Technological, Pedagogical, and Content Knowledge of Elementary Teachers

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***Abstract*— This study was conducted to determine the Technological-Pedagogical and Content Knowledge of elementary teachers. This study utilized a mixed method of research employing both quantitative and qualitative research. Descriptive method was used to describe the Technological-Pedagogical and Content Knowledge of elementary teachers. Meanwhile, basic qualitative research was used to explore the issues and challenges of teachers on their acquisition of TPACK. The respondents of the study were the 31 elementary teachers of the three elementary schools of the Rizal District, Division of Kalinga. It can be shown from the results that they are highly competent along pedagogical knowledge, content knowledge, technological knowledge, pedagogical content knowledge, and technological pedagogical knowledge. Meanwhile, they are competent along technological content knowledge and technological-pedagogical-content knowledge. In general, elementary teachers of Rizal District of Division of Kalinga are highly competent along TPACK. There are three major issues that respondents stressed in terms of their issues and challenges on the attainment of TPACK. These issues revolve around the following: (1) technological issues, (2) pedagogical issues, and (3) content issues.**

Keywords*— TPACK, elementary teachers, Pedagogical Knowledge, Content Knowledge, Technological Knowledge, Pedagogical Content Knowledge, Technological Pedagogical Knowledge, Technological Content Knowledge, Technological-Pedagogical-Content Knowledge*

I. Introduction

Due to the development of Information and Communication Technology (ICT) and the Fourth Industrial Revolution's advancement of technology, the world in the twenty-first century is developing very quickly (4IR). The 4IR involves extremely disruptive technologies that alter the global economic, social, and political systems. As a result, it puts enormous pressure on a nation's leaders and policy-makers to adapt to these changes. Examples of these disruptive technologies include artificial intelligence, the Internet of Things, robotics, and virtual reality (Skilton & Hovsepian, 2018). Additionally, there has been a significant change in educational learning objectives, as most recently evidenced by Goal 4.7 of the Sustainable Development Goals, which is now centered on education for global citizenship and sustainable development. The change relates to the realization that educational systems must provide students with skills like communication, teamwork, critical thinking, and problem-solving. The emphasis on these 21st-century goals is evident in curriculum and educational reform, and it has been encouraged by worldwide discourse on evolving society and workplace needs (Manda & Ben Dhaou, 2019). These improvements and developments have altered not just the political, social, and economic systems, but also the nature of education. Students of the 21st-century, commonly referred to as digital natives or millennials, learn in the classroom with methods that differ from those of students from earlier generations. The pupils in the millennial generation are heavily reliant on technology because it permeates every aspect of their lives and helps them learn. As a result, classroom instruction that relies exclusively on chalk and speaking is no longer acceptable to teachers (Oke & Fernandes, 2020).

Teachers today should be aware of the 4IR requirements, which call for a shift in how they instruct in classrooms of the 21st-century. The teaching strategies must adapt to Education 4.0, a concept that follows the 4IR (Ross & Maynard, 2021). The needs of IR4.0, where humans and technology are in alignment to enable new possibilities, are met by education 4.0. The most modern technologies, such as artificial intelligence, robotics, and the Internet of Things (IoT), will eventually replace some human occupations; hence, it is imperative that students have talents that the technology cannot replace. In today's schooling, this is where 21st-century skills are taught (Shahroom & Hussin, 2018). Teachers and educators must equip students with the 21st-century skills required by the 4IR in order for them to remain relevant in the workplace. However, if the teachers themselves lack the expertise to impart those talents to the pupils, the students will not be able to develop those skills. Due to growing concern over injustice and inequality around the world, the 21st-century has brought up new demands on educational systems. The concerns are about both access to education and the quality of education, as first shown by the Millennium Development Goals and is currently shown by the Sustainable Development Goals (Azhari et al., 2020). Equity-related policies of the 21st-centrury century impact how educational systems must accommodate all children and teenagers. Introducing new

learning domains—domains defined by transferable skills and competencies—is necessary for education systems to deliver educational experiences pertinent to the 21st-century world that students must navigate. Despite hopes for a 21Cs learning agenda at the national, regional, and international levels, full implementation at the school and classroom levels has not yet occurred (Tanriogen, 2018).

