Southeast Asia Mathematics Education Journal
Volume 13, No 1 (2023)

Usage of Classroom Technology and the Technological Pedagogical Content Knowledge (TPACK) of Mathematics Teachers

Junymer C. Plantado
Bicol State College of Applied Sciences and Technology, Philippines
jcplantado@astean.biscast.edu.ph; junymerplantado@gmail.com

Abstract

Technological Pedagogical Content Knowledge (TPACK) is a theoretical framework in technology integration that is highly regarded in today's digital era. Using a descriptive research design, this study investigated 81 secondary mathematics teachers' use of available classroom technology and level of competence in the eight TPACK domains. The findings revealed that classroom technology was rarely employed. This was due to a combination of external and internal factors. While along the TPACK domains, the teachers obtained the highest level of competence in CK (M = 4.29, SD = .59) and lowest in TK (M = 3.69, SD = .70). One-way ANOVA uncovered that there was a highly significant difference in the level of competence along with TPACK domains. Furthermore, correlation and multiple regression analysis unveiled that the level of usage of classroom technology was discovered to be highly significant and served as the best predictor of TK ($F(6, 74) = 6.17$, $p<.001$), TPK ($F(6, 74) = 6.39$, $p<.001$), TCK ($F(6, 74) = 4.30$, $p<.001$), and TPACK ($F(6, 74) = 2.65$, $p = .022$). Implications of the findings and recommendations are discussed.

Keywords: TPACK, technology integration (TI), mathematics teacher

Introduction

Technology continues to progress at a breakneck pace. Technology advancements and innovations have had significant impacts on almost every aspect of human life, including educational-instructional practices (Muhaimin et al., 2019). The proliferation of technology has challenged the status quo of educational settings, resulting in a paradigm shift in the teaching and learning process (Sasota et al., 2021). Technology's opportunities and facilities for teachers have created a new landscape for classroom instruction, altering teachers' roles and expectations (Ozudogru & Ozudogru, 2019).

Teachers' knowledge and competence in teaching have been understood along the lines of Shulman's Pedagogical Content Knowledge (PCK) for over 30 years. The concept of effective teaching, according to Shulman's PCK, is dependent on the teacher's ability to combine the domains of content and pedagogy rather than looking at each domain separately (Ozudogru & Ozudogru, 2019; Schmid et al., 2020). However, many educators and researchers argue that this framework is insufficient, primarily because it lacks an explicit articulation of technology integration (TI), which many believe is essential in this digital era (Jacinto & Samonte, 2021; Ozudogru & Ozudogru, 2019; Schmid et al., 2020).

One of the recent and widely accepted theoretical frameworks that get positive acceptance along TI is the Technological Pedagogical Content Knowledge (TPACK) developed by Mishra and Koehler (Alrwaished et al.,, 2017; Bakar et al., 2020; Muhaimin et al., 2019; Lucenario et al., 2016; Oskay, 2017; Wang et al., 2018). This is an extension and broadening of Shulman's PCK framework, which emphasized the importance of developing an integrated and interdependent understanding of the three primary forms of knowledge - content, pedagogy, and technology - for effective TI. Although TPACK research is widespread, it is pertinent to note that, despite its popularity in educational technology research, the TPACK framework has received some significant criticism. According to Schmid et al. (2020), TPACK was primarily criticized for its lack of conceptual clarity and specificity, as well as the "fuzziness" of its boundaries, which resulted in a body of literature focusing on the development of and relationships between the TPACK components from two opposing perspectives—integrative and transformative.

Figure 1 demonstrates the TPACK framework and a brief discussion of its domains as utilized in several studies (Bakar et al., 2020; Koehler & Mishra, 2009; Mishra, 2019; Oskay, 2017; Ozudogru & Ozudogru, 2019):

