American Journal of Education and Technology (AJET)

ISSN: 2832-9481 (ONLINE)

VOLUME 4 ISSUE 4 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Education and Technology (AJET)

Volume 4 Issue 4, Year 2025
ISSN: 2832-9481 (Online)
DOI: https://doi.org/10.54536/ajet.v4i4.6023
https://journals.e-palli.com/home/index.php/ajet

Integrating Technology, Content, and Pedagogy: A Mixed-Methods Study of Filipino Mathematics Teachers' Knowledge and Adaptation in Thailand

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Article Information

Received: September 01, 2025
Accepted: October 03, 2025
Published: December 13, 2025

Keywords

Instructional Practices, Mathematics Teachers, Technological Knowledge, Technology, TPACK

ABSTRACT

The integration of technology in teaching mathematics has become increasingly important in enhancing instructional delivery and student learning. This study investigated the Technological, Pedagogical, and Content Knowledge (TPACK) of Filipino mathematics teachers based in Bangkok, Thailand. Specifically, it aimed to assess the level of TPACK among teachers and examine the relationship between their TPACK components and teaching practices. A descriptive-correlational research design was employed. Using purposive sampling, 60 mathematics teachers participated in the study and responded to a validated and adapted TPACK questionnaire. Results revealed that while teachers demonstrated strong content and pedagogical knowledge, their technological knowledge and ability to integrate technology into mathematics instruction varied across respondents. Statistical analysis showed a significant correlation between high levels of TPACK and effective classroom implementation of technology-based strategies. These findings suggest that professional development focusing on technology integration is vital to strengthening mathematics instruction. The researcher recommends that school administrators support continuous TPACK-oriented training to ensure teachers are well-equipped to deliver effective, technology-enhanced mathematics education.

INTRODUCTION

In the 21st century, students are really immersed in technology, causing traditional methods of teaching to rapidly transform. Teachers now have the responsibility of adopting various methods to interest learners and meet their individual learning styles. The integration of technology into education is not only a global trend but also a mandated national goal under Republic Act No. 10533 Enhanced Basic Education Act of 2013, which promotes the use of modern technologies in the classroom to improve teaching and learning outcomes. Differentiating instruction is a critical but not easy area since it calls for methods that incorporate technology together with a variety of appealing activities. Technology in the classroom acts as a potent tool to extend instruction, increase students' interest, and make the teaching-learning process a communicative and knowledge-sharing environment.

The Technological Pedagogical Content Knowledge (TPACK) framework encapsulates the intersection of content expertise, teaching methods, and technological tools. This puts emphasis on the strategic knowledge of teachers in regards to technology, not as an add-on but as part of the integral whole in ensuring effective student learning. Those educators able to combine these aspects shaping new learning spaces and use technology to enhance learning for better efficiency.

The need to acquire 21st-century skills, among them TPACK, is internationally recognized and aligned with the Philippine Professional Standards for Teachers (PPST) under DepEd Order No. 42, s. 2017, which explicitly outlines teachers' required technological, pedagogical, and content knowledge to meet national education standards. Despite this mandate, many teachers report difficulty moving beyond using ICT as a presentation tool. According to the 2019 Southeast Asia Primary Learning Metrics (SEA-PLM), Filipino teachers scored lower in digital literacy integration compared to regional counterparts like Thailand and Malaysia, highlighting a skills gap in meaningful technology integration. Programs in countries like the USA and Singapore emphasize constructionist approaches to develop TPACK and engage teachers in lesson design and reflection. TPACK in mathematics is an approach where technology is integrated into pedagogical and content knowledge to enhance teaching and learning. It involves the use of software for simulations, interactive tools, and digital resources to explain mathematical concepts.

Indeed, most teachers require additional training to be able to integrate technology properly with the pedagogical and content knowledge they already possess. One of the barriers is access to enough technological resources, mainly in under-resourced schools or regions. Ensuring that the use of technology aligns with curriculum standards and learning objectives can be difficult. While technology can facilitate learning, it can also be a distractor for students if used unreasonably. Most schools, especially in rural areas, lack the facilities of needed technological tools such as computers, tablets, or even reliable internet access (Hill & Uribe-Florez, 2020). This makes it hard for the teachers to fully implement the TPACK framework since they cannot integrate technology into their practice. Most mathematics teachers are not equipped with appropriate skills in using the technology as a tool in teaching.

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This leads to a failed implementation of the technology where they are either not utilized or just used in manners that do not promote learning. The teachers will require constant professional development in developing confidence and competence in integrating technology with pedagogy and content knowledge. Similarly, the Mathematics curricula are usually quite rigid with a strong emphasis on standardized testing. This constrains teachers from trying out new ways of teaching that incorporate technology, as they feel pressured to 'cover' definite content in the traditional way in order for students to perform well on exams.

In Thailand, Filipino mathematics teachers are forefront in the educational landscape, both challenging and inspiring. In some classrooms, through the use of private schools, Filipino teachers make use of interactive simulations to help make complex geometric concepts more tangible, using available but resourceful technological tools. In some public schools, Filipino teachers use a combination of storytelling and visual aids to relate mathematical problems to real-life situations, overcoming cultural differences in pedagogy. These teachers, while adapting the local Thai curriculum and integrating culturally relevant examples, face hurdles such as language barriers, limited access to advanced technological resources, and adapting their teaching methods to a diverse student body. With these challenges notwithstanding, Filipino math teachers have shown remarkable resilience and adaptability, continuing to seek ways to engage their students even as they undergo an education system quite different from their own. These scenarios illustrate that the use of their Technological Pedagogical Content Knowledge (TPACK) is proper and required.

For many of these Filipino Math teachers, the ability to integrate TPACK is also shaped by their professional development and the length of their stay in Bangkok. Those who have undergone formal training on innovative pedagogy and technology integration generally have a better grasp of TPACK, where their classroom is always interactive and engaging. Those who have taught in Bangkok for more than five years tend to develop deeper cultural and pedagogical insights, which aid in the adjustment of their teaching approaches appropriately. On the other hand, newly-arrived Filipino Math teachers tend to hold on to traditional methods more while they acclimatize themselves with both the Thai educational system and cultural norms. In addition, the study aimed at examining the Technological Pedagogical Content Knowledge of mathematics teachers in private and public schools in Thailand.

This study tried to find out such differences that may exist among these teachers by examining their TPACK levels in detail. Furthermore, the study investigated how these teachers effortlessly adopt and cultivate TPACK in a cross-cultural environment. The insights gained through this investigation will not only expand our knowledge of TPACK in this unique setting but also lay the groundwork for creating a professional development program specifically designed to empower international educators (Adulyasas, 2021). A growing call to explore math educators' competence in the area of technological pedagogical content knowledge has been heard lately within today's dynamic education environment, characterized by the increasingly technological nature of teaching and learning practices at K-12 levels. This arises due to the fact that the effective integration of technology into classroom practices might further students' interests and engagement in mathematics content through offering a dynamic and enriching environment in which to study math (Ozudogru, 2019).

TPACK research has flourished in many countries, including Thailand and others; however, one notes the apparent gap in the lack of dedicated studies relating to the TPACK proficiency of Filipino educators within this unique educational setting of Thailand. This present research endeavor filled this gap by taking an in-depth look at how socio-demographic factors shape the TPACK development among Filipino mathematics teachers in Bangkok from public and private schools. The findings hold the potential to illuminate pathways for enhancing teacher training programs, refining educational policies, and fostering impactful professional development initiatives, ultimately aiming to elevate mathematics education for all students.

MATERIALS AND METHODS

Research Design

This study utilized the explanatory sequential mixed method design as stated by Creswell (2007). This design was defined by a preliminary quantitative period of data collection and analysis, a subsequent qualitative phase of data gathering and analysis, and a concluding phase of linking or integrating the data from the two distinct strands of data. In this design, qualitative analysis was used to give a clear picture of the quantitative analysis (Dawadi *et al.*, 2021). In this study, qualitative data was used to support the findings of the first quantitative data to have a clearer picture of the problem being investigated.

In the quantitative case, the extent to which Filipino teachers in Thailand possess the necessary Technological Pedagogical Content Knowledge (TPACK) to effectively integrate technology into their teaching practices was described.

The quantitative comparative research technique was used in this study to know the significant differences in the levels of TPACK dimensions (Technological Knowledge, Pedagogical Knowledge, Content Knowledge, Technological Pedagogical Knowledge, and Technological Content Knowledge) among Filipino teachers in Thailand and significant variations in TPACK across different demographic factors, such as years of teaching experience in Thailand, age, gender, and educational attainment.

To be able to appropriately address the research objectives, this study made use of the qualitative research by conducting interviews. In qualitative cases, Filipino teachers' perception of their own TPACK and its impact on their teaching practices, primary barriers hindering the development and integration of TPACK among Filipino teachers in Thailand, and factors facilitating the development and integration of TPACK among Filipino teachers in Thailand was explored.

Research Locale

This research was conducted in Thailand, including several private schools and few public schools that employ Filipino mathematics teachers.

Respondents of the Study

Table 1 shows the distribution of respondents in this research, listing the schools in Bangkok where the participants are employed. It provides details of the number of Filipino teachers and the corresponding number of Mathematics teachers in each school for the study. Although, this study aimed for total enumeration of 120 Filipino Mathematics teachers, the final number of participants was reduced to 60. This decreased was due to the sudden earthquake that happened during the data collection period of the study, where potential respondents declined to complete the questionnaires distributed by the researcher.

Table 1: Distribution of the Respondents

Name of School	Total Population of Filipino Teachers	Number of Math teachers	Samples
American School of Bangkok (Green Valley Campus)	15	1	1
Anglo Singapore International School	40	10	3
Anglo Singapore International School – Korat Campus	30	3	2
Assumption School Thonburi	48	6	3
Assumption College Samutprakan	35	2	2
Banlem School	6	1	1
Bodindecha (Singsinghaseni) School	5	1	1
Concordian International School	63	6	2
Debsiromklao School	10	1	1
Interkids Bilingual School	12	2	1
Intertots Trilingual School	14	3	1
Kasintorn Academy	26	1	1
Ladprao Bilingual School	4	2	1
Metaphap School	2	1	
Minder Pattana School	8	3	3
Nongchok Pittaya Nusorn Mattayom School	7	1	1
Panchasap School	10	1	
Panaya Phattanakan School	17	4	4
Patumwan Demonstration School	1	1	
Phrapamontree School 2	10	5	1
Raffles American International School	5	2	1
Ramkamheng Advent International School	48	5	3
Rajinibon School	5	2	2
Sarasas Witaed Minburi	25	3	3
Sarasas Witaed Romklao	50	10	3
Sainampeung School	3	1	1
Sainamtip School	12	3	1
Saparachinee Trang School	5	2	2
Satit Bangna School	14	10	1
St. Joseph Pechaburi	7	3	1
Suraosaikongdin School	9	3	3
Thai Singapore International School	84	3	2
Thai Sikh International School	17	2	1

Trail International School	8	1	1
Trinity International School	8	3	1
Watluxanalarm School	6	2	2
Watonson School	5	1	1
Wat Samut Kodom School	3	1	
Wat Samut Taram	5	3	1
Wattana Wittaya School	6	1	1
Wat Utaming School	2	1	
Yarida School	2	1	
Yindeewit School	10	2	
Total	702	120	60

Sampling Technique Used

The study employed cluster sampling for quantitative data collection. Cluster sampling is a type of probability sampling where the population is stratified into naturally occurring groups or clusters and then units within the clusters are selected randomly. In this research, every school in Bangkok with Filipino instructors was treated as a cluster, and the number of Filipino math teachers per school was the cluster size.

