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Research Article

Examining Teachers' Technological, Pedagogical, and Content Knowledge (TPACK) in Remote Teaching and Learning Modality

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ABSTRACT

This study examined the teachers' technological, pedagogical, and content knowledge (TPACK) in the remote teaching and learning modality. Specifically, it sought to find out if gender (male and female) and age groups (Gen Z, Millenial, and Gen X) have significant differences in the respondents' TPACK skills and if their attendance in the in-service training could cause a significant change in the perceptions of the said skills. The study followed the quantitative survey research design. An adapted research instrument was used to evaluate respondents' perceptions of TPACK abilities during the remote teaching and learning modality. The Mann-Withney u test was used to determine if the gender (male and female) would significantly differ in TPACK. While Kruskal-Wallis H test was used to analyze if the age groups (Gen Z, Millennial, and Gen X) show significant differences in the respondents' TPACK skills. To assess a significant change in the respondents' attendance in the in-service training, the McNemar change test was used. The study sample comprised 60 teachers from several public high schools in Makati City teaching remotely during the pandemic. Based on the results, gender did not show a significant difference in the TPACK abilities of the respondent. While no significant difference was established among the age groups regarding their TPACK skills, one domain (technological knowledge) of TPACK revealed significant results among the age groups. Moreover, it was also proven that respondents showed significant changes in their TPACK skills before and after attending the in-service training. Therefore, this study recommends creating learning communities among teachers of different gender and age groups to share their best practices during the remote learning setup to help improve others' TPACK skills. Also, it is recommended that the school administrations prioritize teachers' professional development by providing them with vital training and seminars to improve the said skills.

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Introduction

The COVID-19 pandemic has significantly disturbed global education systems involving approximately 1.6 billion learners in over 200 countries. Shutting down schools, institutions, and other learning spaces has affected more than 94% of the world's student population (Pokhrel & Chhetri, 2021). There have been reports regarding the high demand for teachers to use information and communications technologies (ICT) with this shift. Based on a Teaching and Learning International Survey (TALIS) study, younger teachers use technology more regularly in the classroom. But, only 60% of teachers received professional development in ICT, while 18% reported a high need for improvement in this area (Schleicher, 2020).

In the Philippines, the remote learning modality's execution posed challenges to students. These challenges are concerned mainly with technology, pedagogy, and content (Rotas & Cahapay, 2020). Likewise, these challenges would cause equity gaps, threaten students' security and safety, compromise the quality of learning, and poor assessment results (Tria, 2020). That is why the government is urged for a safe reopening of schools by focusing on the critical priority areas: (a) targeted programs to carry learners back to school to access tailored services to meet their learning and other needs; (b) effective remedial learning to help students catch up on lost learning; and (c) Support for teachers to address learning losses and incorporate digital technology into their teaching (Wieland & Francia, 2021).

With the demand for integrating technology because of the shift of learning modality, teachers encountered several challenges like unequal distribution of ICT infrastructure, digital literacy and divide, technology cost, and quality of education (Dhawan, 2020). Similarly, a study confirmed that teachers were using technology in teaching because it is the only way to deliver education during this challenging situation. However, only a few confirmed that they are only in the primary stage of understanding technology. Sometimes, they express frustration or lack self-confidence (Winter, Costello, O'Brien, & Hickey, 2021). Therefore, since teachers lack adequate skill in doing online classes and do not have sufficient technical support or ICT infrastructure to handle the technical challenges, this could affect the way they teach a particular subject, thus, affecting the quality of the process (Akram, Aslam, Saleem, & Parveen, 2021)

Considering effective teaching and learning in a remote learning setup, the TPACK framework focuses on three types of knowledge teachers need to associate for effective technology integration – technological, pedagogical, and content knowledge (a.k.a TPACK) (Koehler & Mishra, 2009). Due to the pandemic, the shift from face-to-face classes to remote learning modalities challenged teachers' ability to integrate technology, pedagogy, and content knowledge to conduct online learning well (Juanda, Shidiq, & Nasrudin, 2021).

