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Technological, Pedagogical, and Content Knowledge of Middle-Aged Teachers: Its Influence on Teachers' Effectiveness in District 1, Division of Ozamiz City

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***Abstract*—** The integration of technology in education has become essential, requiring teachers to develop a dynamic set of competencies. The Technological, Pedagogical, and Content Knowledge (TPACK) framework serves as a guide for educators to effectively merge technology, pedagogy, and subject content in their teaching. This study assessed the extent of TPACK among middle-aged teachers, examining the influence of age, training and seminars attended, and years of service. Employing a quantitative, descriptive-comparative research design, data were analyzed using frequency and count, mean, and the Kruskal-Wallis test. Results revealed that while age and participation in seminars did not significantly affect TPACK, years of service played a crucial role in shaping teachers' technological integration skills. These findings emphasize the need for targeted professional development, continuous training, and mentorship programs tailored to experienced educators. Future research should explore how structured training initiatives impact TPACK development over time and investigate strategies to support novice teachers in building these essential competencies.

***Keywords*—** Technological Pedagogical Content Knowledge, technology integration, teaching competencies, professional development, middle-aged teachers.

I. INTRODUCTION

Background of the Study

The integration of technology into teaching has become increasingly significant in today's educational landscape, requiring teachers to develop a complex set of competencies. These competencies are compressed in the Technological, Pedagogical, and Content Knowledge (TPACK) framework, which highlights the need for educators to effectively combine technology with pedagogy and subject content knowledge. Moreover, TPACK recognizes that effective technology integration involves careful and deliberate fusion of technology, pedagogy, and subject matter expertise to maximize student learning outcomes, rather than just employing technological tools. Navigating this intersection of knowledge can be particularly challenging due to generational differences in exposure to digital tools. In the Division of Ozamiz City, TPACK remains avital concern as schools continue to adopt technology-enhanced learning environments.

In the 21st century, the emphasis on integrating technology into teaching is essential. According to Kim (2018), implementing TPACK methods can effectively change students' perspectives from traditional to technology-centric learning.Similarly, several studies emphasize the importance of TPACK in ensuring the successful integration of technology in classrooms. For instance, Koh et al. (2017) argue that teachers' technological knowledge must be complemented by strong pedagogical and content knowledge to create meaningful learning experiences. Likewise, Chai, Koh, and Tsai (2016) have found that teachers who possess high levels of TPACK are better able to engage students and adapt their teaching strategies to include digital tools. However, research by Voogt et al. (2019) points out that middle-aged teachers often struggle to balance technological advancements with traditional pedagogical practices, primarily due to limited professional development opportunities.

While much has been studied about TPACK and its influence on teachers' effectiveness, limited research has focused specifically on middle-aged teachers, particularly within the Philippine context. Most existing studies explore the TPACK of teachers in general, but little attention has been given to how middle-aged educators, who may face unique challenges related to technology integration, perform in this regard. In the Division of Ozamiz City, no comprehensive study has yet been conducted to assess the technological, pedagogical, and content knowledge of middle-aged teachers, thus creating a significant gap in the literature.

This study aims to evaluate the TPACK proficiency of middle-aged teachers in the Division of Ozamiz City. Specifically, it seeks to assess their level of competence in integrating technology with pedagogy and content

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knowledge, identify factors that influence their TPACK development, and examine the challenges they encounter in incorporating digital tools into their teaching practices. The findings will provide insights into the support needed to enhance the technological integration skills of middle-aged teachers, ultimately contributing to the improvement of teaching quality in the region.

Theoretical Framework

This research is anchored on Mishra and Koehler's theory on TPACK Framework. It is a theory that was developed to describe the set of knowledge that teachers need to teach their students a subject, teach effectively, and use technology.

The concept of Technological Pedagogical and Content Knowledge was introduced in educational research as a theoretical framework to comprehend the knowledge essential for proficient technology integration by teachers (Mishra and Koehler, 2006). Additionally, the TPACK framework underscores that effective teaching with technology requires more than just technological proficiency. Teachers must understand how technology interacts with pedagogical strategies and content knowledge to create meaningful and engaging learning experiences. This theoretical perspective is particularly relevant in the 21st century, where educators are expected to integrate digital tools and resources into their instruction.

The TPACK framework is based on three fundamental knowledge areas: technological knowledge (TK), pedagogical knowledge(PK) and content knowledge (CK). In combination, these areas form the following knowledge areas: technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK) and technological content knowledge (TCK), (Voltonen, et.al, 2020).

TPACK constructs

TPACK Constructs	Definition
CK	…knowledge about the taught subject matter containing knowledge of theories, concepts and practices in the field. CK contain deep knowledge fundamentals of the disciplines without consideration about teaching the topic
PK	…knowledge of teaching and learning practices, knowledge of classroom management and assessment, knowledge of how students construct knowledge. PK focuses on learning theories in general without focusing on teaching certain contents
TK	knowledge of technology, understanding and recognizing the possibilities of technology. TK refers to knowledge needed to adapt the fast development of technology without focusing on teaching and learning.
PCK	…knowledge of transforming the subject matter knowledge for teaching, organise conditions for making the learning of certain contents easy. PCK contain also knowledge of typical misconceptions related to certain topic.
TCK	…knowledge of how technology and content influence one another, knowing the technologies used within different subject matter areas. TCK consists of knowledge how subject matter develop with technology, without considering teaching the content area.
TPK	…knowledge of how to support certain pedagogical approaches with appropriate technology, to know pedagogical benefits and constraints of different technologies. Aligning with TK, TPK refers to forward-looking technology use in order to find best ways to support learning without focusing certain content areas.
TPACK	…knowledge of using various technologies and pedagogical approaches while teaching different contents. Understanding that emerges when combining CK, TK and PK, knowledge underlying

(Based on articles Mishra and Koehler (2006 and Chai et al. (2010) cited in Valtonen et al. (2020).)

Furthermore, Mishra and Koehler, (2013) argue that these domains do not function independently but intersect in complex ways, and effective teaching practices arise when educators can integrate these domains seamlessly. Over the years, this framework has been widely adopted as a guiding principle in both

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teacher education and professional development programs, emphasizing the need for teachers to develop an integrated understanding of technology, pedagogy, and subject matter content. Moreover, Chai et al. (2019) highlight the increasing relevance of TPACK as educational technologies evolve, stressing that teachers need continuous professional development to keep pace with technological advancements. Their research underscores that teachers with a strong grasp of TPACK are more likely to implement technology effectively, leading to improved student engagement and outcomes. Similarly, Scherer, Tondeur, and Siddiq (2020) point out that the development of TPACK is crucial for fostering 21st-century skills in students, especially as classrooms become more digitally focused.

In addition, Voogt et al. (2023) emphasize that the integration of technology into teaching cannot rely solely on knowledge of the tools themselves. Teachers must also consider how technological tools align with their pedagogical strategies and the content teachers aim to teach. This notion of dynamic knowledge integration is central to the TPACK framework and is particularly important for middle-aged teachers who may have less exposure to digital tools compared to their younger counterparts. Therefore, the TPACK framework serves as a vital theoretical foundation for understanding how teachers, especially those with varying levels of technological familiarity, can enhance their teaching effectiveness by blending technology, pedagogy, and content knowledge in meaningful ways.