The sample size for each cluster (school) was based on the number of mathematics teachers in their schools. Bigger schools represented more sample size while small schools had fewer participants. For example, Anglo Singapore International School with 40 Filipino teachers, 10 were chosen as a sample, of all whom are Math teachers, while Banlem School with mere 6 Filipino teachers has only 1 Math teacher participant. For each cluster, all the Math teachers were chosen to be a respondent so that this is done in an unbiased way, no selection bias was committed, and also maintain the integrity of the sampling procedure. There was also a bottom-line sampling requirement to guarantee that all small schools would be covered.

The original plan was a total enumeration of 120 Filipino math teachers. However, during the data collection period, an earthquake struck parts of Thailand, affecting several schools and communities. As a result, some teachers experienced disruptions, emotional stress, and in some cases, temporary school closures. Accordingly, due to careful planning and a desire to adhere to the original sampling plan, the sample size was modified to 60 due to availability and consent to participate during this trying time. Despite this, the 60 completed responses were thoughtfully reviewed to ensure they were still fairly and proportionally distributed based on the study's original criteria. This helped maintain the balance and representativeness of the target group, ensuring the data gathered continues to offer meaningful and reliable insights.

To preserve the integrity of the research, the sample was also obtained in the same cluster sampling way. The selection within each school (cluster) remained random, and representativeness remained as much as the situation permitted. This lowered the overall size of the sample but was an ethical and unavoidable adjustment. The researcher decided that sensitivity to the well-being of participants was the issue and only obtained participation from those who could both physically and emotionally respond. This highlights the unpredictable nature of fieldwork. While the reduced response rate is acknowledged as a limitation, the integrity of the data remains intact. Future studies may benefit from longer data collection periods or strategies that allow flexibility when unexpected challenges arise.

For the qualitative component, purposive sampling was used. Purposive sampling is a non-probability method of sampling that considers intentionally choosing participants with some inclusion criteria appropriate to the objectives of the study. The participants must be: Filipino math teachers who are presently teaching in public or private schools in Thailand; Having at least two years of teaching experience, to ensure diverse representation of the local setting and adoption of the TPACK model; Ideally with a background in professional development activities in content knowledge, pedagogy, or technology integration.

Excluded from the qualitative sample were teachers who: Were not Filipino or did not teach mathematics in schools; Had less than two years of experience teaching in Thailand; Were not in active classroom roles like those working in administrative or non-teaching roles. These parameters ensured participants possessed the experience level needed to provide informed comment on incorporating TPACK into math instruction in Thailand.

While the quantitative sampling plan had to be pragmatically adapted due to a natural disaster, the study retained methodological rigor and ethical responsibility, and the sample continued to reflect the diversity and distribution of Filipino mathematics teachers in Bangkok schools.

Research Instrument

For this quantitative study, the researcher used one adopted questionnaire and an interview guide in order to expedite data collection. The questionnaire was delivered to responders using Google Forms, ensuring its accessibility and completion.

After each questionnaire was filled out, data will be collected, processed, and interpreted. The researchers will lead the entire process and make certain that the collection of data is accurate and on time.

Part I: Demographic Information. This section attempts to gather information on personal profiles of the respondents such as their age, sex, highest educational level, and length of service.

Part II: TPACK Assessment. Data gathering tool to be used in getting an insight into the extent Filipino teachers in Thailand have the required TPACK in enabling them to infuse technology effectively into classroom practices. Likert scale will be used since it is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research (Joshi *et al.*, 2015).

The Likert scale is a used tool to gauge opinions and insights, on subjects such as attitudes and values among others (Thanavathi 2022). It comprises a range of statements that individuals can select from to express their feedback, on assessment queries.

In the qualitative phase of the study, the researcher used thematic analysis to examine Filipino mathematics teachers' perceptions of their Technological Pedagogical Content Knowledge (TPACK) and its influence on their teaching practices. Braun and Clarke (2006) thematic analysis was used to guide the researcher in the course of the qualitative research. Braun and Clarke thematic analysis has six-phase framework which is widely recognized for its flexibility and rigor in this kind of research. These six phases include: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report.

Semi-structured interviews were employed to delve further into Filipino mathematics teachers' views on their Technological Pedagogical Content Knowledge (TPACK), how it is being hampered, and the support contributing towards its acquisition in Thai education. Sample size for qualitative study was guided by traditional qualitative research literature regarding sample sizes. According to Guest, Bunce, and Johnson (2006), saturation of data, or when no new data or themes emerge from the data, can be achieved through 6 to 12 interviews when the participants are very homogeneous and the research question are focused. Similarly, Creswell and Poth (2018) recommend 5 to 25 participants are generally sufficient for phenomenology studies, depending upon the depth and nature of questioning.

In this study, 13 Filipino mathematics teachers were interviewed. Participants were purposively chosen according to teaching experience and direct involvement with the integration of technology in the classroom. The sample was not strictly limited but was guided by the data saturation theory. Transcribing, coding, and analyzing the data were done immediately after each interview and used Braun and Clarke's (2006) six-phase thematic analysis framework. The simultaneous collection and analysis of data allowed the researcher to observe while saturation was occurring.

Saturation of the information was determined to be reached after no new themes or codes were generated from the interviews, and the responses were repetitive, which suggested that additional interviews would not provide much new information. Particularly, in the ninth interview, repetition of the themes was guaranteed, and other interviews assured the repetition of the already established themes. This ensured the qualitative data was rich as well as embedded in the life situation of the participants without unnecessarily prolonging the data collection process.

Semi-structured interviews were carried out to gather rich information from sampled Filipino math teachers in Bangkok. Interviewing centered on three major areas: (1) self-concepts of sampled teachers of themselves and their TPACK and how this affects their everyday teaching, (2) major constraints that prevent integration and development of TPACK among Filipino teachers in Thailand, and (3) major facilitators assisting or enhancing the integration and development of TPK in their learning environment.

In thematic analysis, themes and patterns were officially recognized and built to account for the participants' daily experiences, challenges, and strategies about implementing TPACK. This qualitative element infused richer meaning to the quantitative findings and provided cutting-edge insights regarding contextual and individual influences on developing TPK in international school settings. Use of Braun and Clarke's method ensured methodological precision and robustness, enabling the researcher to make meaningful inferences from the data.

Scaling and Quantification

The research assessed grades according to four aspects utilizing the 4 point Likert Scale, Technology Knowledge (TK) Content Knowledge (CK) Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK). Participants were provided with a scale to express their agreement or disagreement, with statements concerning their TPACK proficiency level. It scores from 1 to 4 and implies that the higher one scores will show greater agreement or capability in a selected learning method and score from 1 to 4 indicating extreme lows to very high levels. The level of TPACK among the teachers was measured using a quantitative measure. It has a score range corresponding to different levels, which includes Very High, High, Low, and Very Low.

The researcher planned to utilize the 4-point Likert Scale which involves asking participants to express their level of agreement or disagreement, with a set of statements regarding the objects being studied. Below is Table 2 that outlines the scale and how it is used to evaluate teachers' TPACK proficiency levels.

Table 2: Scale and its interpretation for evaluating the TPACK proficiency of teachers

Option	Score Range	Description
4	3.50 – 4.00	Very High
3	2.50 – 3.49	High
2	1.50 – 2.49	Low
1	1.00 – 1.49	Very Low

Data Gathering Process

The researcher adhered to the outlined method in order to gather data for this study. Before proceeding, the researcher first secures the required approval of the survey questionnaire from the research adviser. The required permissions from the Dean of the University were then be acquired. The researcher will proceed with the study after obtaining these approvals, concentrating on evaluating teachers' TPACK levels as part of the data gathering procedure. The study's main focus was the Filipino math teachers, who will be encouraged to assess their own TPACK proficiency. By using Google Forms to distribute the questionnaires electronically, the researcher guaranteed the timely collection of data; responds were gathered remotely to prevent missing or insufficient data. The researcher then continued and analyzed the information obtained. There was also an acknowledgment of trends or patterns in the responses and drawing meaningful inferences from the data. Findings and discussions served as the foundation upon which conclusions and recommendations were built.

In conclusion this study research utilized a methodical approach to data collection. The required approvals were secured, and the study was remotely administered to Filipino math teachers by the researcher. The teachers' responses were gathered. After then, the data was evaluated, interpreted, and used to draw findings and make suggestions.

Statistical Treatment of Data

The following statistical procedure will be used to the data collected for this study. In assessing the teachers TPACK level a combination of weighted mean and ranking was applied. The TPACK framework was examined across four dimensions. Technology Knowledge (TK) Content Knowledge (CK) Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK). To calculate this value the total number of observations was multiplied by the value of each observation considering its frequency and other relevant factors.

Frequency and percentage will indicate the socio demographic characteristics of the survey participants such, as age group distribution and education level attained along with their tenure, in service roles. For unequal subgroup sizes representation, the percentage method will be implemented. Similarly, in this research the percentage method proved ideal to gauge how many respondents provided responses. Frequency will track the occurrences of each variable throughout the study. In statistics lingo, "frequency" refers to how each score or event takes place.

Statistical tools like descriptive statistics, such as mean and standard deviation, non-parametric tests such as Mann-Whitney U test and Kruskal-Wallis test was used to determine differences between TPACK and demographic factors while Friedman Test was used to determine whether significant differences exist. These findings informed professional development programs and enhanced technology integration in mathematics education.

Thematic analysis was utilized in analyzing the Filipino teachers' perception of their own TPACK and its impact on their teaching practices, primary barriers hindering the development and integration of TPACK among Filipino teachers in Thailand, and factors facilitating the development and integration of TPACK among Filipino teachers in Thailand.

Ethical Considerations

Before collecting data commences a quick review of the research goals was conducted as part of the academic criteria. The researcher sought permission, from the participants of the research. Ask about their availability. The researcher ensured that the participants were briefed about the aims of the research and they willingly agreed to take part in it. The researcher emphasized the importance of honesty and integrity, in ensuring the success of this project and affirm that participants have the option to withdraw their data if they feel pressured or fear reprisal especially when their own interests are, at risk. The data collection process commenced upon receiving agreement from all participants.

RESULTS AND DISCUSSION

Demographic Profile

Age

The largest age group of the respondents are 31-40 years old, and the largest group among the survey respondents. The second largest age group is 41-50 years at 28.3%, and the 21-30 year-old group at 20%. Surprisingly, only two respondents fell into the 51-60 year age bracket, which represents a mere 3.3%. This indicates that the population used for the survey represents a majority of young to middle-aged people. This demographic trend aligns with the conclusion of Abdullahi (2019), which was that socio-demographic attributes vary systematically with time. As 48.3% of the respondents were within the age group of 31-40 years, it can be seen that the majority of Filipino teachers in Thailand are at the height of their teaching careers and have a lot of experience in teaching and actively practicing teaching.