In the context of teachers' TPACK in in-person or face-to-face instructions, Santosa and Absari (2018) confirmed that Gen Z teachers have a relatively high understanding of technology but slightly have limited information on pedagogy and content aspects. Similarly, millennial teachers have shown a strong knowledge of the TPACK elements than Gen X teachers. But unlike Millennial teachers, Gen Xers have a weaker knowledge of the TK element of TPACK but show more robust knowledge in PK and CK than Gen Z and millennial teachers (Santos & Castro, 2021). Furthermore, Millennials have direct experience with the first element of TPACK inherent in the context of social networks linked to the always-connected fabric of their daily lives. Teachers and teacher educators from prior generations—boomers and Gen-Xers—have a deep knowledge of pedagogy and content (Bull, 2010). However, if the sex (male and female) is evaluated, the researchers discovered no difference in the TPACK level between male and female teachers (Cahyani, Azizah, & Evans, 2021).

To improve TPACK among teachers, it was highly proposed that teachers should participate in various professional development

programs (Ersanli, 2016). Likewise, results revealed that pre-service and in-service participants demonstrate the ultimate self-confidence level in the technological and content knowledge domain when immersed in various educational technologies and integrated into the teaching and learning process (Saltan, Arslan, & Wang, 2017).

With limited studies investigating teachers' TPACK in a remote learning modality, this study examined the technical, pedagogical, and content knowledge of teachers of different age groups and sex in remote learning modalities. Specifically, this research aimed to answer the following questions:

1. What are the technological knowledge, pedagogical knowledge, and content knowledge of teachers in terms of:
   a. Sex; and
   b. Age group (by generations)?
2. Is there a difference between male and female teachers in terms of:
   a. Technological Knowledge (TK);
   b. Pedagogical Knowledge (PK); and
   c. Content Knowledge (CK)?
3. Is there a difference among the age group by generations (Gen Z, Millenial, Gen X) of teachers in terms of:
   a. Technological Knowledge (TK);
   b. Pedagogical Knowledge (PK); and
   c. Content Knowledge (CK)?
4. Is there a significant change in teachers' TPACK before and after the yearly in-service training?

Methods

This research is a descriptive-quantitative study that followed a survey research design. The researcher administered an adapted research instrument to describe the respondents' technological, pedagogical, and content knowledge (TPACK) in a remote learning setup.

Also, the researcher employed the purposive sampling technique in determining the respondents. The said sampling technique is a non-random sampling technique where the members of a particular group were decisively sought based on the study's objectives. The study respondents are primary and secondary teachers currently teaching and affiliated with the Department of Education in Metro Manila. Table 1 presents the respondents' information showing the gender and age groups.

Table 1. Respondents' Demographic Profile

Age Group *(by generation)*	**Male**	**Female**	**Total**
Overall	**23**	**37**	**60**
Gen Z *(24 years old and below)*	11	9	20
Millenial *(25 to 40 years old)*	7	13	20
Gen X *(41 to 56 years old)*	5	15	20

As shown in Table 1, the respondents consisted of 46 teachers. Based on gender and age (by generation), 16 teachers belong to Gen Z (male=11, female=9), 16 teachers belong to Millenial (male=7, female=13), and 16 teachers belong to Gen X (male=5, female=15). Thus, the majority of the respondents are female.

This research adopted an existing and validated instrument to measure teachers' technological, pedagogical, and content knowledge (TPACK) (Schmidt, et al., 2010). The owner secured permission to use the research instrument. Moreover, the researcher only used the following components of the survey with its item numbers: technological knowledge (6 items), pedagogical knowledge (7 items), and content knowledge (3 items). Overall, the TPACK survey consists of 16 items rated following the 4-point scale with the following descriptions: 4 - strongly agree, 3 - agree, 2 - disagree, and 1 - strongly disagree. The researcher added a single dichotomous item to answer the third research question.