II. REVIEW OF RELATED LITERATURE AND STUDIES

The Technological, Pedagogical, and Content Knowledge (TPACK) framework, introduced by Mishra and Koehler (2006). The TPACK framework posits that teaching with technology requires not only an understanding of technology (Technological Knowledge, TK) but also how it interacts with pedagogy (Pedagogical Knowledge, PK) and subject content (Content Knowledge, CK) (Mishra & Koehler, 2006). Moreover, the Technological, Pedagogical, and Content Knowledge (TPACK) framework provides a structured approach to understanding how teachers integrate technology into their teaching practices. Research shows that demographic factors such as age, training and seminars attended, and years of service significantly influence a teacher's ability to develop and apply TPACK effectively. These factors affect teachers' proficiency and readiness in technology integration, emphasizing the need for targeted professional development tailored to individual characteristics and experiences (Scherer, Tondeur, & Siddiq, 2020).

Age. Age is a critical demographic factor that influences TPACK competency. Younger teachers, often labeled as "digital natives," are more likely to demonstrate higher levels of Technological Knowledge (TK) because of their exposure to digital tools from an early age. In contrast, middle-aged and older teachers might excel in Pedagogical Knowledge (PK) and Content Knowledge (CK) but may find it challenging to adapt to emerging technologies (Chai et al., 2019). Schmid et al. (2022) found that age-related differences in TPACK competencies necessitate differentiated professional development programs that address the specific technological needs of middle-aged and older educators. This is particularly important for middle-aged teachers, who represent a substantial portion of the teaching workforce and play a pivotal role in shaping students' educational experiences.

Training and Seminars. Participation in training and seminars significantly impacts teachers' TPACK development, particularly in building technological knowledge and its integration with pedagogy and content. A study by Ramírez-Montoya and Mendoza-González (2021) emphasized that consistent and targeted professional development programs help middle-aged teachers acquire new technological skills, enabling them to design and deliver innovative lessons. Additionally, programs that incorporate hands-on activities and collaborative learning opportunities are more effective in building confidence and proficiency in technology use (Martínez et al., 2022). In resource-constrained environments, such as the Division of Ozamiz City, providing access to these opportunities can bridge gaps in technological knowledge and strengthen the overall TPACK framework among teachers.

Years of service. Years of service play a dual role in shaping TPACK competencies. Teachers with extensive experience often excel in CK and PK, as they have refined their teaching methods over time. However, these same teachers may face challenges in developing TK due to limited exposure to technology during the earlier stages of their careers (Wilson & Jones, 2020). According to Niess et al. (2020), years of service also influence a teacher's openness to adopting new teaching technologies, as long-standing practices may be difficult to adjust. Thus, professional development initiatives must not only address technical skills but also provide

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strategies for integrating new technologies into existing pedagogical practices.

Furthermore, research highlights the impact of technological infrastructure and access on the development of TPACK among teachers. In the context of developing countries, where access to advanced technology is often limited, teachers may face greater difficulties in incorporating digital tools into their teaching practices (Chai et al., 2019). This is particularly relevant to the Division of Ozamiz City, where public schools may have less access to modern educational technologies. Studies by Onuma and Nwosu (2020) and Ramírez-Montoya and Mendoza-González (2021) reveal that lack of resources, including limited access to computers, internet, and digital tools, can hinder the development of TPACK, especially among middle-aged teachers who may already be less familiar with these technologies.

Despite the growing body of research on TPACK, there remains a lack of studies focused on middle-aged teachers in specific local contexts such as the Division of Ozamiz City. Much of the existing research is centered on Western contexts, where access to technology and professional development is more readily available (Martínez et al., 2022; Wilson & Jones, 2020). This research gap calls for localized studies that consider the unique challenges faced by middle-aged educators in regions with limited technological infrastructure. Such studies can provide critical insights into how middle-aged teachers in the Division of Ozamiz City can overcome barriers to integrating technology in their classrooms and enhance their overall teaching effectiveness. Addressing this gap through localized research will help inform policy and professional development programs that cater to the specific needs of these teachers, ultimately contributing to improved educational outcomes in the region.

III. RESEARCH METHODOLOGY

Research

This study utilized a descriptive-comparative research design to quantitatively assess the Technological, Pedagogical, and Content Knowledge (TPACK) of middle-aged teachers in the Division of Ozamiz City. A descriptive research design was considered appropriate for this study as it allowed the researcher to describe the current state of the teachers' knowledge in each TPACK domain—technological knowledge, pedagogical knowledge, and content knowledge—without manipulating the environment or variables (Creswell & Creswell, 2018). The study provided an overview of the degree to which middle-aged teachers were proficient in incorporating technology with pedagogy and content into their teaching methods by gathering data using a structured survey.

Furthermore, the study aimed to examine differences between groups based on predetermined criteria. These groups included demographics such as age, gender, or years of experience. For instance, the study compared the Technological, Pedagogical, and Content Knowledge (TPACK) competencies of middle-aged teachers and younger teachers to determine whether age influenced technology integration.

Research Environment

This study was conducted in the selected secondary public schools under the supervision of the Dep.Ed, Division of Ozamis City. The Department of Education was established through the Education Decree of 1863 as the Superior Commission of Primary Instruction under a Chairman. The Education agency underwent many reorganization efforts in the 20th century in order to better define its purpose vis a vis the changing administrations and charters. The present day Department of Education was eventually mandated through Republic Act 9155, otherwise known as the Governance of Basic Education act of 2001 which establishes the mandate of this agency.

The Department of Education (DepEd) formulates, implements, and coordinates policies, plans, programs and projects in the areas of formal and non-formal basic education. It supervises all elementary and secondary education institutions, including alternative learning systems, both public and private; and provides for the establishment and maintenance of a complete, adequate, and integrated system of basic education relevant to the goals of national development (Department of Education-Division of Ozamiz City, 2024).

Respondents of the Study

The respondents of this study were chosen using a sampling method which was the simple random sampling. In surveys and quantitative research designs, the simple random sample method is frequently used to identify the actual number of participants (Rahi, 2017). Moreover, according to Creswell (2012), the goal of random sampling was to select people for the sample who will be a good representation of the community.

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Research Instrument

In this study, the researcher utilized two survey questionnaires including the demographic profile as the Part I. Part II, the data was collected using a researcher-made survey questionnaire, specifically designed to measure the middle-aged teachers' Technological, Pedagogical, and Content Knowledge (TPACK). Furthermore, the survey will consist of a 4 Likert-scale questions with seven indicators and 49 constructs.

Instruments Validation

The survey questionnaire utilized in this study underwent thorough pilot testing to ensure its validity and reliability. The pilot test was conducted with a small group of respondents who shared similar characteristics with the target population but were not part of the actual study. The results of the pilot testing were analyzed, and the instrument achieved a significant score, confirming its suitability for the research objectives. The Cronbach's alpha value of 0.70 indicated that the survey instrument was reliable and could produce consistent results when administered to the larger sample.

Data Gathering Procedure

The data gathering process was conducted systematically to ensure accurate and reliable data collection. Initially, permission was sought from the Division of Ozamiz City's Department of Education (DepEd) to conduct the research in public schools within the division.

Once approval was obtained, the researcher identified middle-aged teachers (ages 40–55) currently employed in these schools and invited them to participate in the study.

Teachers were given clear instructions on how to complete the questionnaire, which were distributed through face to face meeting. Respondents were given adequate time to complete the questionnaire, and the researcher have followed up with any non-responding participants to ensure a high response rate.

Once all surveys are collected, the data was compiled, coded, and statistically analyzed using appropriate software to generate descriptive and correlational results.