Numerous studies demonstrate how challenging an innovation is for teachers to incorporate technology into their teaching practices (Sabiri, 2020; Arredondo-Trapero et al., 2021; Loudova, 2020). Technology integration into the teaching process is challenging for teachers. Therefore, even if an application of information and communications technology (ICT) has been shown to be successful on its own, this does not necessarily mean that the same impacts would be seen in real-world educational contexts. Technology frequently does not fit into the current teaching culture, according to Winter et al. (2021), and it might even make teachers feel less effective. Because of this, teachers who use technology often domesticate the program to fit with their standard methods of instruction, while omitting the benefits that technology can provide. Additionally, kindergarten students' usage of technology should be integrated into (suitable) instructional frameworks. Learning in the 21st-century needs the use of information technology, cooperation, and communication skills (Stein et al., 2020). The development of learning through ICT integration greatly raises students' degree of educational practices. Teachers are expected to be IT literate in order to effectively instruct students using a range of pedagogical strategies. Increasing creativity, collaboration, and accountability in learning are closely related to the concept of TPACK (Araujo & Carvalho, 2022).

The TPACK framework has received a lot of attention in numerous studies on the use of technology in teaching and learning. Based on the work of Koehler and Mishra (2009), the majority of researchers created and developed a self-reported TPACK measurement tool to assess teachers' level of TPACK. However, given the current shift in education toward 21st-century skills, it is critical to ascertain whether teachers can integrate TPACK into their instruction of these abilities.

II. METHODS

This study utilized both quantitative and qualitative research. Descriptive method was used to describe the Technological-Pedagogical and Content Knowledge of elementary teachers. Meanwhile, basic qualitative research was used to explore the issues and challenges of teachers on their acquisition of TPACK. The respondents of the study were the 31 elementary teachers of the three elementary schools of Rizal District, Division of Kalinga.

The study utilized a questionnaire with three parts. The first part of the questionnaire includes the profile of the respondents: gender, age, type of school, teaching rank, number of years in service, educational attainment, and number of seminars attended related to technology, pedagogy, and content for the last 3 years. The second part of the questionnaire consists of items lifted from the TPACK model (2018) with the following elements: pedagogical knowledge, content knowledge, technological knowledge, pedagogical content knowledge, technological pedagogical knowledge, technological content knowledge, and technological-pedagogical-content knowledge. Finally, the third part of the questionnaire is an open-ended question looking into the issues and challenges of the respondents on their acquisition of TPACK.

Data Analysis

Frequency and Percentage were used to describe the profile of the respondents.

Weighted mean was used to determine the level TPACK of teachers in research using the following range and qualitative description:

Range	Qualitative Description
3.50 – 4.00	Highly Competent
2.50 – 3.49	Competent
1.50 – 1.49	Less Competent
1.00 – 1.49	Not Competent

Independent Sample T-Test and One Way Analysis of Variance (ANOVA) were used to determine significant difference on the technological-pedagogical and content knowledge (TPACK) of the respondents when grouped according to profile variables.

Thematic Analysis was used to explore the issues and challenges of teachers on their acquisition of TPACK.

III. RESULTS

Table 1. Profile of the Respondents

Profile	Frequency	Percentage
Gender		
Male	5	16%
Female	26	84%
Age		
30 and Below	8	26%
31- 40	7	23%
41- 50	13	42%
51- 60	2	6%
61 and above	1	3%
Type of School		
Monograde	24	77%
Multigrade	7	23%
Teaching Rank		
Teacher I	12	39%
Teacher II	1	3%
Teacher III	15	48%
Master Teacher I	3	10%

Number of Years in Service		
Less than a year	5	16%
1-3 years	4	14%
4- 6 years	6	19%
7- 10 years	6	19%
11 years and above	10	32%
Educational Attainment		
Bachelor's Degree	6	19.35%
With MA/ MS Units	14	45.16%
Master's Degree	8	25.81%
With PhD/EdD Units	2	6.45%
PhD/EdD Degree	1	3.23%
Number of Seminars Attended		
None	3	10%
1- 3	16	52%
4- 6	6	19%
7 and above	6	19%

Table 1 presents the profile of the respondents. It can be shown from the results that there are more female teacher-respondents than male-respondents. In addition, the highest number of respondents in terms of age comes from the 41-50 age group. Also, almost all of the respondents are currently teaching in a monograde type of school. Furthermore, the highest number of respondents are currently Teacher III in their teaching rank, followed by Teacher I. In terms of the number of years in the teaching service, many of them are already in the profession for more than 10 years. Meanwhile, along their educational attainment, majority of the respondents have at least MA/MS units. Finally, majority of them attended 1-3 trainings and seminars related to TPACK for the last five years.