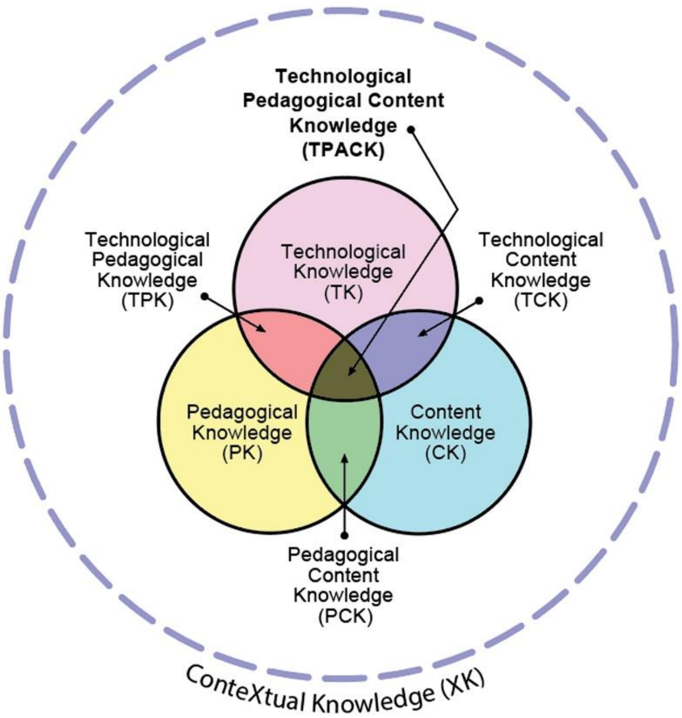

Figure 1. The revised version of the TPACK framework and its knowledge components (Mishra, 2019).

- *Content knowledge (CK)*. This is "knowledge about the actual subject matter to be learned or taught." It includes an understanding of concepts, theories, ideas, organizational frameworks, evidence, and proof, as well as established practices and approaches to developing that knowledge.
- *Pedagogical knowledge (PK)*. This refers to teaching methods and processes, such as classroom management, assessment, lesson plan development, and student learning. They encompass, among other things, overall educational goals, values, and objectives.
- *Technology knowledge (TK)*. This refers to knowledge of various technologies, ranging from low-tech tools like pencil and paper to digital tools like the internet, digital video, interactive whiteboards, and software programs.

- *Pedagogical content knowledge (PCK)*. This refers to pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge, and theories for specific contexts.
- *Technological content knowledge (TCK)*. This refers to the knowledge of how technology can generate new representations of specific content. In other words, TCK implies that teachers recognize that by utilizing a specific technology, they can alter how students practice and comprehend concepts in a specific content area.
- *Technological pedagogical knowledge (TPK)*. This refers to the knowledge of how various technologies can be used in teaching and how using technology may change the way teachers teach. It entails understanding the pedagogical affordances and constraints of a variety of technical tools in relation to disciplinary and developmentally appropriate pedagogical designs and strategies.
- *Technological pedagogical content knowledge (TPACK)*. This refers to the knowledge that teachers must have to integrate technology into their teaching in any content area. By teaching content using appropriate pedagogical methods and technologies, teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK).
- *Context Knowledge (XK)*. This refers to their knowledge of who they teach, where they teach, and what they teach. In other words, XK encompasses everything from a teacher's awareness of available technologies to the teacher's knowledge of the school, district, state, or national policies that they must adhere to in order to implement technology effectively.

TI is a challenging, complex, diverse, and multifarious process. Several studies have been conducted on TI (Abas & David, 2019; Bakar et al., 2020; Gonzales & Gonzales, 2021; Hero, 2019; Ibañez et al., 2021; Jacinto & Samonte, 2021; Mercado et al., 2019; Malubay & Daguplo, 2018; Morales et al., 2021; Roble et al., 2020; Sasota et al., 2021) and reported the positive impact of a technology-infused mathematics teaching and learning (Gonzales & Gonzales, 2021; Roble et al., 2020; Ibañez et al., 2021; Sasota et al., 2021). However, some studies have revealed that TI implementation in the country remains low, and teachers continue to lack the necessary technical skills and knowledge for effective TI to classroom instruction (Jacinto & Samonte, 2021; Roble et al., 2020).

The issue of TI has been present in the country for decades, but it has recently gained prominence due to the growing demand among teachers on issues related to K-12 education implementation. Furthermore, the call to re-examine teachers' ability and knowledge of TI has been amplified in providing quality instruction during the pandemic. Teachers, as the primary carriers of the teaching process, must possess the necessary skills and continuously upgrade themselves with the necessary specialized knowledge for effective mathematics instruction despite adversities, which can be accomplished through continuous engagement in various professional development and advancement programs and activities, such as attending seminars, workshops, conferences, participating in advanced training programs, or pursuing advanced programs.