Ethical Considerations

This study strictly adhered to the principles of ethical standards by Bryman and Bell, (2007) to ensure the protection of participants' rights and the integrity of the research process.First, informed consent will be obtained from all participants prior to data collection. Teachers will be fully informed about the purpose of the study, the procedures involved, the voluntary nature of their participation, and their right to withdraw at any time without any negative consequences. Participants will also be assured that their responses will remain confidential and will only be used for research purposes. Anonymity will be preserved throughout the study, and personal identifiers will not be included in any data reporting or analysis. Data was stored securely, and only the researcher and authorized personnel hasaccess to it. Additionally, the research complied with the ethical guidelines set by the DepEd and other relevant educational and research institutions. Lastly, the study has ensured that participants experience no harm or discomfort as a result of their involvement. All ethical protocols, including adherence to the data privacy policies (such as RA 10173, the Data Privacy Act of 2012 in the Philippines), will be strictly followed to safeguard the welfare of the participants.

Data Analysis

The data in this study was analyzed using frequency and count, mean, and the t-test to address the research objectives. Frequency and count summarized categorical data, such as age groups, years of service, and attendance at training seminars, to identify trends and distributions within the sample. Mean analysis provided a measure of central tendency for continuous variables, such as levels of Technological, Pedagogical, and Content Knowledge (TPACK), offering insights into the average competencies across the population. The Kruskal-Wallis test was employed to compare group means to determine significant differences in TPACK scores based on demographic factors like age, training attendance, or years of service. Together, these methods would comprehensively describe the sample, identify patterns, and uncover significant relationships, contributing to a deeper understanding of TPACK among middle-aged teachers.

The findings were presented in tables to provide a clear and concise interpretation of the data.

Scaling	Scoring	Description	Interpretation
4	3.26-4.0	Strongly Agree	Very High
3	2.51-3.25	Agree	High

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2	1.76-2.50	Disagree	Low
1	1.00-1.70	Strongly Disagree	Very Low

Verbal Interpretation

- 3.26-4.0 – The respondents strongly agree on the TPACK indicators; implying that integrating TPACK in the classroom is VERY HIGH.
- 2.51-3.25 – The respondents strongly agree on the TPACK indicators; implying that integrating TPACK in the classroom is HIGH.
- 1.76-2.50 – The respondents strongly agree on the TPACK indicators; implying that integrating TPACK in the classroom is LOW.
- 1.00-1.70 – The respondents strongly agree on the TPACK indicators; implying that integrating TPACK in the classroom is VERY LOW.

IV. PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

Table 1. *Demographic Profile of Respondents*

Profile	**f**	**%**
Age		
40 – 45 years old	31	29.00
46 – 50 years old	44	41.10
51 – 55 years old	31	29.00
Above 55 years old	1	0.90
Total	107	100.00
Seminars and Trainings Attended in relation to TPACK		
1 – 5 times	82	76.60
6 – 10 times	23	21.50
11 and more times	2	1.90
Total	107	100.00
Length of Service		
6 – 10 years	11	10.30
11 – 15 years	34	31.80
16 – 20 years	41	38.30
21 years and above	21	19.60
Total	107	100.00

Table 1 presents the demographic profile of the respondents in terms of age, seminars and trainings attended din relation to TPACK and years in service. Interpretation of Variables in Relation to TPACK. The data reveals that the majority of respondents fall between the ages of 46 and 50 years old (41.10%), followed by two equally represented groups aged 40–45 years old and 51–55 years old, each comprising 29% of the sample. Only one respondent (0.90%) is above 55 years old. This indicates that most respondents are in the mid to late stages of their teaching careers, suggesting that their TPACK (Technological Pedagogical Content Knowledge) competencies may be shaped by both their years of experience and the level of exposure to professional development.

In terms of seminars and trainings attended relating to TPACK, majority of respondents (76.60%) have attended 1–5 seminars or training sessions related to TPACK, indicating limited formal exposure to technology-related professional development. Meanwhile, 21.50% have attended 6–10 sessions, showing moderate engagement in these opportunities. Only 1.90% have attended 11 or more training sessions, highlighting a minimal number of highly trained individuals. This suggests that while most teachers have some foundational knowledge of TPACK, deeper mastery may require more frequent and advanced training sessions.

Respondents with 16–20 years of teaching experience constitute the largest group (38.30%), followed by those with 11–15 years (31.80%). Teachers with over 21 years of service account for 19.60%, while those with 6–10 years of experience represent the smallest group (10.30%). This distribution suggests that a significant

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portion of respondents are seasoned educators. Their accumulated experience may contribute to their pedagogical expertise, but the relationship to TPACK depends on their exposure to technological training and integration over the years.

Table 2.1 *Extent of Content Knowledge of Middle-Aged Teachers*

Content Knowledge	Sd	Mean
1. I have a deep understanding of the subject matter I teach.	0.32	3.87
2. I can effectively explain complex topics within my subject area.	0.48	3.62
3. I stay updated on new developments and trends in my field of expertise.	0.47	3.67
4. I can identify common misconceptions students have about my subject.	0.53	3.56
5. I can design lessons that align with the depth and scope of my subject.	0.52	3.59
6. I have adequate resources to support my subject knowledge.	0.50	3.54
7. I am confident in answering students' questions about my subject matter.	0.44	3.72
Average Mean	3.658 Very High	

Scale: 1.0 – 1.75 “Very Low”, 1.76 – 2.50 “Low”, 2.51 – 3.25 “High”, 3.26 – 4.00 “Very High”

The data presented in Table 2.1 illustrates the extent of content knowledge among middle-aged teachers, as measured through seven specific indicators. The results highlight the teachers' self-assessed abilities in mastering and applying subject-specific knowledge in their teaching practices. Among the indicators, the highest mean score of 3.87 pertains to having a deep understanding of the subject matter, with a standard deviation of 0.32, reflecting relatively low variability in responses. This suggests a consistently high level of subject mastery among the participants, aligning with findings from Scherer et al. (2020), who emphasize that experienced educators tend to demonstrate strong content expertise due to their accumulated years of practice and professional development.

The mean score for effectively explaining complex topics within the subject area is 3.62, while identifying common misconceptions received a mean score of 3.56, both of which indicate a "very high" level of competence but also reflect slightly greater variability (standard deviations of 0.48 and 0.53, respectively). These findings align with Chai et al. (2019), who noted that experienced teachers often possess robust pedagogical content knowledge but may encounter challenges in addressing nuanced misconceptions without continuous professional learning. Moreover, the results highlight an area for improvement regarding the adequacy of resources to support subject knowledge, which scored the lowest mean of 3.54 but still indicates a "very high" extent of content knowledge. This aligns with Wilson and Jones (2021), who argued that access to updated resources remains a challenge in certain educational contexts, even for skilled teachers.

Overall, the average mean score of 3.658, rated as "very high," indicates that middle-aged teachers in the Division of Ozamiz City possess a strong foundation in content knowledge, supporting their ability to deliver effective instruction. These findings underscore the importance of providing ongoing opportunities for professional development and access to instructional resources to maintain and enhance their expertise (Mishra, 2019; Tondeur et al., 2021). The results also suggest that middle-aged teachers remain confident in their abilities to address student inquiries, aligning with the broader literature that highlights confidence as a key component of teacher effectiveness (Siddiq et al., 2020). This reinforces the value of supporting content knowledge through targeted training and resource provision to sustain high levels of competency among educators.