The 41-50 age group comprises 28.3% of the respondents, which points towards a group having vast experience in teaching. While the younger teaching group of age 21-30, consisting of just 20% of respondents, seems tiny. Also, Eggen *et al.* (2023) highlight the significance of the consideration of socio-demographic differences in research so that biased outcomes are avoided. The relatively few respondents who fall in the range of 51-60 indicate that Filipino educators in Thailand could be changing occupations or heading home before they reach retirement. The most numerous age group of respondents is aged between 31-40 years, which comprises most of the questionnaire respondents.

Gender

The gender distribution of the respondents is fairly

Table 3: Distribution of Respondents in Terms of Age

Age	Frequency (N)	Percentage (%)
21 - 30	12	20
31 - 40	29	48.33
41 – 50	17	28.33
51 – 60	2	3.33
Total	60	100

balanced at 51.7% female and 48.3% male. This virtual parity indicates that Filipino math teachers in Thailand are a diverse group and are subject to little, if any, gender imbalance when it comes to access to work. The balanced ratio indicates that the male and female teachers have the same level of involvement in the profession and make the same contribution to the academic environment in private and state schools. This resonates with Vuksanovic *et al.*'s (2017) results, where the researcher noted that the gender disparities hardly influence the population beliefs and working participation. Moreover, this suggests that the Filipino female and male teachers both enjoy equal chances in professions for employment opportunities in Thailand, confirming non-gendered discrimination in workplace placement among Thai employers. In addition to this, Abdullahi (2019) further attested that socio-demographic factors are shaped by numerous competing forces that encompass demographic and psychosocial dimensions. This gender balance representation means that Filipino mathematics teachers in Thailand have the same career progression, employment demands, and professional acknowledgment regardless of gender.

Table 4: Distribution of Respondents in Terms of Gender

Gender	Frequency (N)	Percentage (%)
Male	29	48.3
Female	31	51.7
Total	60	100

Education

A major majority of respondents (78.3%) hold a bachelor's degree, followed by 11.7% at the master's level, and 8.3% having completed their master's degree. Notably, only 1.7% possess professional certifications, and none have obtained a doctorate, reflecting a scarcity of advanced academic qualifications beyond the master's level. According to Abdullahi (2019), socio-demographic attributes are acquired progressively, meaning higher levels of education generally correspond to greater professional advantages. However, the lack of doctorate holders suggests that Filipino teachers in Thailand may prioritize practical teaching experience over further academic qualifications.

In particular, 78.3% are bachelor's degree holders, most commonly being the criterion in teaching positions among different foreign and private schools. Similarly, 11.7% are currently in the middle of pursuing their master's degree (in progress), while 8.3% are already degree holders. There is clear indication that a meager 1.7% are professional certificate holders, and far removed from that, there are none with doctor's degree and pursuing programs. This pattern indicates that although the majority of Filipino teachers in Thailand are qualified according to typical requirements, few have academic achievement beyond the master's level. The lack of doctorates implies that additional studies and specialization in mathematics education may not be on the priority list of this group, possibly due to limitations like workload, funding constraints, or the type of teaching work.

Eggen *et al.* (2023) noted that socio-economic factors should be taken into account when assessing educational achievement. The dominance of bachelor's degree holders means that most Filipino teachers might not have adequate financial or institutional support for postgraduate study or might not see a doctorate as a prerequisite for their teaching positions. Other than that, Thai schools might have low expectations of postgraduate qualifications, which could reduce motivation to study further.

Table 5: Distribution of Respondents in Terms of Highest Educational Attainment

Highest Educational Attainment	Frequency (N)	Percentage (%)
Doctorate Degree	0	0
Doctor's Level	0	0
Professional Certifications	1	1.7
Master's Degree	5	8.3
Master's Level	7	11.7
Bachelor's Degree	47	78.3
Total	60	100

Length of Service

The majority of the respondents, 38.3%, have taught in Thailand for 10 or more years, followed closely by 35% who have between 5 and less than 10 years' experience. There is a smaller group, 18.3%, who have worked for one to less than two years, and the lowest group is the 8.3% with two to less than five years' experience. This shows that the majority of the respondents have considerable teaching experience in Thailand.

These results uncover a high percentage of veteran teachers among the respondents' sample. The 38.3% of the sample with over a decade of experience is especially striking, and the 35% with 5 to under 10 years of experience also suggests high professional maturity. This suggests that the majority of Filipino mathematics teachers have established long-term careers in Thailand and show job stability and continued professional engagement in the education sector. This aligns with Abdullahi (2019), who described socio-demographic characteristics as evolving through a continuum of professional competition. Those with longer teaching experience likely acquired stronger credentials, adaptability skills, and career advantages over time, enabling them to sustain their employment.

Furthermore, Eggen *et al.* (2023) highlight the importance of considering socio-demographic characteristics in professional settings. About 18.3% of respondents have been teaching for one to less than two years, indicating a steady influx of new Filipino teachers entering the profession. The lowest proportion (8.3%) comprises those who have worked for two to less than five years, which suggest that some teachers either transition to different schools, move to other countries, or return to the Philippines after gaining short-term international teaching experience.

Table 6: Distribution of Respondents in Terms of Length of Service in Thailand

Length of Service in Thailand	Frequency (N)	Percentage (%)
10 years and more	23	38.33
5 years and less than ten 10 years	21	35
2 years and less than 5 years	5	8.33
1 year and less than 2 years	11	18.33
Total	60	100

Extent of Filipino Teachers' Technological Pedagogical Content Knowledge (TPACK) in Thailand Technological Knowledge (TK)

The highest-rated indicator is "I can learn technology easily" (3.58, Very High), while the lowest is "I know about a lot of different technologies" (3.00, High). Overall, the average score across all respondents is 3.34 with a standard deviation of 0.60, categorized as High, which demonstrates a strong but not exceptional level of technology knowledge among them.

The evaluation of Technology Knowledge (TK) among Filipino mathematics teachers in Thailand shows a generally high proficiency in using technology within their teaching practices, achieving an overall mean score of 3.34 (High). Interestingly, the most rated response, "I can learn technology easily" (3.58, Very High), indicates that most of the respondents were confident in learning to accommodate new technology tools and systems. Such adaptability is important in the current technology-based learning system, where skill upgradation needs to be continuous for effective deployment of digital learning.

The Technology Knowledge (TK) test of Filipino math teachers in Thailand reveals a relatively high capacity to use technology in teaching tasks with an aggregate mean score of 3.34 (High). Of note here is the highest-rated statement, "I can learn technology easily" (3.58, Very High), indicating that most of the respondents believe in learning new technology tools and systems. This flexibility is essential in the technology-based learning environment of today, where continuous skill development is necessary to properly integrate digital learning.

These findings corroborate with the findings of Lyublinskaya and Kaplon-Schilis (2022) where they noted that most teachers are faced with difficulties in the incorporation of technology in their instruction since they lack adequate training, lack familiarity with digital tools, and are lost with respect to applying technology. Although the respondents in this survey demonstrated a fairly high technology literacy, the low scores on exposure to varied technologies reflect that professional development activities should make them familiar with a variety of digital technologies. Mailizar *et al.* (2021) also stressed the significance of on-going learning and professional growth as they explained OTPD as an easy and flexible method of maintaining teachers updated with new trends.

The findings, highlighting teachers' high capacity for self-learning, indicate that they are best placed to capitalize on online learning environments that have the potential to bridge technology knowledge gaps. Yet, the findings also indicate that teachers might require guided leadership to navigate multiple technologies besides what they are already doing.

Furthermore, Hill and Uribe-Florez (2020) underscored that TPACK is not an issue of understanding technology but having the capability to integrate it with pedagogy and content knowledge. Although the respondents are highly technology-enabled, it is possible that their capacity for using technology in a strategic way to improve instruction may need some professional development and guidance. This affirms that teachers need better access to education technologies from schools, not simply in an individual learning capacity but through organized, collaborative training modules.

The demographic results help explain the high but not exceptional level of technology knowledge among Filipino mathematics teachers in Thailand. The majority of teachers (61.7%) fall within the 27-42 age group, an age range where educators are likely to be comfortable with digital tools but may not have grown up with advanced technology as part of their education. This could explain why they find it easy to learn new technologies (3.58, Very High) but may not have extensive exposure to a variety of digital tools (3.00, High).

Furthermore, the fact that 78.3% of respondents hold only a bachelor's degree suggests that many have not undergone advanced technology training at the graduate level. This supports Lyublinskaya and Kaplon-Schilis (2022), who noted that the lack of formal training in digital pedagogy can be a significant barrier to technology integration. While they possess basic digital literacy skills, their exposure to specialized technology-enhanced teaching strategies may be limited.

Additionally, 38.3% of respondents have been teaching in Thailand for over 10 years, while 35% have 5 to 10 years of experience. This suggests that most respondents began their teaching careers prior to the widespread adoption of digital learning tools. Their evident adaptability to technology implies that they have actively upgraded their skills over the years. But their lower marks in their knowledge of most technologies can confirm that their exposure is mainly limited to the software they have learned within their present learning systems.

The findings of the research show that Thai Filipino mathematics teachers possess a solid base for using technology, and there are more than enough of them who can benefit from more exposure to other computer technologies. Their high adaptability and learning mentality affirm that they are high when it comes to being able to accumulate their technology skills through adequate training and teaching.

Table 7: Mean Perception of the Respondents on the of Level of Technology Knowledge (TK) of Mathematics' Teachers

Statements	Mean	SD	Interpretation
I know how to solve my own technical problems.	3.52	0.54	Very High
I can learn technology easily.	3.58	0.53	Very High
I keep up with important new technologies.	3.43	0.56	High
I frequently play around with the technology.	3.28	0.64	High
I know about a lot of different technologies.	3.00	0.64	High
I have the technical skills I need to use technology.	3.30	0.70	High
I have had sufficient opportunities to work with different technologies.	3.25	0.60	High
Overall Score	3.34	0.60	High

Content Knowledge (CK)

The most highly rated was "I can use a mathematical way of thinking" (3.48, High), and the lowest rated was "I have sufficient knowledge about mathematics" (3.42, High). Having an average score of 3.45 (High) and a standard deviation of 0.63, suggests that the respondents are well aware of mathematics, but there is still room for improvement.

The results show that Filipino mathematics teachers in Thailand have a good content knowledge (CK) with a mean of 3.45. The most highly rated statement, "I can use a mathematical way of thinking" (3.48, High), is the self-evaluation by respondents that they can use logical thinking and mathematical structures for solving problems. This indicates their sound theoretical background in mathematics to effectively teach.

At the same time, the lowest-rated statement, "I have enough knowledge on mathematics" (3.42, High), indicates that though teachers are assured of their subject, there may be some areas where their confidence wanes. This may be due to gaps in knowledge of advanced mathematical concepts or ongoing need for professional growth so as to keep up with progress in mathematics education. The measure "I have different ways and strategies for building up my knowledge of mathematics" (3.45, High) affirms that teachers are investigating many ways of developing their math knowledge, but there is still scope for enhancing their knowledge as well as teaching practices.