Several studies on TPACK have recently been conducted in the country. It has been studied with one’s self-efficacy (Cahapay & Anoba, 2021; Gonzales, 2018; Jacinto & Samonte, 2021;

Mercado & Ibarra, 2019; Ramos et al., 2020), teachers' training and their teaching competencies (Mercado et al., 2019; Santos & Castro, 2021; Ramos, et al., 2020; Gonzales & Gonzales, 2021; Mercado & Ibarra, 2019), and level of TI implementation in the classroom (Morales et al., 2021; Mercado et al., 2019; Malubay & Daguplo, 2018; Santos & Castro, 2021). The findings are varied and inconclusive, particularly when it comes to determining what truly influences the level of competence of mathematics teachers across the TPACK domains affecting TI. Along these lines, the researcher decided to investigate the relationship between the teacher's level of competence in the TPACK domains and some demographic variables such as the level of classroom technology usage. Furthermore, no study on profiling the characteristics of secondary mathematics teachers and their potential implications for teaching and learning mathematics has been conducted in the target division, Division of Naga City, during the pandemic (the year 2020).

The primary objectives of this study were to (1) determine the level of usage of available classroom technologies by teachers; (2) identify the level of competence of teachers along the TPACK domains; and (3) determine the level of association between demographic profile variables and level of competence of teachers in TPACK domains.

Methods

A quantitative descriptive research design was used in this study. Descriptive research design is a scientific method that entails observing and describing a subject's behavior without influencing it in any way (Shuttleworth, 2019). The primary objective of this design is to "describe" individuals, situations, issues, behaviors, or phenomena in nature (Siedlecki, 2020). A survey, on the other hand, was used as the primary data collection methodology. However, while the survey method can be thought of as purely descriptive in nature, this research methodology can also be used to explain (explain) and assess the influence of various factors, which can be manipulated by public action, on some phenomenon (Moser & Kalton, 2017).

All of the respondents were secondary mathematics teachers from junior and senior high schools in Naga City, Camarines Sur, Philippines. As a sampling technique, total enumeration was employed. However, due to the pandemic's restrictions and teachers' personal reasons, only 81 out of 91 (89.01%) total mathematics teachers responded to the online survey. These 81 teachers came from the division's 11 secondary schools, including the two newly created and inaugurated high schools for the current school year.

The primary instrument was a two-part questionnaire created by the researcher. Part I is intended to obtain the demographic profile of the teacher-respondents, including gender, age, academic rank, educational attainment, teaching experience, and commonly used technology in mathematics teaching and learning. Part II is a TPACK survey with 60 statements distributed across the eight domains of the TPACK framework. The distribution of items is as follows: TK: 1 to 6; PK: 7 to 17; CK: 18 to 26; TPK: 27 to 34 (TPK offline: 27 to 30 and TPK online: 31 to 34); TCK: 35 to 40; PCK: 41 to 46; TPACK: 47 to 55; and XK: 56 to 60. The primary instrument was a two-part questionnaire created by the researcher. Part I is intended to obtain the demographic profile of the teacher-respondents, including gender, age, academic rank, educational attainment, teaching experience, and commonly used technology in mathematics teaching and learning. Part II is a TPACK survey with 60 statements distributed across the eight domains of the TPACK framework (Schmid et al., 2020).

Five experts in education and mathematics education research content- and face-validated the survey questionnaire. These experts rated the survey questionnaire's acceptability and validity by checking yes or no against the criteria in the validation form, which covers the meaningfulness, appropriateness, and relevance of each statement in the survey. After that, the validated questionnaire was pilot tested with 27 mathematics teachers from neighboring districts and outside the target division. The results of the pilot testing were analyzed and subjected to reliability testing. Based on the computed Cronbach alpha, $\alpha = .98$, excellent internal consistency reliability was obtained.

To determine the level of usage of common classroom technologies, a five-point scale was used with 5 being the highest (Always) and 1 as the lowest (Never). The mean scores were then calculated and interpreted using the guide: 4.21 – 5.00: Always; 3.41 – 4.20: Often; 2.61 – 3.40: Sometimes; 1.81 – 2.60: Seldom; and 1.00 – 1.80: Never. On the other hand, to assess teachers' level of competence across the TPACK domains, a five-point scale was used, with 5 being the highest (Completely Competent) and 1 being the lowest (Incompetent). The following guide was additionally utilized to compute and interpret the means: 4.21 – 5.00: Completely Competent; 3.41 – 4.20: Fairly Competent; 2.61 – 3.40: Somewhat Competent; 1.81 – 2.60: Slightly Competent; and 1.00 – 1.80: Incompetent.