Table 2a. Technological-Pedagogical and Content Knowledge of the Respondents along Pedagogical Knowledge

Indicators	Mean	Description
I can adapt my teaching based upon what students currently understand or do not understand.	3.68	Highly Competent
I can adapt my teaching style to different learners	3.71	Highly Competent
I can use a wide range of teaching approaches in a classroom setting	3.55	Highly Competent
I can assess student learning in multiple ways	3.61	Highly Competent
Category Mean	3.64	Highly Competent

Table 2a presents the technological-pedagogical content knowledge of elementary teachers along their pedagogical knowledge. It can be gleaned from the results that teacher-respondents are highly competent in all domains of pedagogical knowledge, such as adapting their teaching upon what students currently understand and do not understand, adapting their teaching styles to different learners, using a wide range of teaching approaches in a classroom setting, and assessing student learning in multiple ways. In general, elementary teachers are highly competent in their pedagogical knowledge. This means that they already obtained and gained the knowledge of the practices, processes, and methods regarding teaching and learning. In addition, they have already acquired the skills of understanding student learning styles, classroom management skills, lesson planning, and assessments.

Table 2b. Technological-Pedagogical and Content Knowledge of the Respondents along Content Knowledge

Indicators	Mean	Description
I have sufficient knowledge about my teaching subject	3.52	Highly Competent
I can use a subject-specific way of thinking in my teaching subject	3.61	Highly Competent
I know the basic theories and concepts of my teaching subject	3.58	Highly Competent
I know the history and development of important theories in my teaching subject.	3.42	Competent
Category Mean	3.53	Highly Competent

Table 2b shows the technological-pedagogical and content knowledge of the teacher-respondents along their content knowledge. It can be shown from the results that elementary teachers are highly competent in having sufficient knowledge about their teaching subject, use a subject-specific way of thinking in their teaching subject, and are knowledgeable on the basic theories and concepts of their teaching subject. However, it was also revealed in the study that teacher-respondents are competent in knowing the history and development of important theories in their teaching subject. In general, elementary teacher-respondents are highly competent in terms of their content knowledge. This means that they are already experts in their subject matter, such as concepts, theories, evidence, and organizational frameworks within a particular subject matter. In addition, they also grasped the field's best practices and established approaches to communicating this information to their pupils.

Table 2c. Technological-Pedagogical and Content Knowledge of the Respondents along Technological Knowledge

Indicators	Mean	Description
I keep up with important new technologies.	3.68	Highly Competent
I frequently play around with the technology.	3.45	Competent
I know about a lot of different technologies.	3.35	Competent
I have the technical skills I need to use technology	3.52	Highly Competent

Category Mean	3.50	Highly Competent

Table 2c presents the technological-pedagogical and content knowledge of elementary teachers of Rizal District, Division of Kalinga along their technological knowledge. The findings reveal that they are highly competent in keeping up with important new technologies and also with technical skills needed in using technology. However, the respondents are competent in frequently playing with technology and knowing about a lot of different technologies. In general, teacher respondents are highly competent in terms of their technological knowledge. This may imply that they have the ability to use various technologies, technological tools, and associated resources. They already fully understand educational technology, considering its possibilities for a specific subject area or classroom, learning to recognize when it will assist or impede learning, and continually learning and adapting to new technology offerings.