These results reflect the TPACK model of Lyublinskaya and Kaplon-Schilis (2022), who are of the opinion that content knowledge (CK) is a foundational pillar of good pedagogy. They are of the opinion that, in addition to subject matter knowledge, teachers also need to know how to teach it. The very high CK scores reveal that Filipino teachers in Thailand are mathematically well-prepared, but minute discrepancies in scoring reveal that there is still a demand for ongoing training to build and hold more information.

In addition, Valtonen *et al.* (2019) elaborate that possessing content knowledge is not sufficient but should also be coupled with technology and pedagogical knowledge to ensure quality learning experience. Although evidence indicates that Filipino math teachers possess superb math foundations, passing on such knowledge in some other alternative forms of pedagogies and also being capable to incorporate technology without difficulty in instruction are what require examination. Especially so now wherein technology-inclu-sion teaching has turned more into focus.

Further, Goos *et al.* (2020) emphasize the growing demand for mathematics teaching through online professional development. Their findings indicate that despite the fact that teachers possess an effective grasp of mathematics, platforms of online learning could be most instrumental in maintaining their capabilities. This supports the imperative of continuous education and contact with new math theories, pedagogies, and computer-aided resources in order to empower teachers with enhancing their own pedagogic approaches and capacities in solving complex mathematical problems.

The demographic characteristics of the participants put into perspective the high, yet not outstanding, prevalence of content knowledge observed. A large number of the participants (61.7%) belong to the age group of 27-42 years, a group where teachers are usually experienced but still willing to continue their development. This is proof that even though they possess good mathematics skills, they require continuous education to remain updated on advancements in their profession.

Also clearly visible is the level of educational background among the respondents. With a paltry 78.3% possessing only a bachelor's degree, their knowledge base would thus largely be derived from undergraduate studies, depriving them of exposure to graduate-level mathematics. The lack of doctorate degree holders also bring to light this fact. As mentioned by Lyublinskaya and Kaplon-Schilis (2022), technical education and graduate studies have a highly crucial role in enhancing the ability of a teacher to be effective in delivering complex material. This would mean that, although Filipino math teachers in Thailand are familiar with their subject matter, more opportunities for graduate studies or technical education in mathematics can further enhance their content knowledge.

It is also interesting to note that 38.3% of the participants possess over 10 years of class experience, meaning a tremendous amount of class exposure. Classroom exposure does not always translate to control over content knowledge, and this is seen from the moderate reading of "I have enough knowledge about mathematics" (3.42). This suggests that even though their class experience is high, formal mathematical knowledge needs to be updated, especially in new ideas and pedagogy.

The overall findings reveal that Filipino mathematics teachers in Thailand have a strong mathematical foundation, but there is scope for enhancing their knowledge and teaching methods. Their high content knowledge (CK) is aligned with their extensive experience and undergraduate studies; however, pursuing further professional development, higher studies, and exposure to new mathematical theories would make them more confident and effective in the subject.

Table 8: Mean Perception of the Respondents on the of Level of Content Knowledge (CK) of Mathematics' Teachers

Statements	Mean	SD	Interpretation
I have sufficient knowledge about mathematics	3.42	0.59	High
I can use a mathematical way of thinking.	3.48	0.65	High
I have various ways and strategies of developing my understanding of mathematics.	3.45	0.65	High
Overall Score	3.45	0.63	High
I have the technical skills I need to use technology.	3.30	0.70	High
I have had sufficient opportunities to work with different technologies.	3.25	0.60	High
Overall Score	3.34	0.60	High

Pedagogical Knowledge (PK)

All indicators received very high ratings, with "I know how to assess student performance in a classroom" (3.78) ranking as the highest. The lowest-scored item was "I am familiar with common student understandings and misconceptions" (3.53, very high). The overall mean score of 3.65 (very high) and standard deviation of 0.50 reflect the very high pedagogical knowledge of the respondents. Results show that Filipino mathematics teachers in Thailand have very high PK, which has a mean overall score of 3.65. This indicates that these teachers are more effective at assessing student performance, modifying their teaching style, employing multiple instructional strategies, and managing classrooms. The highest-rated measure, "I know how to evaluate student learning outcomes in a classroom" (3.78, Very High), indicates the teachers' confidence in being able to assess student learning outcomes, which is important to making informed instructional decisions and providing targeted support.

On the other hand, the least-rated indicator, "I am familiar with common student understandings and misconceptions" (3.53, Very High), although still within the very high range, shows that there are a few teachers who might benefit from additional training to be better at recognizing and dealing with specific misconceptions in mathematics. This points to a potential lack of diagnostic teaching practices, which are central to being able to tailor teaching to the needs of students. However, the uniformly high scores in all domains attest to the fact that Filipino teachers are not just exceptionally competent at pedagogy but also effective in imparting quality mathematics lessons.

The findings concur with the study of Mohammadpour and Maroofi (2023), whose research established that professional training programs significantly increase the pedagogical knowledge of teachers. Their research underscored the importance of systematic teacher training programs, such as those implemented in TTU, which support graduates with better content knowledge (CK) and pedagogical knowledge (PK). This can mean that Filipino mathematics teachers in Thailand most likely underwent strong pre-service teacher education but may also require ongoing professional development to handle student misconceptions more effectively.

In yet another similar study, Aktaş and Özmen (2020) illustrated how TPACK development training enhances the PK, CK, and TK of instructors. This attests to the fact that repeated training and microteaching exposure have a central role to play in strengthening the pedagogical skills of teachers. The very high levels of PK scores among Filipino math teachers attest to a strong pedagogical base, but the addition of technology-facilitated interventions could further enhance their capacity to assess and fill the learning gaps of students.

Moreover, Lyublinskaya and Kaplon-Schilis (2022) emphasized the importance of systematic assessment instruments, such as the TPACK Levels Rubric, in evaluating pedagogical skills of teachers. The consistently high scores in PK suggest that Filipino mathematics teachers are confident in their pedagogical practices, but incorporating technology-enabled assessment methods may further improve their ability to identify student misconceptions and adjust their lessons accordingly.

The demographic characteristics of the respondents help explain their high pedagogical knowledge levels. The majority of teachers (61.7%) belong to the 27-42 age group, a stage in their careers where they likely have gained substantial teaching experience and developed adaptive instructional techniques. The high PK scores reflect the experience and expertise that comes with years of practice, supporting the idea that mid-career teachers have refined their ability to assess student performance and employ a variety of teaching strategies.

Additionally, the high percentage of bachelor's degree holders (78.3%) suggests that most teachers received formal training in pedagogy but may have limited exposure to advanced education techniques at the graduate level. This aligns with Mohammadpour and Maroofi (2023), who emphasized the need for specialized pedagogical training programs beyond initial teacher preparation. The lack of doctorate holders in the sample indicates that while teachers have strong foundational PK, there may be opportunities for further academic enrichment in instructional methodologies.

Moreover, 38.3% of respondents have been teaching in Thailand for over 10 years, and 35% have 5 to less than 10 years of experience. This extensive classroom experience likely contributes to their high PK scores, as they have had years to refine their teaching techniques and classroom management skills. However, the lower rating on identifying student misconceptions suggests that even experienced teachers could benefit from professional development focused on diagnostic teaching techniques and formative assessment strategies.

The results indicate that Filipino mathematics teachers in Thailand exhibit strong pedagogical knowledge, with very high proficiency in student assessment, classroom management, and instructional adaptability. These strengths are likely shaped by their formal teacher training, years of teaching experience, and exposure to diverse student needs. However, the slightly lower rating on identifying student misconceptions suggests a potential area for improvement.

Table 9: Mean Perception of the Respondents on the Level of Pedagogical Knowledge (PK) of Mathematics' Teachers

Statements	Mean	SD	Interpretation
I know how to assess student performance in a classroom	3.78	0.42	Very High
I can adapt my teaching based upon what students currently understand or do not understand.	3.77	0.46	Very High
I can adapt my teaching style to different learners.	3.70	0.50	Very High
I can assess student learning in multiple ways.	3.63	0.55	Very High
I can use a wide range of teaching approaches in a classroom setting.	3.57	0.53	Very High
I am familiar with common student understandings and misconceptions	3.53	0.50	Very High
I know how to organize and maintain classroom management.	3.55	0.57	Very High
Overall Score	3.65	0.50	Very High

Pedagogical Content Knowledge (PCK)

This category received the lowest mean scores among the knowledge components, with a single item, "I know that different mathematical concepts do not require different teaching approaches", scoring 3.07 (High) with standard deviation of 0.82. This suggests that while respondents understand pedagogical strategies, they may have limitations in integrating content-specific instructional methods.

The results indicate that Filipino mathematics teachers in Thailand have a high level of Pedagogical Content Knowledge (PCK), with an overall mean score of 3.07. However, this category received the lowest scores among the different TPACK components. The single item assessed, "I know that different mathematical concepts do not require different teaching approaches", suggests that while teachers are aware of general pedagogical strategies, they may face challenges in adapting their instructional methods to different mathematical topics.

A score of 3.07 (High) and SD of 0.82 suggest that teachers somewhat agree with the idea that mathematical concepts can be taught using similar approaches. However, research indicates that effective mathematics instruction necessitates a variety of pedagogical techniques customized to specific topics (e.g., problem-solving methods for algebra compared to visual representations for geometry). This finding suggests that there are some teachers who do not use content-specific instructional strategies entirely, which may restrict students' knowledge and engagement in learning mathematics.

The lower ranking of PCK in comparison to other TPACK components aligns with the findings of Mohammadpour and Maroofi (2023), who noted major variation in teachers' PCK levels depending on their training background. Their study emphasized that structured professional development programs, like those provided by teacher training universities (TTUs), can greatly enhance PCK by exposing educators to a wide array of instructional strategies. The relatively lower PCK score in this research indicates that the majority of Filipino teachers in Thailand might not have received specialized mathematics pedagogy training, which can be the reason why they have limited differentiation in instructional strategies.

In a similar vein, Aktaş and Özmen (2020) highlighted the importance of TPACK-specialized training and reported that pre-service teachers who were instructed in TPACK-oriented training possessed greater pedagogical content knowledge. Their research suggested that factors like training, microteaching, and school practice applications lead to improved integration of pedagogical and content knowledge for teachers. The findings of this research indicate that Filipino mathematics teachers in Thailand would highly benefit from professional development interventions aimed at diversifying pedagogical strategies for different mathematical concepts.

Also, Hill and Uribe-Florez (2020) highlighted the foundational relationship between teacher technology confidence and teaching styles. From their findings, teachers with higher confidence in teaching strategies are better at integrating technology into curriculum-specific instruction. The lower PCK score in this research suggests that teachers might struggle to differentiate their pedagogical practices, which in turn affect their ability to use technology optimally to a specific content. Secondly, Rakes *et al.* (2022) found that secondary maths teachers showed better teaching practice but showed minimal PCK growth, showing a lack of alignment between pedagogical practice and knowledge about content.