Experts have already validated the 16-item TPACK survey. Also, the overall Cronbach's alpha value of the instrument was 0.85, which showed good internal consistency and reliability, as shown in Table 2.

Table 2. Internal Consistency of TPACK Survey (by Schmidt et al., 2010)

TPACK Domains	Cronbach alpha
Overall	**.85**
Technological Knowledge	.86
Pedagogical Knowledge	.82
Content Knowledge	.87

The researcher identified the respondents fit for the study during the data gathering. Due to some restrictions brought by the pandemic, the survey was administered online using Google forms. The respondents agreed to the informed consent before answering the survey in the said form. The consent form informed the respondents about the conduct of this study and ensured them that all information gathered would be treated with the utmost confidentiality.

After the target respondents answered the survey, the responses were downloaded in Google forms as an MS Excel file. Then, using the replace command in MS Excel, the string responses were replaced by the researcher with the equivalent numeric values, which are as follows: Strongly agree = 4, agree = 3, disagree = 2, and strongly disagree = 1. This file was saved as TPACK raw data in MS Excel. Using SPSS, the data collected were analyzed using descriptive and non-parametric statistics. Table 3 presents the research questions and the corresponding descriptive and non-parametric tests employed.

Table 3. Research questions and Statistics Used

Research Questions	Statistics used
RQ1: What are the technological knowledge, pedagogical knowledge, and content knowledge of teachers in terms of: a. Sex; and b. Age group (by generation)?	Descriptive (Mean and Standard Deviation)
RQ2: Is there a difference between male and female teachers in terms of: a. Technological Knowledge (TK); b. Pedagogical Knowledge (PK); and c. Content Knowledge (CK)?	Mann-Whitney U test
RQ3: Is there a difference among the age group by generations (Gen Z, Millenial, Gen X) of teachers in terms of: a. Technological Knowledge (TK); b. Pedagogical Knowledge (PK); and c. Content Knowledge (CK)?	Kruskal-Wallis H test
RQ4: Is there a significant change in teachers' TPACK before and after the yearly in-service training?	McNemar Change test

As shown in Table 3, descriptive statistics were used to summarize the respondents' perceptions of their TPACK abilities regarding sex and age group (by generation). Likewise, non-parametric tests were used to address RQs 2 to 4. For RQ 2, the Mann-Whitney U test was used to see a significant difference in the TPACK domains of the two independent groups (male and female respondents). For RQ 3, the Kruskal-Wallis H test was employed to examine the significant differences in the TPACK domains among the three groups (Gen Z, Millenials, and Gen X). Lastly, to determine the significant change in a dichotomous dependent variable between two related groups, the McNemar Change test was applied.

Results and Discussion

This part of the statistical analysis report includes sections containing a description of

the main findings and interpretations of the results for readers and provides the significance of the findings. Likewise, all the findings and interpretations addressed the research questions stated in the introduction part of this paper.

Descriptions of Respondents based on Sex and Age Group (by generation)

Descriptive statistics enables the researcher to present the data meaningfully, allowing a more straightforward interpretation. In this section, the respondents' TPACK perceptions were based on their sex and age (by generation). To interpret the mean ratings, the researcher used the following legend.

Descriptions	**Range**
Strongly Agree (SA)	3.26 – 4.00
Agree (A)	2.51 – 3.25
Disagree (D)	1.76 – 2.50
Strongly Disagree (SD)	1.00 – 1.75

Table 4 depicts the TPACK perceptions between male and female respondents. The descriptive statistics showed male and female respondents have comparable perceptions of their TPACK. Specifically, male respondents have a stronger level of agreement in their perception of their TPACK abilities ($\bar{X} = 3.326$) as compared with the female respondents ($\bar{X} = 3.249$). Likewise, based on the specific domains of TPACK, male and female respondents have agreements on their technological and content knowledge. Still, their level of agreement is higher in the latter domain. On pedagogical knowledge, male respondents have a stronger agreement than female respondents. However, both male and female repondents agreed on their TPACK abilities based on the overall agreement level. This result confirms Cahyani, Azizah, and Evans (2021) study findings that there is no difference in the TPACK level between male and female teachers.

