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The Technological, Pedagogical, and Content Knowledge (TPACK) Of Mathematics Teachers in a Polytechnic College, Philippines

Rowel S. Ramos

College of Arts and Sciences, Camarines Sur Polytechnic Colleges, Philippines
E-mail: rowelasher@cspc.edu.ph

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ABSTRACT With the advent of technology, it is imperative that there is alignment along the integration of technology, suitable pedagogy, and content in the classroom. This concern helps to realize this study, "The Technological, Pedagogical, and Content Knowledge (TPACK) of Mathematics Teachers in a Polytechnic College, Philippines," which aimed to determine the extent of the Camarines Sur Polytechnic Colleges (CSPC) Mathematics teachers' appropriate technology use in their instruction. 32 teachers were assessed on their TPACK perceptions, employing descriptive and inferential statistics to analyze and interpret the gathered data. Findings revealed that teachers have the highest perception in technological content knowledge (TCK) and lowest in technology knowledge (TK) and are generally completely competent in all TPACK components. There are no significant differences in their demographic profiles along their TPACK perceptions. This contributes valuable insights for CSPC and similar educational institutions, informing strategies for professional development and resource allocation to strengthen teachers' TPACK.

INTRODUCTION

Nowadays, 21st-century educators are projected to focus not only on the content and pedagogy of their subject matter but also on technology and its integration into their teaching. Since this is a developing world, a continuous call for change in the educational process also arises. Today is a millennial era in every aspect of 21st-century educators with their millennial teaching. Knowledge of technology is rapidly increasing, as Kaput (1992) compared computer technology in mathematics education to that of a newly active volcano. It is an explosion rapidly evolving with forces coming from different directions. Furthermore, the call for educators to incorporate technology into the learning environment is also rising.

Years ago, the problem of technology integration in the teaching-learning process was already evident. As emphasized by Çetin and Erdogan (2018), good knowledge in the field and pedagogy as well as being able to use the technology effectively in learning environments is one of the most important efficient skills needed by teachers. Technology is no longer an innovation, but there has been a tendency to look only at the technology rather than how it is used. The introduction of technology in the educational process is not enough. The question of what teachers need to know to integrate technology into their teaching appropriately has already received significant attention (U.S. Congress Office of Technology Assessment 1995; National Council for Accreditation of Teacher Education 1997; International Society for Technology in Education 2007; U.S. Department of Education 2000; Zhao 2001). Our primary focus should be on how the technology can be used in teaching rather than on what the technology alone can be used (Carr et al. 1998; Mishra and Koehler 2003).

In the Philippines, there is also a challenge for future educators to use technology in a practical, innovative, and engaging manner in their future teaching in K-12 classrooms. Teacher preparation programs should now emphasize supporting teachers as they learn to provide technology-enhanced learning opportunities for students.

Mathematics education in the country is contextualized by the Framework for Philippine Mathematics Teacher Education (FPMTE) and the Mathematics Framework for Philippine Basic Education (MFPBE) authored by the Department of Science and Technology – Science Education Institute (DOST-SEI) with the Philippine Council of Mathematics Teacher Education (MATHTED), Inc. this framework contains resources that could guide higher education institutions, professional organizations of mathematics teachers and school administrators in assessing and improving the performance and career development of mathematics teachers. In this framework, one of the principles listed to develop highly competent mathematics teachers for good quality education in the country is that technology plays an essential role in the teaching and learning Mathematics. Therefore, mathematics teachers must also learn to use and manage technological tools and resources (MATHTED and SEI 2010).

The development of this study is primarily informed by the concept of Technological, Pedagogical, and Content Knowledge (TPACK) by Mishra and Koehler (2006). Teachers' TPACK depends on 7 knowledge domains, namely: content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technology knowledge (TK), technological, pedagogical knowledge (TPK), technological content knowledge (TCK), and the technological, pedagogical, and content knowledge (TPACK). These are the interactions and intersections of these 3 main components. These interactions are the domains of the TPACK framework.

Mishra and Koehler (2006) described the distinctions among the TPACK constructs. CK is the teacher's knowledge about the subject matter to be learned or taught, including concepts, theories, ideas, organizational frameworks, evidence, proof, and established practices and approaches toward developing such knowledge (Shulman, 1986). PK is a teacher's deep knowledge about the process and practices or methods of teaching and learning, which includes knowledge about techniques or methods used in the classroom, the nature of the target audience, and strategies for evaluating student understanding. PCK is the knowledge that includes knowing what teaching approaches fit the content and knowing how elements of the content can be arranged for better teaching. TK is knowledge about standard and advanced technologies and skills required to operate particular technologies. TCK is about how technology and content are reciprocally related. TPK is knowledge of the existence, components, and capabilities of various technologies used in teaching and learning settings and how teaching might change due to using particular technologies. TPACK is an emergent knowledge that goes beyond content, pedagogy, and technology. It underlies significant and profoundly skilled teaching with technology, which differs from the knowledge of all 3 concepts individually.