This result validates the result of this research, where Filipino educators in Thailand had both high pedagogical knowledge (PK) and content knowledge (CK) but cannot utilize them (PCK). For this reason, teacher professional development programs must aim not only to enhance the mathematical teacher knowledge but also to increase their ability to implement different instruction techniques into different concepts. Currently, the majority of teachers (78.3%) have only a bachelor's degree, with hardly any group having professional certifications or higher degrees. Research such as that by Mohammadpour and Maroofi (2023) emphasizes that structured teacher training programs considerably enrich PCK development. The lack of doctoral degree holders within the respondent pool suggests that many may have missed out on advanced content-specific pedagogical instruction, potentially leading to the lower PCK scores observed.

Most of the participants (38.3%) have been in service for more than a decade, and then 35% with experience ranging from 5 to 10 years. Although much teaching experience is desired, remember studies show years in service do not necessarily translate to greater PCK unless teachers receive constant professional development (Andrian *et al.*, 2022). These results suggest that while Filipino teachers in Thailand have gained pedagogical experience, they might not have undergone focused training in applying instructional strategies to targeted mathematical knowledge. Mailizar *et al.* (2021) discussed that more TPACK-proficient teachers use online professional development. The comparatively low PCK score indicates that the Filipino teachers in Thailand might not have access to organized training to differentiate instruction strategies for different math concepts.

The results are so that although Filipino math teachers in Thailand score quite high (3.07) in the domain of PCK, it is a limitation to them, especially in utilizing varied mathematical content in order to develop educational plans. Their lower score in PCK, relative to the higher scores in CK and PK, would require content-based instructional practices-oriented professional development courses.

Table 10: Mean Perception of the Respondents on the Level of Pedagogical Content Knowledge (PCK) of Mathematics' Teachers

Statements	Mean	SD	Interpretation
I know that different mathematical concepts do not require different teaching approaches	3.07	0.82	High
Overall Score	3.07	0.82	High

Variation of TPACK Across Demographic Factors Among Filipino Teachers in Thailand

Table 11 presents results of non-parametric tests, i.e., Mann-Whitney U test and Kruskal-Wallis test, to determine whether there are significant differences among TPACK levels along some demographic variables such as, age, gender, education, and years of service. All demographic variables' p-values and TPACK dimensions' p-values are higher than the 0.05 significance level, showing there are no significant differences among TPACK levels of Filipino teachers in Thailand along these variables.

This discovery indicates that demographic variables like age, gender, educational level and years of service do not have any effect on teachers' ability to employ technology in instruction. Filipino educators in Thailand must have had equal levels of access to technology and professional development training irrespective of their demographic characteristics. Having a similar method of integrating technology into classrooms in schools may have helped different demographic groups to have equal levels of TPACK.

This finding is consistent with that of Rakes *et al.* (2022), who established that though teachers showed differences in teaching practice during the COVID-19 pandemic, growth in TPACK was not significantly affected by demographics like age or teaching years. As in this research, professional development and institutional support appear to have a more significant effect on

TPACK than demographic variation. In addition, Hill and Uribe-Florez (2020) highlight the significance of pedagogy and teacher self-efficacy in the integration of technology over age and gender, further corroborating the argument that external factors are more integral to technology uptake than personal demographic attributes. No significant gender differences indicate that the level of TPACK between male and female teachers is not drastically different for Thai Filipino instructors. This might be due to chances of professional growth without consideration for gender plus open access to computers, an evidence that demonstrates gender equality as regards provision of training, teaching devices, pedagogy for fostering their proficiency when it comes to applying computerization in the job. The absence of significant disparity indicates the existence of wider cultural or institutional influences in the school environment, which prefer equal technological assistance to both men and women.

This finding aligns with Hill and Uribe-Florez (2020), who found that teachers' self-efficacy in teaching mathematics using technology was more influenced by pedagogical practices and continuous training than by gender disparities. Similarly, Mohammadpour and Maroofi (2023) highlighted that certain teacher preparation programs, such as TTU's, raise content and pedagogical knowledge without being influenced by the teacher's gender. This supports the notion that gender-neutral training programs are effective in promoting TPACK regardless of gender, aligning with the findings from Table 12.

Table 11: Differences of TPACK across Demographic Factors

Demographic Variable	TPACK Dimension	Test Used	p-value	Interpretation
Gender	TK	Mann-Whitney U test	0.347	No differences
	PK	Mann-Whitney U test	0.784	No differences
	CK	Mann-Whitney U test	0.073	No differences
	PCK	Mann-Whitney U test	0.739	No differences
Age	TK	Kruskal-Wallis Test	0.953	No differences
	PK	Kruskal-Wallis Test	0.969	No differences
	CK	Kruskal-Wallis Test	0.432	No differences
	PCK	Kruskal-Wallis Test	0.204	No differences
Educational Attainment	TK	Kruskal-Wallis Test	0.576	No differences
	PK	Kruskal-Wallis Test	0.287	No differences
	CK	Kruskal-Wallis Test	0.128	No differences
	PCK	Kruskal-Wallis Test	0.653	No differences
Length of Service	TK	Kruskal-Wallis Test	0.653	No differences
	PK	Kruskal-Wallis Test	0.956	No differences
	CK	Kruskal-Wallis Test	0.534	No differences
	PCK	Kruskal-Wallis Test	0.251	No differences

Differences in TPACK Dimensions Among Filipino Teachers in Thailand

Table 12 displays the results of the Friedman test, which examines whether important differences exist among the TPACK dimensions. The p value result of <0.001 shows that there is statistically significant difference in the median scores across different TPACK dimensions. The chi-square value of 24.928 (df = 3) means that not all dimensions were rated equally, which suggest variability in the teacher's perspective in all four areas. The mean rank showed that Filipino teachers in Thailand were more confident in their Pedagogical Knowledge being given the highest mean rank score of 3.08. On the other hand, PCK received the lowest mean rank of 2.05, which showed that this was the least emphasized or developed among the four dimensions. TK and CK were given somewhere in the middle positions based on mean rank scores of 2.28 and 2.58 respectively.

This result agrees with present literature among educators emphasizing variability between TPACK elements. For example, a survey study by Wen and Shinas (2020) assessed growth in TPACK development by pre-service instructors with significant advancements in all elements except Pedagogical Knowledge (PK), variability dominating in self-assessment ability across TPACK elements. In the same vein, Doukakis *et al.* (2021) had investigated in-service computer science teachers, and they obtained higher ratings in Content Knowledge (CK) and Technological Knowledge (TK), but lower self-confidence in Pedagogical Content Knowledge (PCK) and Technological Content Knowledge (TCK), reflecting unbalanced TPACK component development.

The studies point to the imperative necessity of professional workshops designed to bridge specific deficiencies in technological consciousness, finally leading to a more equally balanced TPACK profile for instructors. Teachers are able to enhance the application of technology in their teaching practices by developing their technological skills, finally leading to improved teaching performance.

Table 12: Differences of TPACK among Filipino Teachers in Thailand

Ranks	**Test Statistic**			**Rank**
	Mean Rank			
TK	2.28	N	60	
PK	3.08	Chi-square	24.928	
CK	2.58	Df	3	
PCK	2.05	Asymp.Sig.	<0.001	significant

Table 13 shows the result of the Wilcoxon Signed-Rank Tests, which were performed to determine significant differences among TPACK dimensions. Post-hoc pairwise tests were carried out after determining significant effects when three or more levels of a factor were present. Bonferroni-adjusted alpha level of 0.0083 (0.05 ÷ 6) was also employed.

A Wilcoxon signed-rank test found that between the comparisons, TK vs CK, PK vs PCK and CK vs PCK were significantly different. Teachers rated their PK significantly higher than their TK ($z = -4.4144$, $p<0.001$). This can also be observed in their ratings of PK which is significantly higher than their PCK ($z = -4.404$, $p<0.001$). Similarly, CK was also rated significantly higher compared to PCK ($z = -2.883$, $p<0.004$).

Among these TPACK dimensions PK was rated significantly higher than TK and PCK. Moreover, CK was also rated significantly higher than PCK. These results suggest than even though teachers were confident in their CK and PK, the integration of them in PCK still remains as a challenge.

There were no significant differences TK vs CK, TK vs PCK and PK vs CK. It can be observed that although PK vs CK results were very close, it still misses the Bonferroni-adjusted alpha level of 0.0083.

Table 13: TPACK Dimension Comparison Summary

Tpack Dimensions Comparisons	**Test Used**	**z-value**	**p-value**	**Significant (at <0.0083)**
TK vs PK	Wilcoxon Signed Ranks Test	-4.4144	<0.001	significant
TK vs CK	Wilcoxon Signed Ranks Test	-1.626	0.104	not significant
TK vs PCK	Wilcoxon Signed Ranks Test	-2.153	0.031	not significant
PK vs CK	Wilcoxon Signed Ranks Test	-2.652	0.008	not significant
PK vs PCK	Wilcoxon Signed Ranks Test	-4.404	<0.001	significant
CK vs PCK	Wilcoxon Signed Ranks Test	-2.883	0.004	significant

Perception of Filipino Teachers on Their TPACK and Its Impact on Teaching Practices

This segment of the study examines how Filipino math teachers in Thailand understand and apply TPACK. TPACK is where subject matter, instructional strategies, and technological tools intersect in the classroom. The teachers described how they brought the three components together in practice, demonstrating how they apply content, instructional strategies, and technological tools in order to make teaching function. This section describes three broad themes of what they had to say: how they incorporate the TPACK components, issues with technology, and how they accomplish it with technology in order to support students without having issues.

Holistic Integration

Teachers conceptualize TPACK as an integrated whole in which mathematics content, pedagogy, and technology are synthesized. The Filipino maths teachers in Thailand focus on integral integration when debating Technological Pedagogical Content Knowledge (TPACK). According to them, TPACK represents an integrated model where content knowledge, instructional strategy, and technology should work cooperatively to further teaching and learning processes. From this perspective, there is focus on balancing mathematics content with due instructional strategy as well as technical media to achieve a smooth and effective learning process.

This integrated strategy is in line with the results of Aktaş and Özmen (2020), who discovered that advanced TPACK development courses for pre-service science teachers greatly improved their technological, pedagogical, and content knowledge. These results illustrate how a targeted training can construct soft infrastructure where technology is integrated into the curriculum, in an integrated way. Similarly, Lyublinskaya and Kaplon Schilis (2022) tested the TPACK model using their Levels Rubric that demonstrated that it was possible to integrate technology, pedagogy, and content successfully and measure it.