Table 2.2 *Extent of Pedagogical Knowledge of Middle-Aged Teachers*

Pedagogical Knowledge	Sd	Mean
1. I am knowledgeable about a variety of teaching strategies.	0.50	3.47
2. I can adapt my teaching style to meet the needs of different learners.	0.49	3.56
3. I am skilled at managing classroom dynamics effectively.	0.49	3.56
4. I can assess students' understanding using diverse methods.	0.49	3.57
5. I understand how to motivate students to engage with the material.	0.49	3.59
6. I can scaffold learning activities to support student understanding.	0.49	3.55

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7. I am skilled in designing lessons that promote critical thinking and creativity.	0.50	3.53
Average Mean	3.550 Very High	

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

The data in Table 2.2 reveals the extent of pedagogical knowledge among middle-aged teachers based on self-assessment across seven specific indicators. With an average mean score of 3.550, the results fall within the "very high" category, demonstrating the strong pedagogical competencies of the respondents. The highest mean score of 3.59 pertains to the teachers' understanding of how to motivate students to engage with the material, indicating a key strength in fostering student interest and participation. Research by Chai et al. (2019) underscores the importance of motivation as a core element of effective pedagogy, especially for diverse classroom settings. Other areas, such as the ability to assess students using diverse methods with a mean score of 3.57 and manage classroom dynamics effectively, mean= 3.56, further highlight the teachers' adaptability and classroom management skills, which align with findings by Tondeur et al. (2021) on the importance of dynamic teaching approaches in contemporary education.

The indicators with slightly lower mean scores, such as being knowledgeable about a variety of teaching strategies with a mean of 3.47 and designing lessons that promote critical thinking and creativity, mean:3.53, suggest areas where additional professional development could be beneficial. While these scores still indicate a very high level of pedagogical knowledge, they align with studies like that of Mishra (2019), who emphasized that pedagogical innovation often requires ongoing training to ensure teachers can effectively integrate advanced strategies and support critical thinking in students. The relatively consistent standard deviations 0.49–0.50 across all items suggest that responses are uniform among the teachers, indicating shared strengths and challenges in their pedagogical practices.

Generally, these findings support the assertion that middle-aged teachers in the Division of Ozamiz City possess strong pedagogical skills that contribute to effective teaching. The results align with Scherer et al. (2020), who found that experienced educators are often equipped with strong classroom management and motivational strategies, which are critical components of effective pedagogy. However, the data also highlights areas for improvement, such as enhancing the variety of teaching strategies and fostering higher-order thinking, which resonate with recommendations from Wilson and Jones (2021) for continuous professional learning. By addressing these gaps, educational leaders can further support teachers in maintaining and enhancing their pedagogical competencies in evolving educational contexts.

Table 2.3 *Extent of Technological Knowledge of Middle-Aged Teachers*

Technological Knowledge	**Sd**	**Mean**
1. I am confident in using technology tools to support my teaching.	0.50	3.64
2. I am familiar with emerging technologies and their applications in education.	0.51	3.55
3. I can troubleshoot common technical issues during lessons.	0.57	3.46
4. I actively seek opportunities to learn new educational technologies.	0.54	3.41
5. I can effectively evaluate the usefulness of technological tools in my teaching.	0.55	3.52
6. I understand how to use technology to streamline administrative tasks (e.g., grading).	0.51	3.53
7. I can easily adapt to changes in educational technology platforms.	0.50	3.50
Average Mean	3.519 Very High	

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

The data in Table 2.3 highlights the extent of technological knowledge among middle-aged teachers, with an overall average mean of 3.519, categorized as "very high." The highest mean score 3.64 pertains to teachers' confidence in using technology tools to support teaching, which aligns with findings by Scherer et al. (2020) that emphasize the role of teacher confidence in fostering effective technology integration. However, slightly lower mean scores, such as their ability to troubleshoot technical issues (Mean:3.46) and seek opportunities to learn new technologies (Mean:3.41), suggest areas where targeted interventions, such as technical training and professional development opportunities, may be necessary. Studies by Koh et al. (2020) and Tsai et al. (2021) similarly advocate for sustained professional learning programs to

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address these gaps and ensure teachers remain adaptable in the evolving technological landscape.

Teachers' ability to evaluate the usefulness of technological tools and streamline administrative tasks demonstrates their practical application of technological knowledge in daily responsibilities. These findings align with research by Tondeur et al. (2021), which underscores the increasing importance of technology for administrative efficiency and pedagogical enhancement. The results also reflect middle-aged teachers' adaptability to changes in educational platforms (Mean:3.50), a vital skill given the rapid advancement of digital tools. Consistent standard deviations across items (ranging from Mean:0.50 to Mean:0.57) indicate moderate variability in responses, suggesting a relatively uniform level of technological proficiency among the respondents. Mishra and Koehler's (2019) TPACK framework further emphasizes that this integration of technology into teaching requires not only skill but also continuous reflection and learning to optimize its effectiveness.

In general, middle-aged teachers' "very high" level of technology expertise indicates that they are prepared to use digital technologies in the classroom, but it also identifies certain areas for improvement, such troubleshooting and ongoing education. Middle-aged instructors can benefit from professional development programs designed to enhance their technology competencies and boost their confidence in handling technical issues, as Wilson and Jones (2021) advice. According to Siddiq et al. (2020), school systems must also offer continuous assistance, such mentorship and access to modern technology, to make sure teachers are prepared to meet the demands of education in the twenty-first century. The significance of cultivating a culture of ongoing technological education in order to preserve and improve instructors' digital literacy is emphasized by these findings.

Table 2.4 *Extent of Pedagogical Content Knowledge of Middle-Aged Teachers*

Pedagogical Content Knowledge	**Sd**	**Mean**
1. I can design lessons that make complex concepts more understandable for students.	0.52	3.50
2. I am aware of the teaching methods that work best for my subject matter.	0.52	3.49
3. I know how to address students' misconceptions about my subject.	0.46	3.69
4. I can integrate examples and analogies to explain my subject better.	0.51	3.55
5. I understand how to sequence my subject's content to build on students' prior knowledge.	0.51	3.53
6. I can design assessments that align with my subject's learning objectives.	0.51	3.54
7. I can modify my teaching approach based on students' performance in my subject.	0.51	3.56
Average Mean		3.554 Very High

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

The data presented in Table 2.4 highlights the extent of Pedagogical Content Knowledge (PCK) among middle-aged teachers, with an overall average mean of 3.554, which is categorized as "very high." This finding indicates that middle-aged teachers in the Division of Ozamiz City are proficient in designing lessons and assessments that align with their subject's learning objectives and students' needs.

The highest mean score 3.69, pertains to teachers' ability to address students' misconceptions about their subject, a critical skill that supports deeper learning (Schneider & Plasman, 2011). Similarly, their ability to integrate examples and analogies (Mean:3.55) reflects their capacity to make abstract concepts more relatable, a practice aligned with the findings of Roegman et al. (2021), who noted that PCK enhances students' understanding of complex topics.

Teachers' understanding of sequencing content to build on prior knowledge (Mean:3.53) and their skill in modifying teaching approaches based on student performance (Mean:3.56) further emphasize their adaptive teaching strategies. These results align with research by Shulman et al. (2021), which underscores the significance of linking pedagogy and content knowledge to scaffold learning effectively. Additionally, the moderate consistency of responses, as indicated by the standard deviations (Mean:0.46–Mean:0.52), suggests shared strengths among the teachers in employing PCK in their classrooms. However, slightly lower mean scores, such as their awareness of the teaching methods that work best for their subject (Mean:3.49), suggest potential areas for refinement, particularly in adopting innovative instructional strategies. Koh et al. (2020) emphasize that continuous professional development is crucial in

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helping teachers explore diverse pedagogical approaches tailored to specific content areas.

Ultimately, middle-aged teachers' "very high" level of PCK highlights their proficiency in fusing material and pedagogical knowledge to enhance student learning. These findings are in line with research such as Tondeur et al. (2021), which emphasizes that years of practice and introspection lead to the development of strong PCK in seasoned teachers. Nonetheless, scholars like Mishra and Koehler (2019) contend that in order to further improve teaching efficacy in contemporary classrooms, PCK must be integrated with technical expertise. In providing ongoing support in the form of professional learning opportunities and updated teaching resources, schools can help educators optimize their PCK and address any remaining gaps. Such efforts are essential for fostering effective teaching practices and improving student outcomes in a rapidly evolving educational landscape.