Objectives of the Study

This study sought to understand the level of TPACK perceptions of CSPC Mathematics teachers. Specifically, this study answered the following research questions:

1. What is the profile of the CSPC Mathematics teachers in terms of:
   a. sex;
   b. length of service;
   c. academic rank;
   d. educational attainment; and
   e. attendance to TPACK-related seminars?
2. What is the level of teachers' perception along the TPACK components?
3. What demographic factors are associated with the teachers' level of perception along the TPACK components?

METHODOLOGY

A pre-existing instrument developed by Onal (2016) was implemented to find the mathematics teachers' TPACK perceptions. The Cronbach's Alpha reliability of the utilized instrument is .97. After accomplishing the necessary permits from the respective deans of the respondents, the instruments were distributed to 32 teachers of the institution purposely chosen by their respective deans for the study since they were the ones who teach mathematics during the duration of the gathering of data which was 2nd semester of academic year 2021-2022. Respondents are members of different colleges, and most are not considered generalists as much as mathematics is concerned. They are only teaching specific areas of mathematics, such as engineering mathematics for the College of Engineering and Architecture (CEA) faculty members, business mathematics for College of Tourism, Hospitality, and Business Management (CTHBM) faculty members, and discrete mathematics and the likes for the College of Computer Studies (CCS) faculty members.

The distribution of the teacher respondents is shown in Table 1.

The instrument was created through Google form with a total of 54 items assessing the different TPACK perceptions excluding the 5 items

Table 1: Frequency and distribution of the respondents according to college affiliation

College affiliation	*Number of teacher respondents*
College of Arts and Sciences	9
College of Engineering and Architecture	13
College of Computer Studies	6
College of Tourism, Hospitality, and Business Management	4
TOTAL	**32**

about their demographic profiles. The item distribution includes 7 in TK, 11 in PK, 9 in CK, 6 in TPK, 5 in TCK, 7 in PCK, and 9 in TPACK. It would only take less than 10 minutes of the teachers to answer the instrument and the researcher spent almost a month to wait for all the participants to respond to the questionnaire.

This research study employed the descriptive research methodology as it aimed to describe the teachers' profiles and their perceptions along the TPACK components. The other aim of this study is to investigate the possible differences among the CSPC Mathematics teachers' demographic profiles in their technological, pedagogical, and content knowledge (TPACK) perceptions. Therefore, in this study, inferential research methodology was also used. Considering the purposes and the research design definitions, the study utilized a harmony of descriptive-inferential research methodology.

Descriptive statistics, including percentages, weighted means, were used to analyze the teachers' profiles and their perceptions along the TPACK components. The chi-square test of independence was utilized to find out the possible differences in the profiles of the teachers along these TPACK perceptions.

RESULTS AND DISCUSSION

Profile of the CSPC Mathematics Teachers

It can be seen in the table that 32 respondents participated in the study: Males are 17 or 53.13 percent of the respondents, while females are 15, 46.88 percent of the respondents. Thus, making the male respondents dominant in number. Table 2 presents the frequency and percentage distribution of the respondents according to sex.

Table 2: Frequency and distribution of the respondents according to sex

Sex	*f*	*%*
Male	17	53.13
Female	15	46.88
TOTAL	**32**	**100.00**

It was gleaned from the data that 53.13 percent or 17 of the respondents have rendered their service in teaching 2 years and below. Moreover, 11 Math instructors have been working within 3-5 years. Some respondents have been dedicating their passion to teaching for longer: 2 respondents for 6-8 years, 1 for 9-11 years, and another for 15 years and above. This entails a balance between teachers who have just started their service in teaching and those who have been in the profession for many years. The data in the Table 3 presents the respondents' frequency and distribution according to their service length.

Table 3: Frequency and distribution of the respondents according to length of service

Length of service	*f*	*%*
2 years and below	17	53.13
3-5 years	11	34.38
6-8 years	2	6.25
9-11 years	1	3.13
12-14 years	0	0.00
15 years and above	1	3.13
TOTAL	**32**	**100.00**

Attending seminars or trainings that will widen teachers' knowledge about classroom management and pedagogies is essential. Thus, the table shows the frequency and distribution of the respondents according to their attendance in TPACK-related seminars. Out of 32 respondents, 24 attested that they have experienced attending seminars related to TPACK. In contrast, 8 respondents asserted that they have yet to experience any single seminar related to TPACK. The data in the Table 4 presents the respondents' frequency

Table 4: Frequency and distribution of the respondents according to TPACK-related seminars

Attendance to TPACK-related seminars	*f*	*%*
Yes	24	75.00
No	8	25.00
TOTAL	**32**	**100.00**

and distribution according to their attendance in TAPCK-related seminars.