Table 4. Descriptive Statistics of Respondents' TPACK by Sex (N=60)

TPACK Domains	Sex	Mean	SD	Interpretation
Overall TPACK	**Male**	**3.326**	**.364**	**Strongly Agree**
	Female	**3.249**	**.352**	**Agree**
Technological Knowledge (TK)	Male	3.102	.473	Agree
	Female	3.006	.481	Agree
Pedagogical Knowledge (PK)	Male	3.287	.370	Strongly Agree
	Female	3.221	.346	Agree
Content Knowledge (CK)	Male	3.594	.471	Strongly Agree
	Female	3.523	.448	Strongly Agree

Table 5 presents the respondents' perceptions of their TPACK abilities by age group. The researcher determined three age groups – Gen Z, Millennials, and Gen X. The Gen Z age group included respondents aged 24 years old and below, the Millennial age group included respondents aged 25 to 40 years old, while the Gen Xers were those aged 41 years old and above. Based on the results, all age groups have similar perceptions of their TPACK abilities. Even though they all agreed on their TPACK skills, they have stronger content knowledge than technological knowledge. In the case of their pedagogical knowledge, Gen Z and Millennial respondents have stronger PK than Gen X respondents. These results corroborated with the findings of Santos and Castro (2021) that Gen Z and millennial teachers have shown a strong knowledge of the TPACK elements than Gen X teachers.

Table 5. Descriptive Statistics of Respondents' TPACK by Age Group (N=60)

TPACK Domains	Age Group	Mean	SD	Interpretation
Overall TPACK	**Gen Z**	**3.371**	**.333**	**Strongly Agree**
	Millennial	**3.307**	**.379**	**Strongly Agree**
	Gen X	**3.158**	**.336**	**Agree**

TPACK Domains	Age Group	Mean	SD	Interpretation
Technological Knowledge (TK)	Gen Z	3.176	.410	Agree
	Millennial	3.142	.490	Agree
	Gen X	2.811	.459	Agree
Pedagogical Knowledge (PK)	Gen Z	3.336	.391	Strongly Agree
	Millennial	3.265	.321	Strongly Agree
	Gen X	3.137	.332	Agree
Content Knowledge (CK)	Gen Z	3.600	.491	Strongly Agree
	Millenial	3.517	.465	Strongly Agree
	Gen X	3.534	.425	Strongly Agree

Differences in the TPACK Perceptions Between Male and Female Respondents

A Mann-Whitney U test was utilized to compare the differences between the male and respondents' overall TPACK and specific TPACK domains. Table 6 shows no significant difference in the overall TPACK abilities of male and female respondents, U=367.500, p=.377. Similarly, no significant difference was seen in the technological knowledge, U=359.000, p=.306, pedagogical knowledge, U =390.500, p =.585, and content knowledge, U=384.500, p=.507, of the male and female respondents in the remote learning modality. This result agrees with the conclusions of Cahyani, Azizah, and Evans (2021) study findings that there is no difference in the TPACK levels between male and female teachers.

Table 6. Summary of Differences in TPACK Domains Between Male and Female Respondents (N=60)

TPACK Domains	Sex	Mean Ranks	U	Z	p-value
Overall	**Male**	**33.02**	**367.500**	**-.883**	**.377**
	Female	**28.93**			
Technological Knowledge (TK)	Male	33.39	359.000	-1.024	.306
	Female	28.70			
Pedagogical Knowledge (PK)	Male	32.02	390.500	-.547	.585
	Female	29.55			
Content Knowledge (CK)	Male	32.38	384.500	-.663	.507
	Female	28.93			