Teacher 12 also explained TPACK as something "to incorporate your lesson with the technology," indicating technology should be incorporated into the lesson, not as an addition, along with content and pedagogy. This too identifies that technology is not merely a tool but also integral to the medium, which supports the learning

process.
Likewise, Teacher 9 defines TPACK as "a combination of three: subject matter, approaches to teaching or strategies, and the use of technologies." That is, good instruction necessitates balance between subject matter, teaching approach, and available technology. The combination of these three is at the heart of a good approach to teaching, with technology playing a supportive role to both content presentation and pedagogical strategy.
Teacher 3 further goes in the direction of this broad integration by explaining, "TPACK is the capacity to effectively combine technology in teaching and reconcile subject matter content, instruction strategies, and electronic tools to enhance student understanding." This is employed to explain that effective teaching is based on a lively integration between content knowledge, pedagogic strategies, and technological tools as a method of enhancing the students' comprehension, mostly abstract mathematical concepts.
For Teacher 13, TPACK signifies "knowing how to use technology and blend it with the right teaching methods and the specific content I'm supposed to teach." This perspective emphasizes the importance of purposefully integrating technology into the curriculum. The teacher perceives the combination of content, pedagogy, and technology as a "sweet spot" that enhances student learning and makes lessons more impactful.
Teacher 10 also stresses the intertwinement of these three, insisting that "TPACK means integrating content, pedagogy, and technology so that makes math lessons more interactive and meaningful." This position explains that technology cannot be used just for the sake of using it; it has to provide meaning and depth to lessons, which render them engaging and perceptive to students.
Personal accounts from the teachers of what they do in order to incorporate technology during instruction demonstrate unanimity that TPACK is not merely a formula to be executed, but an overarching philosophy concerning teaching. Teacher 9 articulates this succinctly by stating, "I think TPACK is about knowing how to use technology and blend it with the right teaching methods and the specific content I'm supposed to teach." This underlines the notion that technology is most effective when it is aligned with both the content being taught and the pedagogical strategies employed.
The Filipino mathematics teachers in Thailand share a common perspective of TPACK as a holistic model where pedagogy, content knowledge, and technology supplement and complement each other. From their responses, the three aspects are in balance to significantly contribute to learning by the students in order to make learning more engaging, interactive, and effective. Mailizar *et al.* (2021) and HabiBi *et al.* (2019) studies also confirm that the higher level of TPACK is associated with a higher level of readiness to implement digital innovations, thereby resulting in a more interactive and richer learning process.

Confidence Gap in Tech Skills

Although the majority of the teachers are self-assured in math content and teaching practice, they point to "Technological Knowledge" as an area that needs enhancement. The self-reported deficit is also consistent with Rakes *et al.* (2022), which reported that although there were instructional practice improvements in mathematics instruction during the COVID-19 pandemic, tremendous technological deficits in TPACK existed. Hill and Uribe-Florez (2020) also provide emphasis on the confidence of teachers with the utilization of technology, where effective integration has high correlation with ongoing support and professional development of teachers.
The Filipino math teachers' remarks in Thailand reveal a broad "Confidence Gap in Tech Skills." They have good content knowledge and sound pedagogical practices, but a clear technological knowledge (TK) gap exists. The gap is particularly apparent since most teachers are confident that they can teach but acknowledge that enhancing their technological skills continues to be a priority.
For instance, Teacher 6 expressed feeling "entirely confident mainly in the teaching strategies and instructional methods," demonstrating a strong grasp of pedagogy and content delivery. However, they acknowledged that the technological side of teaching is an area for potential growth, stating, "I would like to improve my Technological Knowledge because I believe it's essential to stay current with new tools." This is a common sentiment across the responses, where participants generally feel well-prepared in pedagogy and content but are eager to refine their technological skills.
Teacher 2, while expressing satisfaction with how technology enhances the learning process, acknowledges the need for improvement in their technological skills. They rated their confidence in technology at "7," stating, "There is always room for improvement," highlighting the fast-paced nature of technological advancements and the necessity of staying updated. Teacher 3 similarly utters their strengths in pedagogy and content, saying, "I feel confident in using technology for instruction, especially in blending technology with content and pedagogy," but acknowledges the need to improve technological knowledge, specifically in "learning advanced features of mathematical software to personalize learning."
Teacher 4 also shows confidence in their content and pedagogy, remarking, "Content Knowledge in math is something I'm comfortable with because it's my major," but identifies the need to improve technological knowledge. Teacher 5 and Teacher 6 echo similar sentiments, with Teacher 5 focusing on enhancing their "Technological Knowledge" to keep up with new teaching tools, and Teacher 6 looking to refine their "Technological Content Knowledge" by exploring more advanced tools for teaching mathematics.
The concern about technological skills is not limited to the teachers themselves but also extends to their students' adaptability and how technology can either support or hinder learning. Teacher 11 noted that while technology

makes the classroom more interactive and fun, "it takes a lot of time preparing the lesson" and dealing with "technical issues." Similarly, Teacher 7 pointed out that while they are confident in their pedagogical knowledge, they are still improving their technological knowledge, saying, "I'd say I'm quite confident, especially now that I've been exploring various educational software. My greatest strength lies unquestionably in Pedagogical Knowledge."

These answers are an unambiguous consensus that although Filipino mathematics teachers in Thailand are aware of the topics which they are teaching and of pedagogic strategies which they implement, there is a common understanding that information regarding technology is an incredibly vital subject which always has to be acquired and re-acquired. This technology confidence deficit creates the demand for professional development in ongoing format, particularly in incorporating new technologies and digital tools into instruction-related goals. Similarly, Teacher 8 also indicated, "I want to investigate more deeply into more sophisticated software or perhaps try coding activities," with a demonstration of intent to dig deeper into what would enhance both their teaching practice as well as students' learning results more effectively. The answers of the teachers confirm the need to reconcile pedagogical competencies with technological competencies. Despite a majority of teachers thinking that they are sufficiently prepared to teach mathematics, constant seeking to become better in terms of technological awareness is an absolute priority. This shows the educational technology context and its effect on learning and teaching. The studies of Shin (2022) and Max *et al.* (2022) indicate that teachers may first overestimate their level of TPACK proficiency but specific interventions like makerspace or training modules play a significant role in actually augmenting technological skill. Furthermore, Aktaş and Özmen (2020) illustrate how systematic development programs in TPACK are able to fill the gap so that teachers can be adequately equipped to utilize technology effectively in the classroom.

Improved Interaction with Precautions to Evade. While technology can support motivation, interactivity, and enhanced comprehension, it needs to be used cautiously lest it causes distractions or technical problems. This aligns with HabiBi *et al.*, (2019), who posit that a robust TPACK foundation is crucial in order to ensure learning via proper ICT integration and transforming technology into an effective tool for learning. Rakes *et al.* (2022) also add that without deliberate support, otherwise successful technology integration will be unlikely to fulfill its pedagogical potential, especially during periods of high turnover within the learning environment.

The Filipino math teachers' experience in Thailand illustrates how technology can enhance student motivation and enhance learning outcomes when strategically employed in the classroom. Some of the teachers explained that computer-based technologies make abstract mathematical concepts concrete, visual, and interactive, stimulating motivation and greater understanding. For example, as one educator mentioned, "after covering a subject, I let students use their phones to respond to practice questions on the subject, and all the students love seeing the instant results," highlighting the excitement and instant feedback that technology provides.

While doing this, however, teachers also spoke out against possible downsides of technology in classrooms. Teacher 13 stated, "Technology makes complicated things simple with diagrams and simulations," but warned that "technical problems can halt classes," and that too much prep time shortens actual learning time." This two-way view suggests that technology can enhance engagement and interactivity significantly, but its use must be carefully controlled so that technical issues and distractions do not occur. Teacher 8 suggested the fine balance by saying, "Technology has a profound effect on student engagement and learning outcomes because it dictates how well I can marry technology and pedagogy with content." However, they warned that over-reliance on digital tools risks distracting students. Similarly, one educator observed, "when my TPACK is strong, I see that students are more engaged because lessons flow smoothly," contrasting this with concerns that "sometimes technology can also be a distraction, especially if the devices aren't working well or if students are focusing on the gadget more than the lesson." These insights collectively stress that the benefits of technology are maximized only when its integration is deliberate and well-supported.

The teachers agree that technology can revolutionize math instruction, making lessons more engaging and accessible. But they also recognized that success lies in the hands of careful implementation and solving technical problems. One of the teachers captured it best when she said, "I think about technology as a guide that helps me design lessons where the use of technology brings authentic value to what students are studying," highlighting the need for even-handedness that leverages technology to enhance the learning process without sacrificing its potential negatives. Andrian *et al.* (2022) also assume that whereas motivation and creativity impact TPACK, its effect on teacher performance is moderated by long-term conditions like leadership and organizational climate.

Barriers to the Development and Integration of TPACK Among Filipino Teachers in Thailand

This part of the research shows the frequent challenges of Filipino mathematics teachers in Thailand to apply TPACK in instruction. The teachers presented several challenges that prevent them from using technology in the classroom, such as financial constraints, lack of gadgets and access to the internet, lack of training, and inadequate school assistance. Others also noted that cultural and normal school reasons prevent them from innovating in teaching. Identifying these roadblocks is important to create better support and solutions in order to assist teachers in performing better using TPACK in the classroom.

Limited Technological and Financial Resources

The comments from the Filipino teachers of mathematics in Thailand always relate back to the limited technological and financial resources as one of the most significant disadvantages to introducing technology integration into the classroom. Most educators noted the straightforward lack of equipment and inconstant internet access. Teacher 9 summarized this dilemma by saying, "When no one has a phone or computer to use." This somber observation emphasizes that without even the most minimal of technological devices, the revolutionary potential of online learning is left unfulfilled, disadvantaging both teachers and students.

Literature reports such issues HabiBi *et al.* (2019) highlight that successful ICT integration in classrooms depends on the availability of effective technological means and proper support, a concern in poor-resource environments. Mailizar *et al.* (2021) further uncover that educators with greater TPACK capacity can better embrace digital innovations as an asset whose deficiency hinders resource insufficiencies. Furthermore, Andrian *et al.* (2022) highlight the significant role of environmental factors, including organizational support and leadership, in influencing teachers' performance. They note that limited resources can possibly significantly limit even highly trained teachers from fully utilizing technology in instruction.

Another issue is the schools' limited funding for provision, which keeps them far from current hardware and software. Teachers have grumbled about these budget issues, with one of the interviewees explaining, "A huge hindrance is the school budget. We can only do so much with what we are provided." These budget issues result in the fact that even if teachers come up with creative ways to integrate technology, they typically remain on paper because they lack the resources required.

Additionally, a lack of funds not only restricts the purchase of hardware but also erodes the infrastructure as a whole to allow adequate use of technology. Most of the teachers recounted tales of bad internet connectivity and old computers, which handicap class sessions. One teacher made the following poignant remark, "the greatest challenge is often the intermittent availability of the internet. I may have a great lesson plan, but when the Wi-Fi is down, I have to improvise." This comment illustrates how insufficient funding for upkeeping technological infrastructures can develop into usual interruptions that diminish the quality and consistency of instruction.

Furthermore, a lack of funding impacts teachers' professional development as well as achieving solid TPACK competency. The budget restraints deter schools from spending on extended training modules or continuous technology upgrades. One of the respondents commented, "The biggest limitation on my capacity to acquire TPACK knowledge is economic. Not every student has stable internet for online learning." This very much suggests that, in the absence of adequate financial resources, both students and teachers are restricted by unstable technology, which keeps opportunities for innovative teaching and effective learning out of reach.

Others pointed out that although theoretically, there could be policy support, the practical implementation is shortchanged because of limited budgets. This was mentioned by a teacher who said, "Yes, without proper funding, your ideas are just ideas." This emphasizes the fact that despite a policy-friendly environment, insufficient actual investments in technology render innovative teaching methodologies ineffective. The existing issue of limited technological and financial resources surfaces as a main challenge that must be overcome to make it easier for Filipino mathematics teachers in Thailand to utilize the technology to its full potential for student learning enhancement.