Before beginning the study, a letter of request was provided to the Schools Division Superintendent (SDS) to seek approval and endorsement. The rationale, objectives, purpose, and timeline were all stated in the letter. It was stressed that all information derived from the study would be treated with the utmost confidentiality in accordance with the existing Data Privacy Law. Following receipt of the letter of approval and recommendation, a similar letter of request was sent to each school head and principal. However, because face-to-face survey administration is prohibited, we devised an online survey schedule and distributed the link to the online questionnaire in Google Forms to all interested mathematics teachers. For smooth administration of the survey and ease of monitoring, contact persons were identified upon the recommendation of the school head or principal.

Google Forms responses were tabulated and organized in MS Excel. Initially, data examination and cleansing were performed, with a focus on ensuring the homogeneity and normality of the data sets. The homogeneity assumption was evaluated using Levene's test for homogeneity. Levene's Test of Homogeneity, $F(7, 640) = 6.218$, $p = 0.6678$, indicates that the null hypothesis was not rejected. Thus, the homogeneity requirement is met because there are no significant differences between the group variances. The Kolmogorov-Smirnov test, on the other hand, was used to ensure that the data sets were normal. This test revealed that data sets for PCK and XK were not normally distributed with computed p-values of .045 and .038, respectively. Furthermore, outliers were identified using the box and whisker plot, and necessary adjustments were made before subjecting the data sets to further statistical tests.

The tabulated data is then statistically analyzed. The mean, standard deviation, and ranks, as well as the various demographic variables and TPACK domains, were used to describe the characteristics of the teacher-respondents. Pearson's Product-Moment Correlation and Spearman Rank Rho Correlation were used to test for significant correlations between demographic variables and teacher competence levels, as well as the TPACK domains. A multiple regression analysis was also performed to determine the impact of demographic variables on TPACK domains. Finally, a one-way analysis of variance (ANOVA) was used to identify significant differences in the teachers' level of competence as well as the eight domains of the TPACK framework. Tukey-Kramer test was utilized as a post hoc analysis test in determining which pairwise groups have means that differ significantly.

Results and Discussion

Teachers' Demographic Profile

The majority of teachers (74.1%) are female (74.1%), between the ages of 35 and 50 (49.4%), organize Teacher I - III academic rank positions (93%), have at most 10 years of teaching experience (50.6%), and do not yet have a master's degree (78%). This finding indicates that mathematics teachers are generally young, both in terms of age and teaching experience and are classified as beginning or approaching proficiency in the Philippine Professional Standards for Teachers (PPST) career stage.

Table 1 summarizes the technology that teachers frequently employ in the mathematics classroom. An instant messaging app, such as Facebook Messenger (or simply Messenger), emerged first and was described as "always." The widespread use of various classroom technologies can be attributed to their utility (Anwar et al., 2020), effectiveness (Anwar et al., 2020; Baker et al., 2018; Rosmiati & Siregar, 2021), and availability of the technologies (Jones, 2003). Considering the socio-economic status of teachers and students, as well as the perennial issue of internet connectivity in the area, one of the most viable ways for teachers to stay connected and easily communicate academic-related concerns with their students is through an instant messaging app like Messenger. According to Garzon et al. (2019), Facebook and its products such as Messenger are the most popular and widely used social networking apps in the Philippines. As one of the top ten Facebook users countries in the world (Statista, 2017), it is safe to assume that almost all Filipino students have a Facebook account and use Messenger. Teachers can easily send instant messages and other multimedia files, such as pictures, voice recordings, video recordings, file documents, and others, to their students using this type of app at a low cost.

Table 1
Frequency Distribution of the Commonly Used Technologies in Mathematics Classroom

Classroom Technologies	*M*	*SD*	Interpretation
1. Computer/Laptop/Desktop	4.30	.95	Always
2. Radio or other similar audio devices	2.20	.91	Seldom
3. Projector or other similar devices	3.28	1.16	Sometimes
4. Calculator or other similar tools	3.83	1.14	Often
5. Interactive whiteboard/other interactive tools	3.30	1.37	Often

Classroom Technologies	*M*	*SD*	Interpretation
6. Graphing calculator/similar tools/app	2.79	1.18	Sometimes
7. PPT/other similar app	4.32	.88	Always
8. Spreadsheet/other similar web app	3.60	1.25	Often
9. Statistical Tool/Packages	2.62	1.32	Sometimes
10. LMS (Google Classroom, Edmodo, etc.)	3.33	1.34	Sometimes
11. Online assessment apps/programs	2.32	1.02	Seldom
12. Video conferencing app	3.80	1.32	Often
13. Facebook messenger/messaging app	4.72	.68	Always
Overall	3.42	1.12	Often

Radio and other similar audio device use, on the other hand, ranked at the bottom and was interpreted as "seldom." The low use of radio and other audio devices was attributed to their inherent limitations, even during face-to-face teaching. Teachers would rather employ other devices that offer the same features as well as extras like video playback.