Table 2.5 *Extent of Technological Content Knowledge of Middle-Aged Teachers*

Technological Content Knowledge	**Sd**	**Mean**
1. I know how to use technology tools specific to my subject area.	0.51	3.56
2. I can identify digital resources that effectively support my subject teaching.	0.50	3.46
3. I can design subject-specific activities using technology tools.	0.58	3.50
4. I understand how technology can enhance students' understanding of my subject.	0.49	3.55
5. I use technology to provide real-world examples related to my subject.	0.52	3.52
6. I stay updated on the latest technological advancements in my field.	0.52	3.49
7. I can evaluate the effectiveness of technology in improving student learning outcomes in my subject.	0.52	3.39
Average Mean	3.499 Very High	

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

Table 2.5 illustrates the extent of Technological Content Knowledge (TCK) among middle-aged teachers, with an overall mean score of 3.499, classified as "very high." This indicates that middle-aged educators in the Division of Ozamiz City possess significant competency in integrating technology into their subject-specific teaching practices.

The highest-rated item (Mean:3.56) pertains to teachers' ability to use technology tools specific to their subject area, aligning with the findings of Chai et al. (2020), who emphasized the role of subject-specific technological proficiency in enhancing teaching effectiveness. Similarly, the ability to use technology to enhance students' understanding of the subject (Mean:3.55) showcases teachers' efforts to leverage digital tools in facilitating better comprehension, as supported by the research of Koehler et al. (2021).

While the results highlight substantial strengths, areas such as evaluating the effectiveness of technology in improving student learning outcomes (Mean:3.39) and identifying digital resources to support teaching (Mean:3.46) indicate room for improvement. These findings are consistent with conclusions drawn by Tondeur et al. (2021), who noted that teachers often struggle to critically assess the impact of technological tools on learning outcomes. Furthermore, staying updated with the latest technological advancements (Mean:3.49) received a slightly lower score, which may reflect challenges in accessing professional development opportunities tailored to emerging educational technologies, as noted by Mishra and Koehler (2019). This highlights the need for targeted training programs that equip teachers with skills to evaluate and adopt innovative technologies effectively.

In general, the "very high" level of TCK demonstrated by middle-aged teachers underscores their capability to blend technological tools with subject-specific instruction, fostering engaging and relevant learning experiences. However, the slightly lower scores in areas like critical evaluation and resource identification suggest a need for ongoing support to ensure sustainable technological integration.

As Darling-Hammond et al. (2020) argue, continuous professional development and collaboration among educators can significantly enhance their technological content knowledge.

Strengthening these areas will not only boost teaching effectiveness but also align educational practices with the demands of the 21st-century learning environment.

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Table 2.6 Extent of Technological Pedagogical Knowledge of Middle-Aged Teachers

Technological Pedagogical Knowledge	Sd	Mean
1. I can integrate technology into my teaching strategies to engage students.	0.51	3.54
2. I use technology to differentiate instruction based on students' needs.	0.51	3.53
3. I can design collaborative learning activities using technology.	0.51	3.57
4. I am aware of how technology affects students' learning behaviors.	0.51	3.56
5. I know how to use technology to promote critical thinking and problem-solving.	0.51	3.40
6. I can manage classroom technology to ensure a smooth lesson flow.	0.48	3.64
7. I can design lessons that leverage technology to enhance teaching and learning processes.	0.50	3.52
Average Mean	3.539 Very High	

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

Table 2.6 exhibit the extent of Technological Pedagogical Knowledge (TPK) among middle-aged teachers, with an average mean of 3.539, classified as "very high." This result indicates that teachers are skilled at integrating technology into their pedagogical practices to foster effective teaching and learning. The highest-rated indicator (Mean=3.64) pertains to managing classroom technology to ensure a smooth lesson flow. This finding highlighted the importance of operational proficiency in classroom technology management for minimizing disruptions and optimizing instructional time. Teachers' ability to design collaborative learning activities using technology (Mean:3.57) also suggests their proficiency in leveraging digital tools to enhance collaboration, as supported by the research of Voogt et al. (2021), which emphasizes the role of collaborative technology in fostering student engagement.

Despite the "very high" classification, the indicator for using technology to promote critical thinking and problem-solving (Mean:3.40) was rated relatively lower compared to other aspects of TPK. This may point to challenges in aligning technological tools with higher-order thinking skills, as corroborated by Koh et al. (2021), who found that while teachers often incorporate technology in their lessons, its application for developing critical thinking requires targeted professional development. Furthermore, the ability to use technology to differentiate instruction (Mean:3.53) indicates an opportunity to further enhance personalized learning strategies, consistent with the findings of Chai et al. (2020), who noted that differentiation through technology demands a deep understanding of both students' needs and technological capabilities.

Generally, the "very high" level of TPK among middle-aged teachers underscores their capacity to integrate technology into pedagogical practices effectively, particularly in managing classroom technology and designing collaborative activities. However, the slightly lower mean scores for promoting critical thinking and differentiation highlight the need for ongoing support in these areas. This aligns with the recommendations of Mishra and Koehler (2019), who emphasized that professional development tailored to enhancing TPK can significantly improve teaching outcomes. Addressing these gaps through training and resource allocation will ensure that teachers continue to innovate their teaching strategies, fostering both student engagement and deeper learning outcomes in a technology-driven educational landscape.

Table 2.7 Extent of Technological Pedagogical Content Knowledge of Middle-Aged Teachers

Technological Pedagogical Content Knowledge	Sd	Mean
1. I can design lessons that effectively integrate technology, pedagogy, and content.	0.51	3.44
2. I understand how to balance content, pedagogy, and technology in my teaching.	0.52	3.41
3. I use technology to create innovative teaching approaches in my subject.	0.51	3.52
4. I can adapt my teaching methods when new technologies are introduced.	0.51	3.52
5. I can assess the effectiveness of a technology-integrated lesson in meeting learning goals.	0.51	3.48
6. I am confident in my ability to combine pedagogy, technology, and content seamlessly.	0.53	3.47
7. I can effectively troubleshoot challenges in technology-integrated lessons.	0.56	3.42
Average Mean	3.471 Very High	

Scale: 1.0 – 1.75 "Very Low", 1.76 – 2.50 "Low", 2.51 – 3.25 "High", 3.26 – 4.00 "Very High"

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The findings in Table 2.7 reveal the extent of Technological Pedagogical Content Knowledge (TPACK) among middle-aged teachers, with an average mean of 3.471, classified as "very high." This suggests that these educators demonstrate a strong capacity to integrate technology, pedagogy, and content effectively into their teaching practices. The highest-rated indicators include the ability to use technology to create innovative teaching approaches (Mean:3.52) and adapt teaching methods when new technologies are introduced (Mean:3.52). This supports the findings of Voogt et al. (2021), who emphasized that teachers with high TPACK competencies are adept at leveraging technology for innovation and adaptability in their teaching strategies.

However, slightly lower ratings were observed in understanding the balance between content, pedagogy, and technology (Mean:3.41) and troubleshooting challenges in technology-integrated lessons (Mean:3.42). These results align with Koh et al. (2021), who noted that while teachers may effectively use technology, challenges in balancing the three TPACK domains and addressing technical issues remain common. Furthermore, the ability to assess the effectiveness of technology-integrated lessons (Mean:3.48) highlights the need for professional development aimed at improving evaluation skills, as highlighted by Tondeur et al. (2020), who argued for the importance of reflective practices in enhancing TPACK competencies.

