public schools. These gaps indicate the need for contextualized studies that examine the association between TPACK and mathematics teaching anxiety among in-service mathematics instructors in the Philippines.

This study looked at the relationship between Technological Pedagogical and Content Knowledge (TPACK) and mathematics teaching anxiety among public elementary school math teachers in Loon, Bohol, during the School Year 2024–2025, while accounting for existing gaps and context. The study particularly examined the level of mathematics teaching anxiety among teachers, the depth of TPACK among instructors across all seven categories, and whether these aspects were significantly associated with demographic variables such as gender, age, and length of service. Finally, the study's findings may spur the development of responsive upskilling initiatives to increase math teachers' emotional preparation, technological integration, and instructional competency.

RESEARCH METHODOLOGY

Design. This study employed a quantitative–correlational research design using a cross-sectional survey approach to determine the relationship between Technological Pedagogical and Content Knowledge (TPACK) and mathematics teaching anxiety among public elementary mathematics teachers in Loon, Bohol. Correlational research design is appropriate when examining the degree and direction of relationships among variables without manipulating them (Creswell & Creswell, 2018).

Environment. The study was conducted in selected public elementary schools in Loon, Bohol, Philippines, during the School Year 2024–2025. The locale was selected because many mathematics teachers are non-specialists and belong to the generation commonly referred to as digital immigrants.

Respondents of the Study. The respondents were public elementary school teachers teaching mathematics. Using proportional random sampling, 115 teachers were initially identified as respondents; however, only 89 completed and returned the questionnaires, constituting the study's final sample.

Instruments. The study utilized two standardized instruments. The first was the TPACK. The questionnaire developed by Schmid et al. (2020) and

modified by Relator (2022) measured seven dimensions of TPACK. The second instrument was the Mathematics Teaching Anxiety Scale developed by Alkan et al. (2019), which assessed anxiety experienced during mathematics instruction.

The TPACK questionnaire had adequate reliability coefficients across dimensions, whereas prior studies reported that the Mathematics Teaching Anxiety Scale had outstanding internal consistency. Prior to administration, pilot testing was conducted to ensure that the instruments were clear and contextually suitable.

Data Gathering Procedure. Approval to conduct the study was secured from the appropriate educational authorities and school heads. Informed consent was obtained from all respondents prior to data collection. The questionnaires were personally distributed and retrieved by the researcher.

Ethical Considerations. The study adhered to ethical principles, including voluntary participation, informed consent, confidentiality, anonymity, and the secure handling of data. The study protocol was reviewed and approved by the institutional Research Ethics Committee prior to data collection.

Statistical Treatment. Weighted mean, frequency counts, and percentages were used for descriptive analysis. Since the normality assumption was violated, the Spearman Rank-Order Correlation was used to determine the relationship between TPACK and mathematics teaching anxiety.

RESULTS AND DISCUSSION

Level of Technological Pedagogical and Content Knowledge (TPACK). The results showed that the respondents' overall level of Technological Pedagogical and Content Knowledge (TPACK) was extremely high ($M = 3.40$). Pedagogical Knowledge (PK) had the highest mean score ($M = 3.62$) of the seven characteristics, suggesting that teachers were highly competent in classroom management, instructional techniques, and pedagogical decision-making. This result confirms Shulman's (1987) claim that pedagogical knowledge is still essential to good instruction. Furthermore, respondents received very high ratings for Pedagogical Content Knowledge (PCK) ($M = 3.48$) and Technological Pedagogical Content Knowledge (TPCK) ($M = 3.45$), demonstrating that they could integrate pedagogy, content, and technology into mathematics instruction. The findings support those of Koehler et al. (2013), who concluded that effective technology integration requires integrating knowledge across all areas rather than discrete technological skills.

Although it was still regarded as reasonably high, Technological Knowledge (TK) had the lowest mean score ($M = 3.17$). This result shows that although teachers were generally confident in their pedagogy and content delivery, their technology proficiency remained a relative weakness. The outcome supports the findings of Singer and Teclehaimanot (2019), who found that, with

respect to pedagogical competences, teachers frequently show less confidence in technology operations.

Many teachers are digital immigrants who received their education and training before the widespread integration of educational technologies, which may explain respondents' relatively low level of technological proficiency. This finding emphasizes the continued need for professional development courses focused on technology-enhanced math instruction and digital literacy. Respondents' comparatively limited technological knowledge may reflect greater structural and generational obstacles in technology integration among public school instructors in rural educational settings. Many instructors who are digital immigrants were trained when educational technology was not yet a priority in pedagogical training. As a result, even with strong pedagogical competencies, teachers may struggle to confidently use digital resources for mathematics instruction. This research emphasizes the persistent gap between pedagogical expertise and technological adaptability in developing-country educational situations.

Level of Mathematics Teaching Anxiety. The findings also showed that respondents' anxiety related to teaching mathematics was somewhat low ($M = 2.08$). This implies that when teaching mathematics, teachers' levels of discomfort and anxiety were generally tolerable. Concerns about student involvement and instructional efficacy—specifically, worry about students' comprehension of mathematical ideas and the application of suitable teaching techniques—were linked to the greatest anxiety markers. These results are consistent with Terrenghi et al. (2019), who highlighted that teachers' top concerns are student engagement and instructional attentiveness.