Overall, the composite mean score of teachers in the level of use of classroom technologies indicates that teachers "often" use technology when teaching mathematics. This finding was consistent with the findings of Roble et al., (2020) and Abas and David (2019), in which the extent of TI implementation was considerably low. While there are some areas where teachers received high mean scores, the results show that there are some areas where teachers need to improve in terms of TI, particularly in this era of distance learning education. A literature review revealed some common factors that could explain the low level of TI implementation in the classroom. Hamutoglu and Basarmak (2020) revealed that beliefs towards teaching-learning activities, beliefs towards expert support, technological self-efficacy beliefs, family resistance, assessment, and pedagogical self-efficacy beliefs are some internal barriers while lack of vision, lack of money, lack of training, infrastructure, content, and time are all part of external factors that serve as TI barriers.

Level of Competence along TPACK Domains

Table 2 summarizes the characteristics of mathematics teachers across the TPACK framework domains. The teachers with the highest mean score in CK, as illustrated in the table, were interpreted as "completely competent." The high mean CK score demonstrates that mathematics teachers have a very high level of understanding and knowledge of mathematical concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof, and established practices and approaches to developing mathematical knowledge. Furthermore, PCK and PK were ranked second and third, respectively, and were both interpreted as "fairly competent." These results represent that teachers are well-versed in various teaching methods and processes, as well as pedagogical techniques for teaching mathematical concepts. These findings are consistent with other studies that discovered high levels of competence or confidence in teachers along CK, PC, and PCK (Muhaimin et al., 2019; Ozudogru & Ozudogru, 2019; Alrwaished et al., 2017).

Table 2
Teachers' Characteristics Along the TPACK Domains

Domains	*M*	*SD*	Interpretation
TK	3.69	.70	Fairly Competent
PK	4.06	.59	Fairly Competent
CK	4.29	.59	Completely Competent
TPK	3.83	.67	Fairly Competent
TCK	4.01	.70	Fairly Competent
PCK	4.13	.63	Fairly Competent
TPACK	3.87	.69	Fairly Competent
XK	3.96	.69	Fairly Competent
Overall	3.97	.66	Fairly Competent

On the other hand, the teachers got the lowest mean score at TK and whose score was interpreted as "fairly competent." Teachers at this level are characterized as having a basic understanding of the various educational technologies that can be used in mathematics instruction. It is also worth noting that other domains with TK as a sub-component, such as TCK, TPK, and TPACK, ranked relatively low in the survey. The teacher's lack of competence in TCK, TPK, and TPACK can be attributed to their lack of competence in TK. TK is the weakest component among the domains that require more attention and consideration, according to the integrative perspective (Schmid et al., 2020). This current observation was similar to previous studies in which TK was discovered to lag among the domains of teachers in the TPACK framework (Gonzales, 2018; Malubay & Daguplo, 2018).

Except for CK, the teacher's overall level of competence is explained as "fairly competent" across all domains. The obtained overall mean score indicates that teachers have a fair level of knowledge or skills in integrating various technologies in teaching and representing mathematical content in their community. While there are some areas with promising results, it cannot be denied that some domains, particularly with TI, require improvement. This finding is consistent with the previous finding regarding the extent to which various classroom technologies are implemented (Jacinto & Samonte, 2021; Malubay & Daguplo, 2018; Roble et al., 2020).

In addition, an analysis of variance (ANOVA) was performed to determine whether there is a difference in the levels of competence of mathematics teachers across the eight domains. The test was highly significant; thus, it can be concluded that there was a significant difference between the levels of teacher's competence along the eight domains, ($F(7, 638) = 6.48$, $p<.01$). Post hoc analysis employing the Tukey HSD test revealed that there was a highly significant difference between TK and PK; TK and CK; TK and PCK; CK and TPK, but not between TK and TCK; CK and TPACK; and CK and XK. Taken together, the findings demonstrate that teachers' levels of competence across the eight domains differ statistically, with teachers' levels of competence between TK and CK appearing to differ the most.