In general, the "very high" TPACK rating among middle-aged teachers underscores their ability to integrate the three domains into their instructional strategies. However, areas like balancing the domains and troubleshooting indicate the need for ongoing training and resources. As Mishra and Koehler (2019) emphasized, developing TPACK is an iterative process that requires continuous learning and application in diverse teaching contexts Addressing these areas of improvement will ensure that teachers remain proficient in leveraging technology to enhance teaching and learning outcomes in an ever-evolving educational landscape.

Table 2.8 *Summary on the Extent of Technological Pedagogical Content Knowledge of Middle-Aged Teachers*

Components	Mean	Interpretation
Content Knowledge	3.658	Very High
Pedagogical Knowledge	3.550	Very High
Technological Knowledge	3.519	Very High
Pedagogical Content Knowledge	3.554	Very High
Technological Content Knowledge	3.499	Very High
Technological Pedagogical Knowledge	3.539	Very High
Technological Pedagogical Content Knowledge	3.471	Very High
Average Mean	3.541	Very High

Scale: 1.0 – 1.75 “Very Low”, 1.76 – 2.50 “Low”, 2.51 – 3.25 “High”, 3.26 – 4.00 “Very High”

The table highlights the summary of the extent of Technological Pedagogical Content Knowledge (TPACK) of middle-aged teachers across seven components. Among these, the two highest-rated components are Content Knowledge (Mean: 3.658) and Pedagogical Knowledge (Mean: 3.550), both interpreted as "Very High." Conversely, the two lowest-rated components are Technological Pedagogical Content Knowledge (TPCK) (Mean: 3.471) and Technological Content Knowledge (TCK) (Mean: 3.499), though they remain within the "Very High" interpretation. The grand mean of 3.541 further underscores the strong TPACK competencies of middle-aged teachers.

The high rating for Content Knowledge reflects the teachers' deep understanding of their subject areas and ability to convey complex ideas effectively, which aligns with Voogt et al. (2021), who emphasized the foundational role of content mastery in TPACK. Similarly, the high score for Pedagogical Knowledge indicates proficiency in implementing diverse teaching strategies and adapting to various learner needs. This is supported by Mishra and Koehler (2019), who argued that pedagogical expertise significantly complements technological integration. On the other hand, the lower ratings for Technological Pedagogical Content Knowledge (TPCK) and Technological Content Knowledge (TCK) suggest challenges in balancing and integrating the three domains effectively. Teachers may require further support in evaluating the effectiveness of technology-specific applications within their subject areas, as highlighted by Koh et al. (2021), who noted that TCK and TPCK demand continuous development due to evolving technological demands in education.

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The findings suggest that while middle-aged teachers excel in content and pedagogical knowledge, areas involving the integration of technology into subject-specific teaching remain areas for growth. This calls for targeted professional development programs that focus on enhancing TCK and TPCK competencies, such as training in evaluating digital tools and designing technology-enriched lessons (Tondeur et al., 2020). Overall, the "Very High" grand mean reflects a strong foundation of TPACK among middle-aged teachers, underscoring their capability to navigate the modern educational landscape effectively while identifying opportunities for continuous improvement in technology integration.

Table 3.1 *Test of Significant Difference in the Content Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Content Knowledge vs. Age	0.188	retain the H_{o1}
Content Knowledge vs. Seminars and Training Attended	0.142	retain the H_{o2}
Content Knowledge vs. Length of Service	0.005	reject the H_{o3}

Note: If $p \leq 0.05$, with a significant difference

The Kruskal-Wallis test results presented in the table determined the relationship between content knowledge and various teacher demographics, such as age, seminars and training attended, and length of service. For the comparison between content knowledge and age, the P-value of 0.188 indicates that there is no significant difference, leading to the decision to retain the null hypothesis (H_{o1}). This suggests that, in the context of this study, age does not significantly influence teachers' content knowledge, which aligns with previous research that found age-related factors may not always directly correlate with teaching effectiveness or knowledge acquisition (Bennett & Latif, 2019; Parveen et al., 2020).

Similarly, the P-value of 0.142 for content knowledge and the number of seminars or training attended also leads to the retention of the null hypothesis (H_{02}). This result implies that attending seminars or training sessions does not significantly affect the content knowledge of middle-aged teachers, potentially pointing to a gap in the effectiveness of such professional development opportunities (Poon, 2020). This outcome calls into question whether the quality and applicability of the training or seminars attended truly enhance content mastery among middle-aged teachers, highlighting the need for more tailored, targeted programs (Nouri & Shahriari, 2022).

However, a significant difference is observed in the comparison between content knowledge and length of service, with a P-value of 0.005, which is below the threshold of 0.05. This indicates that length of service does have a statistically significant impact on content knowledge, leading to the rejection of the null hypothesis (H_{o3}). This finding aligns with existing literature that suggests more experienced teachers often possess better content knowledge due to years of practice and familiarity with the subject matter (Al-Zaidiyeen et al., 2021; Holt et al., 2023). For this aspect, it could be that the longer teaching tenure is associated with greater subject-matter expertise, and further research might explore how experience correlates with deeper pedagogical understanding and application in the classroom.

Table 3.2 *Test of Significant Difference in the Pedagogical Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Pedagogical Knowledge vs. Age	0.446	retain the H_{o4}
Pedagogical Knowledge vs. Seminars and Training Attended	0.151	retain the H_{o5}
Pedagogical Knowledge vs. Length of Service	0.344	retain the H_{o6}

Note: If $p \leq 0.05$, with a significant difference

The table summarizes the results of the Kruskal-Wallis test assessing the relationship between middle-aged teachers' pedagogical knowledge and three factors: age, seminars and training attended, and length of service. For all comparisons, the null hypothesis was retained as none of the P-values were less than or equal to 0.05. Specifically, the P-value for pedagogical knowledge versus age was 0.446, indicating that age does not significantly influence the pedagogical knowledge of middle-aged teachers. This finding aligns with previous research suggesting that while age may affect physical stamina in teaching, it does not inherently determine

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pedagogical expertise (Holt et al., 2020; Abdulrahman & Lim, 2021).

Similarly, the comparison between pedagogical knowledge and the number of seminars or training attended yielded a P-value of 0.151, again leading to the retention of the null hypothesis (H05). This result suggests that attending seminars and training does not significantly impact the pedagogical knowledge of middle-aged teachers. It raises questions about the quality, relevance, or applicability of such professional development programs for enhancing pedagogical strategies (Mathews & Singh, 2023). Past studies have also highlighted that generic training sessions often fail to translate into practical pedagogical improvements (Ewing & Taylor, 2023).

Finally, the relationship between pedagogical knowledge and length of service showed a P-value of 0.344, indicating no significant difference. This finding implies that years of teaching experience do not necessarily lead to increased pedagogical knowledge for middle-aged teachers.

While experience contributes to classroom management skills and curriculum familiarity, it does not automatically enhance pedagogical knowledge unless coupled with reflective practices and continuous learning. These findings collectively highlight the need for more targeted interventions, such as evidence-based teacher training programs, to strengthen pedagogical knowledge.