Educational attainment plays a crucial role in shaping and enhancing the TPACK among educators. Higher levels of educational attainment, such as advanced degrees or specialized certifications, often indicate a more extensive and in-depth understanding of subject matter and pedagogical principles. This advanced knowledge provides a solid foundation for educators to integrate technology seamlessly into their teaching methods. Thus, Table 5 presents that out of 32 respondents, 19 have a Master's Degree, making it 59.38 percent in totality. Furthermore, 13 respondents have a Bachelor's Degree, making it 40.63 percent.

Table 5: Frequency and distribution of the respondents according to educational attainment

Educational attainment	*f*	*%*
Master's Degree	19	59.38
Bachelor's Degree	13	40.63
TOTAL	**32**	**100.00**

Table 6 shows the academic rank of the Mathematics teachers in Camarines Sur Polytechnic Colleges. Among all the respondents, 78.13 percent or 25 are the institution's Instructor I. Instructor II and Instructor III academic ranks showed 2 respondents each. Moreover, those who have more experience and educational milestones already achieved higher academic ranks: 1 for Assistant Professor I, 1 for Assistant Professor III, and 1 for Associate Professor V. Hence, academic rank holds significant importance in the development and application of TPACK perceptions among educators. As teachers progress in their academic careers, their rank often correlates with increased responsibilities, leadership roles, and opportunities for professional development.

Table 6: Frequency and distribution of the respondents according to academic rank

Academic Rank	*f*	*%*
Instructor I	25	78.13
Instructor II	2	6.25
Instructor III	2	6.25
Assistant Professor I	1	3.13
Assistant Professor III	1	3.13
Associate Professor V	1	3.13
TOTAL	**32**	**100.00%**

Higher academic ranks often signify a deeper understanding of the subject matter, advanced pedagogical skills, and a commitment to ongoing learning. This elevated expertise can positively impact TPACK perceptions as higher-ranking educators are better positioned to influence curriculum design, guide colleagues, and integrate technology effectively into teaching practices.

CSPC Mathematics Teachers' TPACK

The TPACK is a framework that lies at the intersection of technology, pedagogy, and content knowledge, providing a comprehensive approach to effective teaching in the digital age. This innovative framework guides educators in navigating the complex interplay of these components, fostering a dynamic and technologically adept teaching approach that optimally supports student learning. Hence, the researcher of this study analyzed CSPC Mathematics teachers' level of TPACK perceptions. It was gleaned from the data presented that there is a close gap between TPACK components regarding teachers' perceptions. The analyzed data showed 2 interpretations only: thoroughly competent and fairly competent. The following tables present the teachers' perceptions in each of the TPACK components including its respective indicators.

The assessment of teachers' Technology Knowledge (TK) shows that they are generally competent in a number of areas, with a weighted mean of 4.417 indicating a strong ability to use new and developing technologies for teaching. Rakisheva and Witt's (2023) study, which highlights the use of digital competency frameworks in teacher education, is consistent with this. These frameworks offer precise action plans, standards, and measurements to help teachers successfully incorporate technology into their lesson plans.

However, a common issue among educators is highlighted by the lower competency in solving hardware difficulties, with a weighted mean of 3.917. Effective technology integration in classrooms has been found to be significantly hindered by technical problems, such as broken equipment and insufficient technical support. For example, teachers often struggle with poor internet connectivity, broken devices, and a lack of prompt technical support, all of which disrupt the seamless delivery of teachings (Demirbilek 2022).

Improving instructors' technical troubleshooting abilities and offering strong support networks are essential to address these concerns. According to Ghavifekr et al. (2016), teachers can be empowered to effectively handle and resolve technical issues by participating in professional development programs that emphasize real hardware troubleshooting and having access to easily available technical help. This method guarantees that there is less interruption to class instruction while simultaneously boosting instructor's confidence in using technology.

In summary, while teachers demonstrate considerable competence in adopting new technologies for educational purposes, there is a critical need to bolster their skills in hardware problem-solving. Addressing this gap through targeted training and support can lead to more effective and seamless technology integration in educational settings.

Table 7 summarizes the teachers' perceptions of their technology knowledge.

With a weighted mean of 4.523, the results demonstrate that math teachers are generally competent in Pedagogical Knowledge (PK). Their ability to evaluate in-class student performance is their strongest competency (4.833), demonstrating how well they use formative assessment strategies to track and enhance student learning. With a weighted mean of 4.333, their capacity to identify student misconceptions during instruction, on the other hand, is the sign that is perceived the least, suggesting area for improvement. Overall, the high degree of competence in PK shows how well the teachers have mastered key pedagogical abilities such classroom management, student engagement, and effective teaching startegies.

Recent research highlights how competent math teachers are in pedagogical knowledge (PK), especially when it comes to evaluating student performance. For example, the Miller et al. (2022) study shows that instructors' PK helps them to effectively address students' needs and establish helpful learning environments. Their skillful application of formative assessment methods, which are essential for tracking and improving student progress, demonstrates this competency.