Insufficient Professional Development and Technical Support

The survey indicates that among the biggest obstacles for Filipino mathematics teachers in Thailand is the lack of regular, structured professional development, depriving them of proper guidance to effectively integrate technology. Teachers indicated that they required more extensive training, stating, "We could learn more new teaching strategies that incorporate technology." They indicated that newer training programs could significantly enhance their teaching methods. Through consistent training, they believe that they would be able to better adapt their lessons to include digital tools, ultimately leading to more effective teaching practices.

This issue was also backed by Aktaş and Özmen (2020), who proved that a TPACK Development Course with microteaching and in-class applications incredibly improved the pre-service teachers' capability to incorporate technological tools into their classrooms. Lyublinskaya and Kaplon Schilis (2022) also promoted the TPACK Levels Rubric as a powerful tool to facilitate the blending of technological, pedagogical, and content knowledge through systematic training. Rakes *et al.* (2022) additionally add that during the time of the COVID-19 pandemic, while there were overall enhanced math instructional practices, TPACK development remained inadequate bringing out the ever-existing gap where training is optimal. Hill and Uribe-Florez (2020) also contribute adding that ongoing training and technical support are essential in establishing teacher confidence, ensuring the occurrence of technological issues does not hinder the learning process.

Aside from the absence of training programs, inadequate technical support worsens these issues. As one of the participants lamented, "Some of the challenges I have faced include insufficient technical support and lack of training on sophisticated technological tools, which renders integration challenging." This remark mirrors a major problem: not only are teachers deprived of proper professional development, but they also have no on-site technical support in case something goes awry. Without such assistance, even minor technical problems will bring lessons to a halt and reduce overall class engagement.

These impact are compounded by the time-consuming nature of self-learning. As a teacher explained, "When training is not there, I'm left to learn by myself, which takes a lot of time." Such reliance on ad hoc solutions, like online tutorial videos, denies instructors the opportunity to systematically familiarize themselves with new technology tools proficiently. Thus, the chasm between new digital uses and innovations in classrooms is continuously widening, and teachers have no alternative but to turn back to traditional methods that may not wholly engage students.

In addition, the lack of a good, planned strategy for professional growth forces teachers to rely on substandard, makeshift materials. One teacher highlighted the need for a more structured system by saying, "A proper training program is essential because I don't want to depend solely on YouTube tutorials." This view is part of a broader discontent with the existing support system, where the absence of regular, in-depth training sessions makes teachers ill-equipped to deal with the evolving technological landscape. Without formal professional development, teachers are unable to use technology creatively and pedagogically.

The response is that this is not a problem that is confined to Filipino teachers but a cross-cutting issue across contexts that all teachers are experiencing. One of the participants summarized the issue quite succinctly when they said, "Filipino and local teachers have inadequate training in effectively integrating technology." This speaks to the need for schools to make a commitment to a commitment to regular, systematic professional development and adequate technical support. Only with such sweeping changes do educators start to feel empowered and equipped to use technology to enhance learning outcomes in the classroom.

Institutional and Cultural Constraints

The experiences of Filipino math teachers in Thailand indicate that institutional and cultural barriers significantly affect their ability to integrate technology into the classroom. Most of the teachers complained about the support institutions offer, stating that while there might be a willingness to embrace technology in theory, actual implementation falls behind. One respondent said, "It varies depending on the school; some schools embrace it, but sometimes they do not have resources for such innovation," which reflects the unevenness of institutional support that has a direct effect on their pedagogical practices.

Mohammadpour and Maroofi (2023) described the deep differences in teacher training among institutions and noted there were higher content and pedagogy knowledge enhanced by those who undergo more extensive training. With this view, Andrian *et al.* (2022) highlighted the effects of organizational climate and leadership to teacher performance dimensions which are facilitators or hindrances to technology integration. There are also cultural elements that cloud this picture; some teachers indicated that long-standing education traditions, such as over-reliance on rote memorization, inhibit the uptake of new, technology-based pedagogies. Shin (2022) suggests that these cultural hesitations can also underpin apprehensions regarding the uptake of new systems like Intelligent Tutoring Systems, especially when teachers perceive they have not been properly trained. This convergence of institutional and cultural obstacles creates a scenario where even the most brilliant ideas may be left unfulfilled, as a respondent pointed out: "Yes, without them, your ideas will be just an idea."

The majority of the teachers reported that school culture is a two-edged sword. Although there are some schools that do offer bare minimum resources and policy infrastructures that support the use of digital tools, such supports are undermined by budget limitations and old systems. One teacher expressed it like this, "I do think that my school does try to create space for use of technology, but it is not always there. The policies do support innovation, but the infrastructure like Wi-Fi and computer labs just are not up to par." This perspective highlights the gap between models and the real issues teachers are facing in everyday practice.

Compounded to this problem is poor access to quality training schemes and technical support, which is a major institutional weakness. Teachers reported that while training seminars may sometimes be offered, they are more likely to be spasmodic or superficial and not reach the depth required to have an impactful effect. One teacher recalled, "Having experience in training programs makes a big difference in my ability to integrate technology into my teaching. But when such experiences are not available, I am left with no clue on how to use technology effectively in my teaching." Such a lack of professional development not only prevents skill acquisition but also creates a perpetual sense of doubt about the use of new tools and techniques.

The cultural constraints contribute to these institutional difficulties. Pedagogical conventions and conventional expectations are said to still be the standard by some teachers, and therefore, imposing or justifying new, technology-driven approaches is hard to achieve. "Cultural expectations come into play. Some still believe that memorizing formulas is the only way to learn math," one respondent noted, citing a widespread resistance to change on the part of the teaching community. Additionally, language barriers exacerbate these issues, with one teacher stating, "I do think we face unique challenges. Language is definitely one, because most official trainings might be conducted in Thai," pointing to the extra effort required to adapt to a system that is not always designed with them in mind.

The focus on insufficient institutional support, limited training opportunities, and entrenched cultural expectations creates a challenging environment for Filipino math teachers in Thailand. These constraints not only affect their day-to-day teaching but also hinder the broader adoption of innovative, technology-enhanced educational practices. The voices of the teachers “depends on the school. some school supports it but sometimes the school lacks resources for such innovation,” “I feel that my school tries to support technology use, but it’s not always consistent…” and “cultural expectations play a role. Some people still believe that memorizing formulas is the only way to learn math” illustrate the complex nature of these institutional and cultural barriers.

Factors Facilitating the Development and Integration of TPACK among Filipino Teachers in Thailand

This part of the study shows the helpful factors that support Filipino math teachers in Thailand in using TPACK in their teaching. The teachers shared that training, peer support, and personal effort helped them use technology better. They said that workshops and seminars enhanced their abilities. Collaborating with peers and engaging in online forums also motivated them with new ideas. Most teachers broadened their capabilities through independent research on different tools. These activities instilled increased confidence in the use of technology, instructional practices, and content integration in classrooms.

Ongoing Professional Development and Structured Training

One fundamental factor that contributes to the development and integration of TPACK among Filipino teachers in Thailand is placing importance on continuous professional development and structured training opportunities. The majority of participants indicated that attending workshops, seminars, and formal training has been instrumental in increasing their awareness of technology integration. For example, one teacher said, "Yes, it's improved a lot compared to previous times," illustrating the lasting effect excellent training can have on teaching. These courses not only expose teachers to the newest digital software but also provide practical strategies teachers can easily use in the classroom.

Moreover, the presence of targeted professional development is seen as a primary facilitator, which allows teachers to experiment and implement new technology confidently. One of the interviewees had given evidence, "I went to a brief workshop on Google Apps for Education. It opened my eyes to how it could all be made easier," and this shows how even brief training can alter presentation of lessons. Exposure to different approaches, like this, allows teaching staff to integrate technology seamlessly, making students more active and successful.

Moreover, formalized training courses are appreciated for introducing a thorough strategy of technology integration. Students enjoyed training beyond merely tool demonstrations in order to add contextual uses and pedagogical approaches. "Having access to training programs influences my teaching potential to utilize technology greatly, as I am better able to learn how to implement different education tools," a teacher confirmed, "because training enables capability and also confidence." This supports the development of student-focused and interactive learning spaces.

The effect of professional development is then multiplied even more when it is continually updated to keep up with the rapidly evolving technology landscape. Educators underscored the need for ongoing learning opportunities in order to remain acquainted with prevailing digital trends and new pedagogical tools. Since one of the interviewees said, "I take care to join webinars and online training. Whenever I learn something interesting, I consider whether it applies to my math lessons," meaning that ongoing professional growth is vital to maintaining successful technology integration in the long term.

A skillfully designed, timely ever-evolving professional development plan is a cornerstone to building TPACK. It not only prepares the instructors with the newest technical skills but also strengthens best practice regarding how to make use of digital tools in class. The perpetual feedback of the instructors "Yes, it's a lot better," and "Having access to training programs has a huge effect on my ability to incorporate technology" strongly reflects that investment in broad training results in enhanced and innovative pedagogy.

This outcome is in line with Aktaş and Özmen (2020), who illustrated that especially designed TPACK development courses via microteaching and field implementations improve teachers' technological, pedagogical, and content knowledge. Similarly, Lyublinskaya and Kaplon Schilis (2022) endorsed the TPACK Levels Rubric, which helps teachers embed digital tools with teaching strategies. Moreover, Mohammadpour and Maroofi (2023) found that intensive courses like TTU's help prepare teachers in pedagogy and content and stress the importance of formal professional preparation in strengthening overall teaching effectiveness.

Peer Collaboration and Community Support

Another factor that contributes to TPACK integration development is teachers' collaborative culture facilitated by their communities. The majority of participants presented comments indicating collaboration with peers, exchanging best practices, and participating in collaborative learning sessions have improved their pedagogical capabilities significantly. One teacher declared, "Collaborating with peers and piloting digital tools in my classrooms have made it easier to develop my TPACK competences," highlighting peer-to-peer learning as the source of professional development.

This facilitative environment is further complemented by online and offline informal networks and professional communities. Teachers derive a lot of value from this interaction, which gives room for information sharing, challenge solving, and testing new approaches to technology integration. As one of the participants described it, "I depend on professional learning networks on social media, like Facebook groups for maths teachers. People share new tools, have free sources, and debate challenges," reflecting that continuous peer-to-peer exchange facilitates the creation of a climate of successful technological integration.

Apart from that, school support that ensures collaboration is an acknowledged key driver of TPACK development. Most of the participants highlighted the school support in terms of dedicating time and resources to collaboration. "School support should include access to newer technology and technical support staff," noted a teacher, highlighting how the importance of school support to create a facilitative community can never be overemphasized. This assistance, in addition to improving individual capability, also supports an innovation culture for everyone throughout the learning space.

In addition to that, peer support comes in handy in filling the gap between practice and theory since it enables teachers to try out and refine their strategies in the comfort of a safe space. As they collaborate, teachers can provide instant feedback, exchange success stories, and discuss issues together. The second respondent observed, "Colleagues can help by sharing best practices and co-creating tech-integrated lesson plans," providing further confirmation of the fact that collaborative work yields better and more effective technology integration.