On the other hand, respondents reported lower anxiety regarding their teaching experience and mathematical proficiency. This suggests that, despite mild concerns about pedagogical implementation and learner engagement, teachers were largely confident in their mathematical content knowledge.

The influence of teaching expertise, established classroom routines, and adaptive instructional strategies that have been created over time may also be reflected in the fairly low level of anxiety. However, the results highlight the significance of ongoing professional support initiatives that bolster pedagogical flexibility and instructional confidence.

Relationship Between TPACK and Mathematics Teaching Anxiety. The study found no significant relationship between overall TPACK and mathematics teaching anxiety ($r_s = -.04, p = .709$). This indicates that higher TPACK competencies did not necessarily correspond to lower mathematics teaching anxiety among the respondents.

The absence of a statistically significant relationship suggests that mathematics teaching anxiety may be influenced more strongly by affective, contextual, and experiential variables than by technological competencies alone. Factors such as prior experiences in mathematics, institutional support, workload demands, and self-efficacy may exert stronger influence

on instructional anxiety than general TPACK competencies. This finding further indicates that technology integration skills alone may not sufficiently reduce emotional apprehension in mathematics teaching without parallel strengthening of pedagogical confidence and emotional support mechanisms.

It is interesting to note that among the seven TPACK domains, only Pedagogical Knowledge (PK) showed a significant inverse association with anxiety related to teaching mathematics ($r_s = -.222, p = .036$). According to this research, teachers with greater pedagogical competence typically experience less anxiety when teaching mathematics. The outcome validates the findings of Aksu and Kul (2019), who highlighted that instructional confidence and decreased anxiety are strongly influenced by pedagogical ability.

Table 1. Spearman Correlations Between TPACK Dimensions and Mathematics Teaching Anxiety

Variable	r_s	p
Overall TPACK	-.040	.709
Pedagogical Knowledge	-.222*	.036
Content Knowledge	-.151	.158
Technological Knowledge	.177	.098
Pedagogical Content Knowledge	-.189	.077
Technological Pedagogical Knowledge	.051	.632
Technological Content Knowledge	.080	.459
Technological Pedagogical Content Knowledge	.043	.690

Note. $p < .05$.

The findings imply that while technology integration skills are important in contemporary instruction, pedagogical competence remains the most critical factor influencing teachers' emotional preparedness and confidence in mathematics teaching. This further suggests that anxiety in mathematics instruction may stem less from technological limitations and more from concerns regarding instructional delivery, learner engagement, and classroom interaction.

The absence of a significant relationship between overall TPACK and mathematics teaching anxiety also supports the argument of Aydin (2021) that teaching anxiety is multidimensional and may be influenced by several situational and psychological factors beyond technological competence alone.

CONCLUSIONS

The Technological Pedagogical and Content Knowledge (TPACK) framework outlines the core competencies needed for effective teaching in the 21st century. In this study, the respondents generally demonstrated a

high level of TPACK, particularly in Pedagogical Knowledge (PK), followed by Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPCK). Although levels of technological knowledge were slightly lower than those in pedagogical and content domains, they still reflected a solid understanding of how to integrate technology into teaching.

The respondents indicated moderately low levels of anxiety related to teaching mathematics. This comparatively low level of anxiety could be attributed to the advantages of experience and tried-and-true teaching methods that provide teachers with the confidence to handle issues in the classroom.

The connection between TPACK and MTA was also investigated in the study. There was one noteworthy exception to the general lack of link between TPACK and mathematics teaching anxiety: Pedagogical Knowledge (PK) demonstrated a substantial inverse relationship with MTA. This implies that educators with stronger pedagogical skills may be more comfortable teaching math classes. Together, the results emphasize the need to improve instruction quality through professional development. This study contributes to the expanding literature on TPACK and mathematics teaching anxiety by offering local evidence from public elementary schools in the Philippines. The findings imply that pedagogical ability remains crucial to reducing instructional anxiety, especially in the context of education's growing technological orientation. This highlights the need to balance technology integration projects, ongoing pedagogical improvement, and emotional support programs for instructors. Increasing pedagogical competency with continued support for technology integration may help elementary teachers teach mathematics more confidently and effectively. The study shows that pedagogical competency remains important for teachers' emotional preparation and supports the need for permanent pedagogical and emotional support mechanisms to be included in technology integration projects.

RECOMMENDATIONS

Based on the study's conclusions and findings, the researcher proposed the following recommendations.

1. Develop localized professional development programs focusing on pedagogical enhancement and technology-integrated mathematics instruction.
2. Provide sustained mentoring and coaching programs for non-specialist mathematics teachers and digital immigrant educators to strengthen instructional confidence and technology integration competencies.
3. Integrate mathematics teaching anxiety management strategies into in-service training programs, particularly those focusing on classroom engagement, self-efficacy, and emotional resilience.

4. Encourage future researchers to conduct mixed-methods or longitudinal studies examining the mediating effects of self-efficacy, institutional support, and technological adaptability on mathematics teaching anxiety.
- 5.

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