However, it is still difficult to recognize and correct student misconceptions when they are being taught. In their assessment of secondary mathematics teachers' pedagogical content knowledge (PCK), Moh'd et al. (2021) discovered that although teachers are skilled in a variety of teaching techniques, they frequently have difficulty identifying and correcting students' misconceptions. This gap indicates that focus in diagnostic teaching methods in professional development is necessary.

Overall, the high level of competence in PK reflects teachers' mastery of essential pedagogical skills, including classroom management, student engagement, and effective teaching strategies. To further enhance instructional quality, ongoing professional development is recommended, emphasizing the identification and correction of student misconceptions to foster deeper mathematical understanding.

The teachers' PK perceptions for each indicator is presented in Table 8.

Table 7: CSPC mathematics teachers' Technology Knowledge (TK)

	Technology Knowledge (TK)	*Item mean*	*Interpretation*	*Rank*
1	TK 1	4.333	Fairly competent	2.5
2	TK 3	4.333	Fairly competent	2.5
3	TK 3	4.417	Fairly competent	1
4	TK 4	3.917	Fairly competent	7
5	TK 5	4.167	Fairly competent	5
6	TK 6	4.250	Fairly competent	4
7	TK 7	4.083	Fairly competent	6
	General Weighted Mean	4.214	Fairly competent	

Table 8: CSPC mathematics teachers' Pedagogical Knowledge (PK)

	Pedagogical Knowledge (PK)	*Item mean*	*Interpretation*	*Rank*
1	PK 1	4.417	Fairly competent	8.5
2	PK 2	4.333	Fairly competent	11
3	PK 3	4.583	Completely competent	4
4	PK 4	4.583	Completely competent	4
5	PK 5	4.417	Fairly competent	8.5
6	PK 6	4.417	Fairly competent	8.5
7	PK 7	4.583	Completely competent	4
8	PK 8	4.667	Completely competent	2
9	PK 9	4.833	Completely competent	1
10	PK 10	4.500	Completely competent	6
11	PK 11	4.417	Fairly competent	8.5
	General Weighted Mean	4.523	Completely competent	

For the Content Knowledge (CK), the results demonstrate that Mathematics teachers are highly competent, with a weighted mean of 4.593. Of the 9 indications, 8 were rated to be completely competent, demonstrating their mastery of mathematical ideas. With a weighted mean of 4.750, their ability to apply prior mathematical knowledge is the highest-rated competency, highlighting their solid fundamental knowledge. However, with a mean score of 4.333, the skill with the lowest rating indicates difficulty applying mathematical thinking to solve real-world problems.

Teachers' strong grasp of mathematical concepts is demonstrated by their high scores on 8 of the 9 indicators. This fundamental understanding is essential for good teaching because it helps teachers to accurately and concisely convey complex concepts. According to a study by Hill et al. (2005), students' achievement in mathematics is positively influenced by teachers' in-depth content knowledge.

Teachers struggle to apply mathematical ideas to real-world applications, even though they have a solid theoretical understanding of the subject. This disparity may make it more difficult for students to understand how mathematics is used in various fields and in daily life. According to research, teaching mathematics with the integration of real-world problems improves students' critical thinking and problem-solving abilities (Geiger et al. 2023).

While mathematics teachers exhibit strong content knowledge, professional development programs should focus on strategies that help teachers connect mathematical theories to practical applications. This includes training on designing and implementing problem-based learning activities that mirror real-world scenarios. Such approaches not only improve teachers' competencies but also make learning more engaging and meaningful for students.

Table 9 shows the perceptions of the teachers in the content knowledge indicators.

The results show that math teachers believe they are reasonably competent in Technological Pedagogical Knowledge (TPK), with a weighted mean of 4.486. This self-assessment is consistent

Table 9: CSPC mathematics teachers' Content Knowledge (CK)

	Content Knowledge (CK)	*Item mean*	*Interpretation*	*Rank*
1	CK 1	4.750	Completely competent	1
2	CK 2	4.333	Fairly competent	9
3	CK 3	4.583	Completely competent	6
4	CK 4	4.667	Completely competent	2.5
5	CK 5	4.583	Completely competent	6
6	CK 6	4.583	Completely competent	6
7	CK 7	4.583	Completely competent	6
8	CK 8	4.583	Completely competent	6
9	CK 9	4.667	Completely competent	2.5
	General Weighted Mean	4.593	Completely competent	

with recent research showing that teachers are generally confident in incorporating technology into their pedagogy. For example, a study (Özen and Kurtulus 2023) that looked at the TPK competences of math instructors discovered that teachers value technology integration and strive to improve their skills in this area.