Table 3.3 *Test of Significant Difference in the Technological Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Technological Knowledge vs. Age	0.290	retain the H_{o7}
Technological Knowledge vs. Seminars and Training Attended	0.014	reject the H_{o8}
Technological Knowledge vs. Length of Service	0.137	retain the H_{o9}

Note: If $p \leq 0.05$, with a significant difference

The table presents the results of a Kruskal-Wallis test assessing whether there are significant differences in the technological knowledge of middle-aged teachers based on three factors: age, seminars and training attended, and length of service. The P-value for technological knowledge versus age is 0.290, leading to the retention of the null hypothesis (Ho7). This indicates that age does not significantly impact the technological knowledge of middle-aged teachers. Research supports that technological skills are more dependent on exposure and motivation to learn rather than chronological age (Jones et al., 2020). This finding emphasizes the need to shift the narrative from age-based assumptions to encouraging continuous professional development across all age groups. In contrast, the comparison between technological knowledge and seminars or training attended generated a P-value of 0.014, leading to the rejection of the null hypothesis (H08). This indicates that seminars and training have a significant impact on the technological knowledge of middle-aged teachers. Previous studies highlight that targeted and hands-on training sessions significantly enhance teachers' technology integration skills, particularly for those who may lack prior exposure (Ottenbreit-Leftwich et al., 2022; Nguyen et al., 2023). These findings emphasize the importance of well-designed professional development programs tailored to bridge the gap in technological proficiency among educators.

Finally, the relationship between technological knowledge and length of service resulted in a P-value of 0.137, leading to the retention of the null hypothesis (H09). This suggests that years of teaching experience do not significantly influence technological knowledge among middle-aged teachers. Experienced teachers often rely on established practices and may resist adopting new technologies unless adequately supported (Barrera et al., 2021; Chen & Li, 2023). This highlights the importance of fostering a growth mindset among teachers and providing ongoing opportunities for professional learning to ensure technology use becomes a natural part of teaching practices.

Table 3.4 *Test of Significant Difference in the Pedagogical Content Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Pedagogical Content Knowledge vs. Age	0.174	retain the H_{o10}
Pedagogical Content Knowledge vs. Seminars and Training Attended	0.032	reject the H_{o11}
Pedagogical Content Knowledge vs. Length of Service	0.010	reject the H_{o12}

Note: If $p \leq 0.05$, with a significant difference

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The table highlights the results of a Kruskal-Wallis test to analyze the significant differences in Pedagogical Content Knowledge (PCK) among middle-aged teachers based on three variables: age, seminars and training attended, and length of service. For Pedagogical Content Knowledge vs. Age, the P-value is 0.174, leading to the retention of the null hypothesis (Ho10). This result indicates that age does not significantly affect the pedagogical content knowledge of middle-aged teachers. Studies support that Pedagogical Content Knowledge is more influenced by ongoing professional engagement and contextualized experiences rather than chronological age (Shulman et al., 2022; Blanco et al., 2020). These findings suggest that middle-aged teachers, regardless of age, can exhibit comparable levels of pedagogical content knowledge when actively involved in reflective teaching practices.

In contrast, the relationship between Pedagogical Content Knowledge and Seminars/Training Attended generated a P-value of 0.032, prompting the rejection of the null hypothesis (Ho11). This indicates a significant influence of seminars and training on the PCK of middle-aged teachers. Professional development opportunities are widely acknowledged as pivotal in enhancing teachers' ability to integrate pedagogy and content knowledge effectively, as they provide updated methodologies and innovative practices (Darling-Hammond et al., 2021; Nguyen & Lee, 2023). Middle-aged teachers who participate in targeted training often display stronger connections between content delivery and pedagogical strategies, underscoring the importance of sustained professional development initiatives.

Similarly, the relationship between Pedagogical Content Knowledge and Length of Service resulted in a P-value of 0.010, also leading to the rejection of the null hypothesis(Ho12). This suggests that the years of teaching experience significantly impact the pedagogical content knowledge of middle-aged teachers. Research indicates that longer service periods provide opportunities for honing instructional strategies and adapting to diverse classroom scenarios, contributing to a deeper understanding of Pedagogical Content Knowledge (Gess-Newsome, 2020; Rahimi et al., 2022). However, there is also evidence that experienced teachers require continuous learning to stay updated with evolving teaching methods and educational technologies (Chen et al., 2023). These findings highlight the interplay between experience and lifelong learning in enhancing pedagogical content knowledge.

Table 3.5 *Test of Significant Difference in the Technological Content Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Technological Content Knowledge vs. Age	0.126	retain the Ho13
Technological Content Knowledge vs. Seminars and Training Attended	0.938	retain the Ho14
Technological Content Knowledge vs. Length of Service	0.010	reject the Ho15

Note: If $p \leq 0.05$, with a significant difference

The table summarizes the results of a Kruskal-Wallis test analyzing the significant differences in Technological Content Knowledge (TCK) of middle-aged teachers based on age, seminars and training attended, and length of service. For Technological Content Knowledge vs. Age, the P-value is 0.126, leading to the retention of the null hypothesis (Ho13). This suggests that age does not significantly affect TCK among middle-aged teachers. This finding aligns with studies emphasizing that technological skills are not inherently tied to age but to exposure and motivation to learn digital tools (Chai et al., 2022; Guerrero et al., 2021). Regardless of age, teachers' TCK can remain consistent if they continuously engage with technology in their teaching practices.

For Technological Content Knowledge vs. Seminars and Training Attended, the P-value of 0.938 indicates no significant difference, retaining the null hypothesis (Ho14). This result highlights that participation in seminars and training does not necessarily translate into improved technological content knowledge for middle-aged teachers. Research suggests that the quality and relevance of these professional development programs play a crucial role; poorly designed training with limited hands-on application may fail to impact teachers' TCK effectively (Mishra & Koehler, 2022; Chen et al., 2023). This emphasizes the need for tailored, intensive, and practice-oriented training sessions to enhance teachers' integration of technology and content knowledge effectively.

In contrast, Technological Content Knowledge vs. Length of Service generated a P-value of 0.010, leading to the rejection of the null hypothesis (Ho15). This indicates that the length of teaching experience

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significantly influences technological content knowledge. Teachers with longer service often develop deeper pedagogical strategies but may also face challenges adapting to technological advancements if not supported by professional learning (Koehler et al., 2021; Tondeur et al., 2020). The interplay between experience and adaptability appears crucial, as experienced teachers may acquire TCK through consistent classroom application or collaborative peer learning environments. However, without continuous professional development, even long-serving teachers may struggle to stay abreast of technological trends.

Table 3.6 *Test of Significant Difference in the Technological Pedagogical Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Technological Pedagogical Knowledge vs. Age	0.046	reject the H_{o16}
Technological Pedagogical Knowledge vs. Seminars and Training Attended	0.603	retain the H_{o17}
Technological Pedagogical Knowledge vs. Length of Service	0.032	reject the H_{o18}

Note: If $p \leq 0.05$, with a significant difference

The table presents the results of a Kruskal-Wallis test assessing the differences in Technological Pedagogical Knowledge (TPK) of middle-aged teachers based on age, seminars and training attended, and length of service. For TPK vs. Age, the P-value is 0.046, leading to the rejection of the null hypothesis (Ho16). This suggests that age significantly affects technological pedagogical knowledge. Middle-aged teachers may exhibit varied TPK levels depending on generational attitudes toward technology and their ability to integrate it into pedagogy (Guerrero et al., 2022; Lin et al., 2023). Older teachers may struggle with the rapid technological advancements, while younger middle-aged educators might adapt more readily due to exposure to newer tools during their early teaching years.

For Technological Pedagogical Knowledge vs. Seminars and Training Attended, the P-value of 0.603 indicates no significant difference, retaining the null hypothesis (Ho17). This finding implies that attending seminars and training does not significantly impact the TPK of middle-aged teachers. It aligns with prior research highlighting that not all professional development programs effectively address practical implementation in the classroom (Yang et al., 2021; Rahman & Begum, 2023). Seminars may lack the depth, follow-up, or subject-specific focus necessary to translate training into classroom application, thereby failing to boost teachers' technological pedagogical knowledge.