Correlation between Demographic Variables and TPACK Domains

Table 3 depicts the correlation matrix between demographic variables and teachers' level of competence in the eight domains. The majority of the coefficient values are negative, indicating a negative association. A negative association indicates an indirect relationship between the two variables under consideration. Moreover, it can also be seen that these correlation coefficient values, $.01 < |r| < .49$, indicate a very weak to low degree of association. In general, these values imply that the strength of association between the demographic variable and the level of competence of teachers across the TPACK domains being compared is "unsubstantial" or "near negligible." These findings are consistent with the results of Malubay and Daguplo (2018), who discovered that the majority of variables in the respondent's profile, such as gender, age, number of years in service, and number of training, have a weak linear relationship with the different TPACK domains.

Table 3
Teachers' Characteristics along the TPACK Domains

	Domains							
	TK	PK	CK	TPK	TCK	PCK	TPACK	XK
1. Sex	-.21	-.11	-.13	-.12	-.02	-.09	-0.10	-0.19
2. Age	-.32**	-.19	-.23*	-.38**	-.42***	-.22*	-.37***	-.38**
3. Rank	-.38***	-.08	-.11	-.34**	-.28*	-.10	-.27*	-.16
4. Teaching Experience	-.42***	-.26*	-.25*	-.44***	-.44***	-.26*	-.39***	-.39**
5. Educational Attainment	.01	.05	.02	-.02	-.02	-.01	-.01	-.01
6. Use of Classroom Technology	.43***	.17	.15	.49***	.38***	.19	.45***	.23*

Note: *p <.05, **p <.01, ***p <.001, N = 81

It is interesting to note, however, that when significant association was examined among those pairs with positive correlation, the test was discovered to be highly significant between utilization of classroom technology and TK, ($r_s(79) = .43$, $p<.001$); TPK, ($r_s (79) = .49$, $p<.001$); TCK, ($r_s (79) = .38$, $p<.001$); and TPACK, ($r_s (79) = .45$, $p<.001$). Furthermore, the test emerged to be significant between the use of classroom technology and XK (r_s (79) = -.23, p<.001). This implies that the extent of utilization of classroom technology is directly associated with the TK, TPK, TCK, TPACK, and XK of the teachers.

Furthermore, multiple regression analysis was performed to determine whether demographic variables (explanatory variables) and TPACK domains (outcome variables) can influence or predict teacher competence. The demographic variables (sex, age, academic rank, teaching experience, highest educational attainment, and frequent use of classroom technology) were hypothesized to positively predict TK, PK, CK, TPK, TCK, PCK, XK, and TPACK. The test was highly significant for TK (F(6, 74) = 6.17, p<.001), TPK (F(6, 74) = 6.39, p<.001), TCK (F(6, 74) = 4.30, p<.001), TPACK (F(6, 74) = 4.89, p<.001); significant for XK (F(6, 74) = 2.65, p =.022). Only the frequent use of common classroom technologies was determined to have a strong and positive influence on TK (β =.34, t = 3.39, p< .001); TPK (β =.41, t = 4.08, p< .001), TCK (β =.28, t = 2.66, p< .001), and TPACK (β =.38, t = 3.68, p<.001) when each predictor's individual contribution was closely examined. While none of the predictors appeared to correctly predict XK. Thus, regression analysis revealed that frequent use of common classroom technologies served as the best predictor, and an increase in classroom technology use would also increase the teacher's level of competence in addition to TK, TPK, TCK, and TPACK. This differs from the study of Malubay and Daguplo (2018), in which the TPACK domains were considered and investigated as explanatory predictors rather than demographic variables.

Conclusion

This study serves as a baseline for profiling teacher characteristics about the TPACK framework and technology integration. The findings revealed that the majority of mathematics teachers are female, relatively young in terms of age and teaching experience, mostly in entry-level positions, and do not yet organize master's degrees. In terms of the use of various classroom technologies, however, the findings show that teachers "often" used these technologies in mathematics instruction. As a result, the use of classroom technologies was relatively low, which can be attributed to a variety of internal and external factors.

Teachers have been discovered to have a very high level of competence in CK for the TPACK domains, indicating that teachers have a solid foundation on the various mathematical concepts, theories, ideas, organizational frameworks, evidence, and proof knowledge, as well as established practices and approaches. The findings, on the other hand, revealed that teachers have the lowest TK competence. This is consistent with the earlier finding about the low level of common classroom technologies. Furthermore, other domains with TK as a component rank relatively low, indicating that TK is the teachers' weakest domain. Overall, the teachers' level of competence in TI using the TPACK framework is just adequate.

The test was highly significant for TK, TPK, TCK, and TPACK when the overall effect of the teacher's demographic characteristics on their level of competence was investigated along with the eight TPACK domains. When all six demographic variables were employed as predictors, the test was also significant for XK. Only the frequent use of classroom technologies was found to have a positive influence among the six predictors when the individual effect was examined. As a result, the extent and frequency with which classroom technology was utilized served as the best and strongest predictor of TK, TPK, TCK, and TPACK.