Although the overall confidence of teachers is quite high, the least-rated competency in technology-integrated classrooms is evaluation, with 4.417 as weighted mean. Such information indicates that there are challenges in developing new forms of assessment which can be put online. Moreover, the study highlights that teachers may not be as proficient in employing technology for student evaluation despite their ability to use technology in class. This is one of the reasons why teachers face difficulties in these environments when they try to determine the students' progress. Low proficiency at the assessment of student progress using technology was one of the highlighted topics by Johnson et al. (2016), as only 57.6 percent of teachers felt adequately trained enough for that. Therefore, a lot needs to be done in professional development in this area.

Overall, attempts of technology-integration into pedagogy typically exhibit strong technical competence regarding the area. On the other hand, the area where teachers have lower confidence is the application of technology-based assessment. Emphasizing this disparity by specifically addressing it via adequate training and teaching resources can lead to the increase in efficiency of technology-embedded teaching and learning activities.

These TPK indicators and respective weighted means are presented in Table 10.

The results indicated that the mathematics teachers described themselves as highly competent in Technological Content Knowledge (TCK), which is pegged at a mean of 4.633. They are rated with 4.833, which is high, on the use of pre-installed software and web functionalities aimed at teaching mathematics practically, and this rate shows good foundational technology skills in integrating basic technology into their teaching practices. On the other hand, they had a self-assessment of 4.333 on their use of high-level digital tools such as flash animations and drawing programs for drawing graphics to make math classes more interesting.

The discrepancy in capacity to integrate technological resources implies that while teachers feel easy with ordinary ICT tools, they struggle with the adoption and usage of more complex digital resources in lessons. Be it because of inadequate training, constraints of limited access to resources, or a low self-esteem in the employability of these devices, the resistance or difficulty in the adoption of advanced digital tools can be attributed to different reasons. Research by Muhazir and Retnawati (2020) mentions that teachers commonly face challenges like limited professional development opportunities and a lack of technical assistance when trying to incorporate new technologies in the classroom.

To address these challenges, well-structured professional development programs that are focused on useful modern digital mathematical tools are key players in fixing this problem. Such training can greatly help teachers become self-assured and better equipped to make a greater impact on the classroom and education process. Besides, the institutional support in opening the avenues for access of the necessary technology and in the fostering of the culture of continuous learning could be a great deal in cases where the teachers are expected to make use of the innovative digital resources in learning.

Table 11 shows the teachers' perceptions in every indicator of TCK.

Table 10: CSPC Mathematics Teachers' Technological Pedagogical Knowledge (TPK)

	Technological Knowledge (Pedagogical TPK)	*Item mean*	*Interpretation*	*Rank*
1	TPK 1	4.500	Completely competent	3
2	TPK 2	4.500	Completely competent	3
3	TPK 3	4.417	Fairly competent	6
4	TPK 4	4.500	Completely competent	3
5	TPK 5	4.500	Completely competent	3
6	TPK 6	4.500	Completely competent	3
	General Weighted Mean	4.486	Fairly competent	

The results demonstrate a high competence of mathematics teachers in their Pedagogical Content Knowledge (PCK), with a weighted mean of 4.631. The competency they identified as the highest rated is their capacity to teach math classes compliant with the curriculum, with a rating of 4.917. This emphasizes the relevance of the pedagogical principles and curriculum alignment. This proficiency is crucial, as research by Campbell et al. (2014) suggests that teachers' knowledge and beliefs about teaching and learning mathematics are key factors in effective instruction and positively influence student achievement.

On the other hand, the areas that need improvement are evident in competencies related to addressing students' misconceptions, and encouraging student-led researches, both got a score of 4.417. The challenge in overcoming student misconceptions aligns with previous findings where teachers demonstrated lower perceptions in detecting misconceptions within their pedagogical knowledge. It is important that these misconceptions be addressed, as uncorrected misunderstandings can stagnate students' mathematical growth. Anticipating, eliciting, and utilizing student misconceptions to deepen understanding, are effective strategies as highlighted by Ellis (2021).

To enhance these competencies, pedagogical workshops which stress diagnostic teaching and error analysis are the best option. Such programs equip the teachers with the required skills to identify faulty and other misconceptions, which subsequently leads to the provision of the learners with a comprehensive understanding of mathematical concepts. For example, the MAST (Mathematics and Science Teaching) program of staff development highlights the importance of metacognitive training, allowing teachers to plan, evaluate, and change or adjust their instruction; all this is in order to enhance student engagement and achievement. This approach has been found effective in bringing about the major improvements in student mathematics performance (Phillips et al. 2016).

In summary, despite mathematics instructors demonstrating a high degree of competence in regards to curriculum-aligned teaching and content delivery as well, increasing their skills that promote student-determined studies and deal with misconceptions from the student's perspective will yield even greater instructional effectiveness and student academic performances.

The teachers' perceptions along the indicators of PCK are presented in Table 12.