*Note: *p ≤ .05*

Differences in the TPACK Perceptions Among the Age Groups of the Respondents

A Kruskal-Wallis H test was utilized to compare the differences among the overall TPACK and its specific domains of the respondents' age groups (Gen Z, Millennial, and Gen X). Table 7 shows no significant difference in the overall TPACK perceptions and abilities among the respondents' age groups (Gen Z, Millennial, and Gen X), X^2 (2)=3.309, p=.191. However, after examining the specific domains of TPACK, there was a significant difference in the technological knowledge among the respondents' age groups, X^2(2)=6.024, p=.049**.** This result agrees with Santosa and Absari (2018) findings that Gen Z and Millennial teachers have better TPACK abilities than Gen X teachers. On the other hand, when it comes to the pedagogical, X^2 (2)=5.052, p =.080, and content knowledge, X^2(2)=.595, p=.743, there were no significant differences among the respondents' age groups. This was probably due to the teachers' numerous professional development training and seminars before engaging in the remotely learning modality during this pandemic.

Table 7. Summary of Differences in TPACK Domains Among Age Groups of Respondents (N=60)

TPACK Domains	Age Group	Mean Ranks	H	p-value
Overall	**Gen Z**	**34.98**	**3.309**	**.191**
	Millennial	**31.45**		
	Gen X	**25.08**		
Technological Knowledge (TK)	Gen Z	35.40	6.024	.049*
	Millennial	33.23		
	Gen X	22.88		
Pedagogical Knowledge (PK)	Gen Z	35.60	5.052	.080
	Millennial	32.08		
	Gen X	23.83		
Content Knowledge (CK)	Gen Z	32.80	.595	.743
	Millennial	29.15		
	Gen X	29.55		

*Note: *p ≤ .05, df=2*

Change in the TPACK Abilities of Respondents

A McNemar change test was employed to compare the significant change in the overall TPACK of the respondents before and after attending the in-service training program. Table 8 illustrates a significant change in the TPACK of respondents before and after attending the in-service program for teachers, $X^2(1)=16.409$, $p=.000$. This result validates the findings of Ersanli (2016) that teachers' TPACK improves when they attend various professional development programs.

Table 7. Summary of Change in TPACK Respondents Before and After In-Service Training (N=60)

		After		X^2	p-value
		no	yes		
Before	no	5	21	16.409	.000*
	yes	1	33		

*Note: *p ≤ .05, df=1*

Conclusions and Recommendations

This section includes conclusions derived from the study's findings and from which recommendations were based.

Based on the ongoing findings, the following conclusions are drawn:

1. Male teachers have stronger perceptions of their TPACK abilities than female teachers. Also, Gen Z and Millenial teachers have higher perceptions of their TPACK abilities than Gen X teachers.
2. It was proven that male and female teachers ' perceptions of their TPACK abilities during the remote teaching and learning modality have no significant difference.
3. Focusing on the overall perceptions of the respondents, by age groups, it was revealed to have no significant difference among the TPACK abilities. On the other hand, when examining the specific, the respondents showed a significant difference in their technological knowledge.
4. Still, it was proven that continuous professional development training programs are vital in improving teachers' TPACK skills since respondents showed significant change in their perception before and after attending the in-service training in preparation for the remote teaching and learning.

Still based on the findings of the study and the preceding conclusions, the researcher humbly recommends the following to the

concerned individuals, groups, and Department of Education-affiliated institutions:

1. Teachers can create a learning community to share best practices applied during the remote teaching and learning modality. Gen Z and Millennial teachers could share their experiences of effectively using various technologies in teaching students with Gen X teachers. Likewise, Gen X could share some pedagogical practices they employed with the former.
2. The head of various educational institutions should empower teachers by providing them with meaningful and helpful professional development training to be applied by teachers when teaching students during this pandemic.

The Department of Education should prioritize grassroots problems that hinder quality education from reaching students. They should provide technological infrastructures to aid online learning classes. Also, they should gather best practices applied by other countries that made their education system successful even in the middle of a pandemic.

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