As a result, specialized training focusing on improving teachers' competence in technology-integrated mathematics instruction is recommended, which can be accomplished effectively through responsive, localized, and bottom-up professional development programs and activities. In addition, a similar study involving mathematics teachers from various private schools could be conducted to compare and validate the current findings. This will give you a broader perspective on the topic.

Acknowledgements

The researcher would like to extend its gratitude to the people who made this study possible. First, to all the secondary mathematics teachers of the division for their effort and participation in this study. Second, to the DepEd officials (SDS, school heads, focal persons, etc.) who approved and endorsed the study. Third, to the College Administrators and Officials who evaluated, approved, and funded this humble piece of work. Also, special thanks to the research assistant, research enumerator, and editor for their contributions to the success of this study.

References

Abas, M., & David, A. (2019). Teachers' self-assessment towards technology integration in teaching mathematics. *International Journal for Cross-Disciplinary Subjects in Education, 10*(2), 4068-4079. https://doi.org/10.20533/ijcdse.2042.6364.2019.0496

Alrwaished, N., Alkandari, A., & Alhashem, F. (2017). Exploring in-and pre-service science and mathematics teachers' technology, pedagogy, and content knowledge (TPACK): What next? *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(9), 6113-6131. https://doi.org/10.12973/eurasia.2017.01053a

Anwar, Z., Kahar, M. S., Rawi, R. D. P., Nurjannah, N., Suaib, H., & Rosalina, F. (2020). Development of interactive video based powerpoint media in mathematics learning. *Journal of Educational Science and Technology (EST), 6*(2), 167-177.

Bakar, N. S. A., Maat, S. M., & Rosli, R. (2020). Mathematics teacher's self-efficacy of technology integration and technological pedagogical content knowledge. *Journal on Mathematics Education, 11*(2), 259-276. https://doi.org/10.22342/jme.11.2.10818.259-276

Baker, J. P., Goodboy, A. K., Bowman, N. D., & Wright, A. A. (2018). Does teaching with PowerPoint increase students' learning? A meta-analysis. *Computers & Education, 126*, 376-387. https://doi.org/10.1016/j.compedu.2018.08.003

Cahapay, M. B., & Anoba, J. L. D. (2021). Technological pedagogical knowledge self-efficacy and continuance intention of Philippine teachers in remote education amid COVID-19 crisis. *Journal of Pedagogical Research*, 5(3), 68-79.

Garzon, J. D., Kim, N., & Kim, C. H. (2019). Relationship of Facebook use and scholastic performance: The case of Filipino senior high school students. *Asian Journal of Education and E-Learning*, *7*(1). https://doi.org/10.24203/ajeel.v7i1.5742

Gonzales, A. L. (2018). Exploring technological, pedagogical, and content knowledge (TPACK) and self-efficacy belief of senior high school biology teachers in Batangas City. *Palawan Scientist, 10*, 29-47.

Gonzales, G. G., & Gonzales, R. R. (2021). Introducing IWB to preservice mathematics teachers: An evaluation using the TPACK framework. *Cypriot Journal of Educational Sciences*, *16*(2), 436-450.

Hamutoglu, N. B., & Basarmak, U. (2020). External and internal barriers in technology integration: A structural regression analysis. *Journal of Information Technology Education: Research*, *19*, 17-40. https://doi.org/10.28945/4497.

Hero, J. L. (2019). The impact of technology integration in teaching performance. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 48*(1), 101-114. https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/10187

Ibañez, E. D., Subia, G. S., Medrano-Allas, S., Mendoza, J. I., & Mina, J. C. (2021). Modern mathematics applications: Solutions to challenges encountered in teaching spiral progression in mathematics 7. *Open Access Library Journal, 08*(07), 1-7. https://doi.org/10.4236/oalib.1107623.

Jacinto, M. A. T., & Samonte, F. A. (2021). Anxiety and efficacy in computer technology integration among secondary school teachers of Angadanan, Isabela, Philippines. *Journal of BIMP-EAGA Regional Development*, *7*(1), 57-65.