For their Technological, Pedagogical, and Content Knowledge (TPACK), it is revealed that Mathematics teachers perceive themselves as completely competent, with 6 indicators achieving weighted means between 4.500 and 4.667. Their

Table 11: CSPC mathematics teachers' Technological Content Knowledge (TCK)

	Technological Content Knowledge (TCK)	*Item mean*	*Interpretation*	*Rank*
1	TCK 1	4.833	Completely competent	1.5
2	TCK 2	4.333	Fairly competent	5
3	TCK 3	4.417	Fairly competent	4
4	TCK 4	4.833	Completely competent	1.5
5	TCK 5	4.750	Completely competent	3
	General Weighted Mean	4.633	Completely competent	

Table 12: CSPC Mathematics teachers' Pedagogical Content Knowledge (PCK)

	Pedagogical Content Knowledge (PCK)	*Item mean*	*Interpretation*	*Rank*
1	PCK 1	4.917	Completely competent	1
2	PCK 2	4.833	Completely competent	2
3	PCK 3	4.583	Completely competent	4.5
4	PCK 4	4.417	Fairly competent	6.5
5	PCK 5	4.583	Completely competent	4.5
6	PCK 6	4.417	Fairly competent	6.5
7	PCK 7	4.667	Completely competent	3
	General Weighted Mean	4.631	Completely competent	

highest-rated competency is their ability to use technology to provide effective examples aligned with math textbooks, reflecting their strength in integrating technological tools with pedagogical practices to enhance content delivery.

However, 3 skills were rated as fairly competent, which clearly points to some key areas of improvement. These include the capabilities to fully use every technology-assisted evaluation tool to thoroughly assess each teaching-learning process, to make use of technological devices in order to identify students' misconceptions about mathematical subjects, and the ability to assist others in carefully coordinating the employment of mathematical, technological, and instructional strategies.

Current studies have supported mathematics teachers' competence in integrating technology to pedagogy to improve content delivery. According to Abramovich et al. (2024), digital learning games improved middle schoolers' comprehension of decimal concepts. This finding points out the proficiency of teachers who employ technological tools to give effective examples aligned with math curricula, thus considerably improving the learning experience.

Despite these strengths, a few areas still require further improvement. Teachers are good at integrating technology to lessons. However, research shows that they often have trouble using technology-based assessment tools to evaluate teaching and learning. Kadluba and Obersteiner's (2024) study pointed out that every teacher's self-reported technical pedagogical content knowledge (TPACK) did not always align with every performance in technology-assisted assessments. This, therefore, suggested that professional development in this area is required.

In addition, improvement is needed in the skill to assist others in the mathematical, technical, and instructional strategies in a seamless way. Saat et al.'s (2024) systematic review stressed that all collaborative professional development programs are important for improving each teacher's competence in these areas. Such programs can foster a community of practice, enabling teachers to share replicable practices and support each other in the effective technology-integration into mathematics education.

Shown in Table 13 is the teachers' perceptions along their TPACK.

Generally, the teachers have fairly competent – completely competent perceptions along the TPACK components. With a weighted mean of 4.633, the teachers have the highest perception in TCK. This shows that they are able to choose suitable technologies in the subject matters they are handling in mathematics classes. On the other hand, teachers got their lowest perception in the TK with only 4.214 weighted mean. This suggests that teachers should devote themselves more to learning to utilize technologies aside from what they usually use, like computers for hardware and Microsoft Office and the likes for software. Specifically, they also need to take time to learn to navigate hardware and software technologies, as well as troubleshoot when problems involving these technologies arise.

A survey of the TPACK self-perceptions of math teachers has revealed their strengths in some areas and opportunities to be improved in other parts. A study by Abebe and Trainin (2024) also established that preservice teachers for elementary school rated their TCK to be at a higher level,

Table 13: CSPC Mathematics Teachers' Technological, Pedagogical, and Content Knowledge (TPACK)

	Technological, Pedagogical, and Content Knowledge (TPACK)	*Item mean*	*Interpretation*	*Rank*
1	TPACK 1	4.583	Completely competent	3.5
2	TPACK 2	4.417	Fairly competent	8
3	TPACK 3	4.583	Completely competent	3.5
4	TPACK 4	4.417	Fairly competent	8
5	TPACK 5	4.500	Completely competent	6
6	TPACK 6	4.667	Completely competent	1
7	TPACK 7	4.583	Completely competent	3.5
8	TPACK 8	4.583	Completely competent	3.5
9	TPACK 9	4.417	Fairly competent	8
	General Weighted Mean	4.528	Completely competent	

reflecting their ability to select appropriate technologies for specific content in teaching mathematics. This is very much in line with the computed weighted rating of TCK, which was found to be 4.633. This implies that teachers are confident in using technology to explain their subject matter effectively.