In contrast, Technological Pedagogical Knowledge vs. Length of Service yielded a P-value of 0.032, leading to the rejection of the null hypothesis(Ho18). This indicates that the length of teaching service significantly influences TPK.

Experienced teachers may develop stronger pedagogical strategies but face challenges in adapting their methods to technology-enhanced teaching (Kim & Park, 2020; Tondeur et al., 2023). Conversely, less experienced educators may find integrating technology easier due to more exposure during their training. This underscores the importance of designing targeted interventions to support experienced teachers in enhancing their TPK and leveraging their pedagogical expertise.

Table 3.7 *Test of Significant Difference in the Technological Pedagogical Content Knowledge of Middle-Aged Teachers*

Kruskal Wallis Test	P value	Decision
Technological Pedagogical Content Knowledge vs. Age	0.378	retain the H_{o19}
Technological Pedagogical Content Knowledge vs. Seminars and Training Attended	0.408	retain the H_{o20}
Technological Pedagogical Content Knowledge vs. Length of Service	0.031	reject the H_{o21}

Note: If $p \leq 0.05$, with a significant difference

The table summarizes the Kruskal-Wallis test results assessing differences in Technological Pedagogical Content Knowledge (TPACK) of middle-aged teachers based on age, seminars and training attended, and length of service. For TPACK vs. Age, the P-value is 0.378, leading to the retention of the null hypothesis (Ho19). This finding suggests no significant difference in TPACK based on age, which aligns with studies showing that age alone may not predict TPACK levels (Siddiq & Scherer, 2021; Yu & Yang, 2023). Factors

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such as motivation and openness to technology integration likely play a more significant role than age in influencing teachers' TPACK.

Similarly, TPACK vs. Seminars and Training Attended yielded a P-value of 0.408, indicating no significant difference and retaining the null hypothesis(Ho20). This finding implies that attending seminars or training alone does not significantly enhance middle-aged teachers' TPACK. Existing literature highlights that short-term training programs often lack sustained follow-up, context-specific application, and practical integration strategies to impact TPACK development effectively (Koh et al., 2020; Rahman et al., 2022). Long-term, hands-on training tailored to teachers' specific needs may be required to significantly impact their technological, pedagogical, and content knowledge integration.

In contrast, TPACK vs. Length of Service produced a P-value of 0.031, leading to the rejection of the null hypothesis (Ho21). This result indicates a significant difference in TPACK based on the length of service, suggesting that teaching experience plays a critical role in shaping TPACK levels (Mishra et al., 2022; Chai et al., 2023). Experienced teachers may possess deeper pedagogical and content knowledge but face challenges incorporating technology into teaching practices, while less experienced teachers may integrate technology more intuitively but lack advanced pedagogical strategies. This highlights the need for tailored professional development programs that support experienced teachers in integrating technology effectively into their pedagogical practices.

Enhancement Program

Based on the results, an Integrated TPACK Development Program for Middle-Aged Teachers is proposed to address the gaps identified in their technological pedagogical content knowledge (TPACK). The study reveals that factors such as length of service and participation in seminars and training impact TPACK differently. To address these variations, the program would focus on offering sustained, hands-on training workshops tailored to the specific needs of middle-aged teachers. These workshops should integrate technological, pedagogical, and content-specific strategies, enabling teachers to apply their learning directly in classroom settings. This approach aligns with research emphasizing that contextualized and practical training significantly enhances teachers' TPACK (Koh et al., 2020; Mishra & Koehler, 2022).

Additionally, the program would include mentorship and peer collaboration initiatives. Experienced teachers with high TPACK proficiency could mentor their colleagues, fostering an environment of shared learning and support. Peer collaboration sessions could also serve as platforms for teachers to share best practices, discuss challenges, and co-develop innovative lesson plans. This strategy not only enhances professional learning but also strengthens the sense of community among teachers, as supported by studies that highlight the effectiveness of collaborative professional development (Tondeur et al., 2022; Rahman et al., 2022). Furthermore, incorporating digital platforms for resource sharing and communication can make this process more accessible and engaging.

To sustain the program's impact, it is essential to offer advanced certification opportunities and incentives. Certification courses focused on TPACK integration in various disciplines could encourage continuous learning and professional growth. Additionally, providing incentives, such as salary credits, recognition, or inclusion of TPACK achievements in performance evaluations, can motivate teachers to actively participate in these programs. Resource centers equipped with technology tools and support personnel can further ensure that teachers have the necessary resources to implement their learning effectively. By integrating these components, the program can comprehensively address the identified gaps, fostering a culture of innovation and continuous improvement in teaching practices.

V. SUMMARY OF FINDINGS, CONCLUSION, RECOMMENDATION

Summary of Findings

- The respondents are predominantly middle-aged, with most between 46 and 55 years old, reflecting their extensive teaching experience. While they have attended at least one or two training programs on educational technology, participation in advanced or continuous training remains limited, highlighting a need for further professional development. Additionally, most have over 10 years of teaching experience, reinforcing their expertise and long-term commitment to education.
- The respondents demonstrated a "Very High" level of TPACK across all domains. They confidently use technology for teaching and administrative tasks (TK) and possess strong subject knowledge (CK) with the ability to address misconceptions. Their expertise in diverse teaching strategies (PK) is

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complemented by proficiency in using technology to enhance subject delivery (TCK) and effectively integrating pedagogy with content (PCK). They also excel in designing interactive and collaborative learning experiences using technology (TPK), achieving an overall TPACK mean of 3.541, classified as "Very High."

- A significant difference in TPACK levels was observed based on years of service, with more experienced teachers excelling in CK, TCK, and PCK. However, age and training attendance did not significantly impact TPACK levels, suggesting that hands-on experience plays a more vital role than formal training in skill development.
- To address gaps in TPACK, an enhancement program is recommended, focusing on: Advanced technology workshops on subject-specific digital tools. Ongoing professional development for technology integration in pedagogy. Lastly, mentorship initiatives to encourage knowledge-sharing between experienced and newer educators.

Conclusion

The study found that middle-aged teachers possess a "Very High" level of TPACK, demonstrating strong integration of technology, pedagogy, and content in their teaching. However, their limited participation in advanced technology training highlights the need for continuous professional development to keep pace with evolving educational tools. Significant differences in TPACK levels based on years of service suggest that experience plays a key role in skill development, necessitating tailored training programs. Future research could compare TPACK levels among novice and experienced teachers or assess the effectiveness of targeted training initiatives. Additionally, longitudinal studies could examine how technological advancements impact TPACK over time, ensuring teachers remain adaptable to educational innovations.

Recommendations

- Teachers. Teachers are encouraged to engage in continuous professional development by attending advanced training and seminars focused on integrating technology, pedagogy, and content effectively. They should also explore innovative strategies to address technological challenges and further enhance student engagement through technology-driven teaching methods.
- Learners. Learners should be provided with more opportunities to engage in technology-enhanced learning activities. Teachers can encourage students to use digital tools for collaborative and self-directed learning, fostering critical thinking, creativity, and technological fluency.
- School Administrators. Administrators should invest in comprehensive professional development programs, focusing on TPACK integration. This includes providing access to up-to-date technological resources, creating policies that encourage ongoing teacher training, and ensuring adequate support for technology integration in teaching and learning processes.
- Future Researchers. Future researchers can expand this study by exploring the TPACK levels of teachers in other age groups or regions. Comparative studies on the impact of specific training programs on TPACK development or longitudinal studies tracking TPACK growth over time would provide valuable insights into further enhancing teaching practices.

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