Jones, A. M. (2003) The use and abuse of PowerPoint in teaching and learning in the life sciences: A personal overview. *Bioscience Education*, *2*(1), 1-13, https://doi.org/10.3108/beej.2003.02000004

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Lucenario, J. L. S., Yangco, R. T., Punzalan, A. E., & Espinosa, A. A. (2016). Pedagogical content knowledge-guided lesson study: Effects on teacher competence and students' achievement in chemistry. *Education Research International,* 2016, 1-9. https://doi.org/10.1155/2016/6068930

Malubay, J., & Daguplo, M. S. (2018). Characterizing mathematics teachers' technological pedagogical content knowledge. *European Journal of Education Studies*, 4(1), 199-218. http://dx.doi.org/10.46827/ejes.v0i0.1398

Mercado, M. G. M., & Ibarra, F. P. (2019). ICT-pedagogy integration in elementary classrooms: Unpacking the preservice teachers' TPACK. *Indonesian Research Journal in Education*, 29-56.

Mercado, N. L., Panganiban, J. M., & Ramos, M. I. (2019). Technology integration in teaching science using TPACK among pre-service science teachers of St. Bridget College, Batangas City, Philippines. *IOER International Multidisciplinary Research Journal,* 1(1), 63-71

Mishra, P. (2019). Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education, 35*(2), 76-78.

Morales, M. P. E., Avilla, R. A., Butron, B. R., Ayuste, T. O. D., Masangcay, D. B., & Laureano, R. A. (2021). Technology integration traditions, transitions, and best practices in Philippine higher STEAM education. *Philippine Journal of Science, 150*(5), 1265-1278.

Moser, C. A., & Kalton, G. (2017). *Survey methods in social investigation*. Routledge. https://doi.org/10.4324/9781315241999

Muhaimin, M., Habibi, A., Mukminin, A., Saudagar, F., Pratama, R., Wahyuni, S., ... & Indrayana, B. (2019). A sequential explanatory investigation of TPACK: Indonesian science teachers' survey and perspective. *JOTSE, 9*(3), 269-281.

Oskay, Ö. Ö. (2017). An investigation of teachers' self-efficacy beliefs concerning educational technology standards and technological pedagogical content knowledge. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(8), 4739-4752. https://doi.org/10.12973/eurasia.2017.00961a

Ozudogru, M., & Ozudogru, F. (2019). Technological pedagogical content knowledge of mathematics teachers and the effect of demographic variables. *Contemporary educational technology, 10*(1), 1-24. https://doi.org/10.30935/cet.512515

Ramos, R. A., Babasa, E. E., Vergara, I. B., Manalo, B. I., Gappi, L. L., & Morfi, T. G. (2020). The TPACK confidence of preservice teachers in selected Philippine teacher education institutions. *International Journal of Education, Psychology and Counselling, 5*(37), 196-205. https://doi.org/10.35631/ijepc.5370016

Roble, D. B., Ubalde, M. V., & Castillano, E. C. (2020). The good, bad and ugly of technology integration in mathematics from the lens of public-school mathematics teachers. *Science International*, *32*(5), 525-528.

Rosmiati, U., & Siregar, N. (2021). Promoting Prezi-PowerPoint presentation in mathematics learning: The development of interactive multimedia by using ADDIE model. *Journal of Physics: Conference Series*, *1957*(1), 012007. IOP Publishing. https:doi.org/ 10.1088/1742-6596/1957/1/012007

Santos, J. M., & Castro, R. D. (2021). Technological Pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST). *Social Sciences & Humanities Open*, *3*(1), 100110. https://doi.org/10.1016/j.ssaho.2021.100110

Sasota, R.S., Cristobal, R.R., Sario, IS, Biyo, J. T., & Magadia, J. C. (2021). Will–skill–tool (WST) model of technology integration in teaching science and mathematics in the Philippines. *Journal of Computers in Education. 8*(3), 443–464. https://doi.org/10.1007/s40692-021-00185-w

Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. *Computers & Education*, *157*, 103967. https://doi.org/10.1016/j.compedu.2020.103967

Shuttleworth, M. (2019). Descriptive Research Design - Observing a Phenomenon. Retrieved from https://explorable.com/descriptive-research-design

Siedlecki, S. L. (2020). Understanding descriptive research designs and methods. *Clinical Nurse Specialist, 34*(1), 8-12.

Statista. (2017, December 31). Facebook users by country | Statistic. Statista; Statista. Retrieved from https://www.statista.com/statistics/268136/top-15-countries-based-on-number-of-facebook-users/

Wang, W., Schmidt-Crawford, D., & Jin, Y. (2018). Preservice teachers' TPACK development: A review of literature. *Journal of Digital Learning in Teacher Education, 34*(4), 234-258. https://doi.org/10.1080/21532974.2018.1498039