In contrast, the work reported that TK taken by teachers and their assessment of themselves were comparatively lower to their pedagogical and content knowledge. Herein lies the confirmation of a cited weighted mean of 4.214 for TK that is taken to mean that teachers should be well-versed and be skilled in tools beyond commonly used, such as basic computer hardware and common software programs. A vital component of successful technology integration in the classroom is the ability to navigate diverse and complex technological tools as well as troubleshooting technical issues.

The overall high self-perception in TPACK components shows that the teachers are prepared to meet the demands of modern mathematics education, which rely on technology in an increasing level. Nevertheless, in order to maximize teachers' potential in their TPACK, they should keep going on the professional development track. By doing so, they will get the chance to take part in specialized training programs, which will help them improve their technical skills and enable them to work on a wider variety of digital tools and resources effectively. In addition, such development not only again improves pedagogy but also makes the educational process in the technology-based teaching-learning process more engaging and meaningful for students.

Table 14 shows the CSPC Mathematics Teachers' Level of TPACK perceptions along its components.

Demographic Differences among the CSPC Mathematics Teachers' TPACK

The findings reveal variations in the TPACK perceptions of CSPC Mathematics teachers based on their demographic profiles. By sex, female teachers exhibit higher perceptions in technology-related components, such as Technological Knowledge (TK), Pedagogical Knowledge (PK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK). In contrast, male teachers have higher perceptions in content-related components, including Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and the overall TPACK framework.

Research shows a significant difference, based on gender, when it comes to the TPACK teachers' perception among math teachers. Contrary to the findings that female teachers scored significantly higher in technology-related sections, the findings of previously existing studies have found out that male teachers often had higher scores in TK and TCK. For example, a study found that there were notable differences between male and female teachers in TK, which favors male teachers. Moreover, Erdogan and Sahin (2010) reported a similar finding that pre-service mathematics teachers displayed higher TPACK skills relative to their female counterparts (Cho and Hong 2022). Such inconsistencies suggest that male teachers might feel more capable of using technology, hence their positive attitude towards it may affect their technological integration in the classroom.

Educational attainment is a strong factor that appears to be a major determiner of TPACK perceptions among teachers. For those teachers who hold bachelor's degrees, their self-assessments of TK and TPK had made clear that foundational pre-service programs may target technology integration skills in their curricula. On the other hand, master's level teachers' perceptions of CK, PCK, and the total TPACK framework are generally higher due to their contribution to the acquisition of more in-depth content knowledge and teaching competence. These results suggest that as teachers pursue higher education, their focus may shift

Table 14: CSPC mathematics teachers' TPACK

TPACK components	*Weighted mean*	*Interpretation*	*Rank*
TK	4.214	Fairly competent	7
PK	4.523	Completely competent	5
CK	4.593	Completely competent	3
TPK	4.486	Fairly competent	6
TCK	4.633	Completely competent	1
PCK	4.631	Completely competent	2
TPACK	4.528	Completely competent	4

from basic technological skills to a more integrated understanding of content and pedagogy.

Generally, enhanced self-perceptions along TPACK components are due to the participation in TPACK-related professional development seminars. A study conducted by Young and colleagues (2019) reported considerable improvement in the mathematics teachers' self-perception regarding their knowledge of pedagogy, technology, pedagogical content, and technology content as a result of a 3-week professional development program. This is in agreement with the statement made by Koehler and Mishra (2006) regarding the critical TPACK workshops which lead teachers to be proficient in integrating technology, delivery, and content knowledge. These results therefore represent the fundamental importance progress of professional growth as a strategy in the promotion of teachers' efficiency and quality in technology integration.

While these studies provide valuable insights, limitations exist, particularly concerning the analysis of TPACK perceptions based on length of service and academic rank due to insufficient respondents in certain categories. Future research with larger, more diverse samples could offer a more comprehensive understanding of how these factors influence TPACK perceptions. Overall, the findings highlight the importance of considering demographic factors when designing professional development programs. Tailoring these programs to address specific needs related to gender and educational background can enhance teachers' technological integration skills, ultimately improving the quality of mathematics education in an increasingly digital world.

The demographic comparisons of the teachers' perceptions are shown in Table 15.

The analysis of demographic factors among teachers reveals no significant differences in their TPACK perceptions, indicating a uniform level of competence regardless of sex, years of teaching experience, academic rank, educational background, or attendance at TPACK-related seminars. This challenges assumptions that demographic characteristics significantly influence educators' ability to integrate technology into teaching, as previously noted in studies such as Chai et al. (2011a). In a study by Ozudogru and Ozudogru (2019), they investigated the TPACK levels of mathematics teachers and revealed that demographic factors such as sex, educational background, and years of experience bring significant differences along their technology integration competency into teaching. These findings suggest that the TPACK framework offers a universal approach to integrating technology, pedagogy, and content knowledge, emphasizing its applicability across diverse teaching populations.