Collegial teachers construct a robust and sustainable learning community. Not only does this support system enable the transfer and sharing of knowledge and resources, but it also constructs the confidence to embrace technological innovations. The partnerships stated "Collaborating with my colleagues have helped me develop my TPKK skills" and "I rely on professional learning networks on social media" clearly show that a robust, networked community is an important factor in enabling Filipino teachers in Thailand to integrate technology effectively into their classrooms.

This cooperative spirit is what generates the interaction between practice and theory, as much stressed by Rakes *et al.* (2022), who developed that professional learning networks reduce the gap between effective teaching and technology integration, particularly during challenging times. Moreover, Mailizar *et al.* (2021) established that highly TPACK-skilled educators are likely to embrace digital innovations, again highlighting the value of continuous peer support. Andrian *et al.* (2022) highlight the institutional support as a key enabler of access to time and resources for collective action that sustains an environment where teachers are enabled to experiment and embrace new technologies.

Self-Directed Learning and Effective Use of Digital Resources

A third key aspect that arose out of the responses is the value of independent learning and the successful use of web-based materials in developing TPACK. Most teachers highlighted the role that their own initiative to acquire knowledge of new technologies, to play around with computer tools, and to take advantage of online learning materials has played in their professional development. One of the participants explained, "I think that my curious nature and experimenting in my free time really helped to develop my TPACK," which summarizes self-directed learning as a primary driver.

Self-directed professional development allows teachers to tailor their technology integration according to their needs and situations, thereby improving how they integrate technology to facilitate teaching in the best possible way. For example, a teacher explained, "I use interactive tools like Desmos and Geogebra, as they help represent math concepts more visually," explaining how inquiry exploration of digital resources enhances their presentation of content and student understanding. This autonomous approach not only fills in gaps left by formal training but also fosters a culture of ongoing improvement.

Besides, access to different digital content ranging from instructional videos and websites on the Internet to educational podcasts and blogs assists instructors in being abreast of the most recent trends and best practices in technology. As noted by one teacher, "I read educational technology blogs, join webinars, and interact with online teacher communities," noting that the abundance of freely accessible digital content is a never-ending source of ideas and experience-based learning. This ongoing process of learning keeps teachers in good stead at the cutting edge of technology development, an achievement that is particularly significant in an increasingly changing educational landscape.

Additionally, autonomous learning challenges teachers to test different digital tools and techniques, so they can find ways that suit their learning style and students' needs. Venturing this way is probably going to result in discovering new methods that can transform the classroom experience considerably. As one educator described, "Using Kahoot for rapid formative assessments keeps kids on track and gives instant feedback," showing that through testing and experimentation, teachers can identify and implement procedures that maximize learning outcomes.

The need to educate independently, and the reflective utilisation of cyber resources, necessitates a celebratory learning environment where TPACK can thrive. Affirmative pro-activity expressed in declarations such as, "I thought that my own curiosity and want to try things out on my own outside class helped to make my TPK much better" indicates the benefits of individual effort in transcending the constraints of compulsory training sessions. This dedication to continuous, self-initiated learning is a strong enabler that allows Filipino teachers in Thailand to optimize the use of technology, enhancing teaching methods and ultimately influencing learner achievement.

This is evident in the work of Max *et al.* (2022), which confirms that the use of self-assessment tools in addition to hands-on activities like makerspace can easily close technology integration competency gaps. Moreover, instructors who utilize interactive platforms like Desmos, GeoGebra, and educational blogs and webinars regularly update themselves to make sure that they are at the edge of technological advancement, as outlined by Shin (2022). These self-led exercises not only bridge the gaps left by formal education but also foster a culture of lifelong learning that is so essential in the fast-evolving learning space of today.

Proposed Professional Development Framework to enhance the TPACK of Filipino Teachers in Thailand

In this section, there is outlined an overall plan with the aim of empowering Thai Filipino instructors to utilize TPACK (Technological Pedagogical Content Knowledge) more efficiently. It involves low-cost ICT tools, periodic training, collaborative work among teachers, and mentorship support accessible. Periodic collaborations with other agencies, self-study, and in-built feedback loops are also encouraged. All these elements of the plan synergize together in giving teachers more freedom for maximizing the utilization of technology in the classroom. Its primary goal is to equip teachers with the knowledge and skills needed for more efficient teaching through combining content knowledge, instructional methods, and the use of technology.

The model is centered on inexpensive digital resources, formal professional development, peer collaboration, mentorship and coaching, resource partnerships, and continuous feedback complemented by self-directed learning. It begins with the clear solution of resource deficiency by foregrounding the employment of free or inexpensive digital resources to reduce economic dependency while maximizing exposure to technology. This beginning emphasis on low-cost technology creates a foundation for all future training endeavors.

Subsequent to this, the model stresses the imperative need for systematic professional growth, with frequent, experiential training sessions and micro-modules of training. This systematic method significantly improves teachers' ability in the effective utilization of technology in their pedagogical practices. The second vital component is the facilitation of peer collaboration, wherein teachers are motivated to share best practices and innovative approaches through formal and informal networks, generating a culture of ongoing learning and peer support.

Mentoring and coaching is also a central pillar, providing one-to-one guidance and instant technical assistance to enable teachers to manage everyday issues. This is also complemented by building resource alliances with local institutions, which can offer further technical and financial assistance.

Lastly, the model includes continuous feedback loops and allows for independent learning, thus making the process of professional development adaptive and dynamic. This evolution from low-cost solutions to formal training, collaboration, mentoring, resource improvement, and continuous assessment creates a sustainable and holistic setting for the development of TPACK among Filipino teachers.

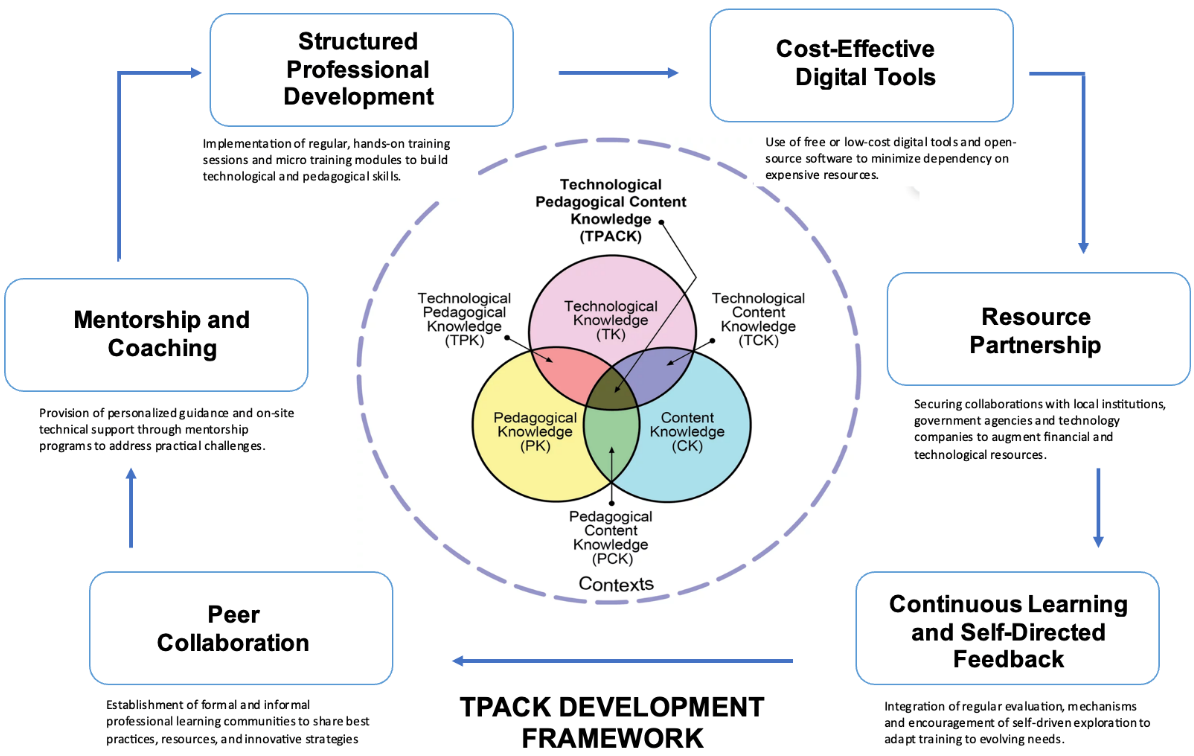

Figure 1: Track Development Framework

Summary of the Framework

The suggested professional growth model is designed to advance the TPACK of Filipino teachers in Thailand. It provides practical ways for teachers to easily integrate technology into teaching practices and content knowledge. The strategy is easy, inexpensive, and easy to apply. It consists of six basic conditions that lead teachers to be more proficient and self-assured to apply technology in the classroom.

Structured Professional Development

The first step is on-job training and brief learning periods. Teachers shall undergo workshops and micro-training modules aimed at educating them on how to effectively incorporate technology into the curricula they oversee. The training must be regular and synchronized with the very classroom needs.

Cost-Effective Digital Tools

This section entails the use of free or low-cost digital tools. Open-source software and free apps can be used by teachers to teach mathematics and other courses. This is important where money is tight for schools. It allows teachers to have access to technology without breaking the bank.

Resource Partnership

Schools may explore alliances with other institutions, government offices, or private entities to gain more resources. Alliances can allow for securing crucial access to the internet, computers, and training assistance, making teachers available with the tools and assistance they need.

Continuous Feedback and Self-Directed Learning

Teachers are also motivated to think back on their learning experience and experiment with new tools on their own and get constant feedback from peers and mentors. This encourages continuous involvement in the learning process and helps in facilitating continuous improvement.

Peer Collaboration

Direct teachers to collaborate in small groups or online forums to share ideas and brainstorm together. Group work provides support for learning from one another, overcoming obstacles, and creating ways to incorporate digital tools into teaching.

Mentorship and Coaching

This project involves assigning teachers mentors or coaches who provide one-on-one guidance to boost their technical competencies. Such mentors may also provide problem-solving guidance whenever teachers feel lost when using digital materials.

Plan for Professional Development

To start this program, schools can first choose free online tools appropriate for teachers. Second, they can organize monthly training sessions and provide online modules. Teachers can be allocated to study groups to exchange experiences and concepts, with a mentor each to guide them. School administrators can contact collaborators to assist with machinery and internet. Teachers' comments should be gathered regularly, and they should be motivated to make learning from websites available at all times.

CONCLUSION

Filipino math teachers in Thailand are mid-career practitioners, predominantly women, with a majority holding baccalaureate degrees and extensive teaching experience in the country. They are well-rounded, with a strong foundation in pedagogy, content, and technology, yet may benefit from continued professional development in bridging the gap between pedagogy and content. TPACK development among Filipino math teachers is relatively uniform, regardless of their individual differences. Despite uniform TPACK levels across individuals, key differences among dimensions highlight the need to enhance technology integration and the connection between pedagogy and content.

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