The results contrast with earlier research highlighting demographic influences on TPACK. For instance, Erdogan and Sahin (2010) found that male teachers generally scored higher in TPACK than female teachers, while Jang and Tsai (2012) observed that less experienced teachers sometimes exhibited stronger TPACK components than their more experienced counterparts. Additionally, Luik et al. (2018) noted that senior teachers often displayed relatively lower TPACK compared to younger educators, and studies such as those by Koehler and Mishra (2006) suggested that school level can significantly impact TPACK development. These variations emphasize the complexity of TPACK and its responsiveness to various contextual and individual factors.

Table 15: CSPC mathematics teachers' TPACK perceptions according to their demographic profiles

TPACK components	*Sex*		*Educational attainment*		*Attendance to TPACK-related seminars*	
	Male	*Female*	*Bachelor's Degree*	*Master's Degree*	*Yes*	*No*
TK	4.09	4.33	4.25	4.17	4.29	4.14
PK	4.30	4.75	4.48	4.57	4.53	4.52
CK	4.63	4.56	4.54	4.65	4.57	4.61
TPK	4.37	4.60	4.50	4.47	4.50	4.48
TCK	4.52	4.75	4.62	4.65	4.64	4.63
PCK	4.67	4.59	4.50	4.76	4.63	4.63
TPACK	4.57	4.49	4.52	4.54	4.56	4.49

However, the uniformity observed in this study underscores the idea that TPACK's effectiveness is not bound to specific personal attributes but rather reflects a shared capacity among educators to adopt and implement its principles.

Overall, the findings highlight the universal applicability of the TPACK framework while challenging earlier studies that link TPACK disparities to demographic factors. This uniformity reinforces the potential for broadly tailored professional development programs, supporting teachers in their shared goal of effective technology integration, as emphasized by Chai et al. (2011b) and Koehler and Mishra (2006). Adulyasas' study (2017) identified key factors influencing mathematics teachers' TPACK, including teaching experience, access to technology, and professional development opportunities. It was also affirmed in this study the importance of institutional support and continuous training to strengthen teachers' effective technology integration in mathematics instruction.

Table 16 shows the significant differences along the TPACK perceptions of the mathematics teachers along their demographic profiles.

CONCLUSION

The profile of CSPC Mathematics teachers exhibits diversity across various dimensions. There are more male than female educators who participated in the study. The length of service varies, ranging from seasoned instructors with extensive experience to newer faculty members contributing fresh perspectives. Academic ranks within the department span from Instructor I to Associate Professor V, reflecting a mix of expertise. Educational attainment is notable, with many instructors holding advanced degrees in mathematics or related fields, such as Master's and Doctorate degrees. Many teachers have participated in TPACK-related seminars, demonstrating a commitment to enhancing their teaching practices through integrating technology, pedagogy, and content knowledge.

The TPACK perceptions of the teachers range from fairly to completely competent. They have the highest perception in their TCK and the lowest in TK. Of all the components, the teachers have higher perceptions in the content-related areas than the pedagogy and technology-related areas. Moreover, the analysis of personal and professional factors influencing the levels of perceptions among CSPC Mathematics teachers in TPACK components reveals no significant associations. Variables such as gender, length of service, academic rank, educational attainment, and attendance to seminars related to TPACK do not exhibit discernible correlations with teachers' proficiency in all the TPACK components.

RECOMMENDATIONS

Educational institutions should prioritize ongoing and targeted professional development for teachers of all demographics. Workshops, seminars, and training sessions should focus on the technical aspects of technology integration and emphasize the pedagogical strategies that en-

Table 16: Significant differences among the CSPC mathematics teachers' demographic factors in their TPACK perceptions

TPACK components	*Significant difference by sex*	*Significant difference by length of service*	*Significant difference by academic rank*	*Significant difference by educational attainment*	*Significant difference by attendance to TPACK-related seminars*
	p-value	*p-value*	*p-value*	*p-value*	*p-value*
TK	0.97447	1.00000	1.00000	0.93438	0.88464
PK	0.95256	1.00000	1.00000	0.99999	0.99843
CK	0.99659	0.99934	1.00000	0.87974	0.99281
TPK	0.99798	1.00000	1.00000	0.99940	0.97153
TCK	0.99843	0.99991	1.00000	0.94111	0.94631
PCK	0.99995	1.00000	1.00000	0.99969	0.99940
TPACK	0.95498	0.99865	1.00000	0.71003	0.67895

At á = 0.05, there are no findings of significant differences in the TPACK Perceptions among the demographic factors.

hance content delivery. Specifically, teachers have the need to improve their skills in troubleshooting and assisting others of their technology-related concerns, assisting students in technology-utilized assessment and evaluation. Technical support for technology-related concerns should also be available for the teachers. Finally, schools should invest in up-to-date technological resources and infrastructure. Ensuring teachers have access to devices, software, and reliable internet connectivity is fundamental to successful TPACK integration.

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