Table 2d. Technological-Pedagogical and Content Knowledge of the Respondents along Pedagogical Content Knowledge

Indicators	Mean	Description
I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.	3.58	Highly Competent
I know how to develop appropriate tasks to promote students complex thinking of my teaching subject.	3.55	Highly Competent
I know how to develop exercises with which students can consolidate their knowledge of my teaching subject	3.61	Highly Competent
I know how to evaluate students' performance in my teaching subject.	3.68	Highly Competent
Category Mean	3.60	Highly Competent

Table 2d shows the technological-pedagogical and content knowledge of the respondents along pedagogical content knowledge. It can be gleaned from the results that they are highly competent in all indicators along this domain, such as knowing how to select effective teaching approaches to guide student thinking and learning in their teaching subject, knowing how to develop appropriate tasks to promote students complex thinking of their teaching subject, knowing how to develop exercises with which students can consolidate their knowledge of their teaching subject, and knowing how to evaluate students' performance in their teaching subject. In summary, teacher-respondents are highly competent along pedagogical content knowledge. This means that teachers know the foundational areas of teaching and learning, including curricula development, student assessment, and reporting results. They also promote learning and tracing the links among pedagogy and its supportive practices in curriculum, assessment, and others.

Table 2e. Technological-Pedagogical and Content Knowledge of the Respondents along Technological Pedagogical Knowledge

Indicators	Mean	Description
I can choose technologies that enhance the teaching approaches for a lesson.	3.61	Highly Competent
I can choose technologies that enhance students' learning for a lesson.	3.58	Highly Competent
I can adapt the use of the technologies that I am learning about to different teaching activities.	3.48	Competent
I am thinking critically about how to use technology in my classroom.	3.45	Competent
Category Mean	3.53	Highly Competent

Table 2e presents the technological-pedagogical and content knowledge of the respondents along technological-pedagogical knowledge. Accordingly, teachers are highly competent in choosing technologies that enhance the teaching approaches for a lesson and in choosing technologies that enhance students' learning. Meanwhile, they are competent in adapting the use of the technologies that they are learning about to different teaching activities and thinking critically about how to use technology in the classroom. In general, they are highly competent along technological pedagogical knowledge.

Table 2f. Technological-Pedagogical and Content Knowledge of the Respondents along Technological Content Knowledge

Indicators	Mean	Description
I know how technological developments have changed the field of my subject.	3.48	Competent
I can explain which technologies have been used in research in my field.	3.32	Competent
I know which new technologies are currently being developed in the field of my subject.	3.29	Competent
I know how to use technologies to participate in scientific discourse in my field.	3.26	Competent
Category Mean	3.34	Competent

Table 2f presents the technological-pedagogical and content knowledge of the respondents along technological content knowledge. It can be noted from the results that teachers are competent along all the indicators of this domain, such as knowing how technological development have changed the field of their subject, explaining which technologies have been used in research in their field,

knowing which new technologies are currently being developed in the field of their subject, and knowing how to use technologies to participate in scientific discourse in their field. In general, teachers are competent in terms of their technological content knowledge. This means that they have understanding of how technology and content can both influence and push against each other. They also understand how the subject matter can be communicated via different edtech offerings and consider which specific edtech tools might be best suited for specific subject matters or classrooms.

Table 2g. Technological-Pedagogical and Content Knowledge of the Respondents along Technological-Pedagogical- Content Knowledge

Indicators	Mean	Description
I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	3.39	Competent
I can choose technologies that enhance the content for a lesson.	3.42	Competent
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	3.52	Highly Competent
I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.	3.52	Highly Competent
Category Mean	3.46	Competent

Table 2g shows the technological-pedagogical and content knowledge of the respondents along technological-pedagogical-content knowledge. It can be gleaned from the results that teachers are highly competent in selecting technologies to use in their classrooms that enhance what they teach, how they teach, and what students learn. In addition, they can also teach lessons that appropriately combine their teaching subject, technologies, and teaching approaches. Meanwhile, they are competent in using strategies that combine content technologies and teaching approaches that they learned about in their coursework in their classroom. At the same time, they can also choose technologies that enhance the content of a lesson. In general, teachers are competent along this domain. This means that they understand how particular technologies can change both the teaching and learning experiences by introducing new pedagogical affordances and constraints. In addition, they also have an understanding on how such tools can be deployed alongside pedagogy in ways that are appropriate to the discipline and the development of the lesson at hand.

Table 2h. Summary Table on the Technological-Pedagogical and Content Knowledge of the Respondents

Area	Mean	Description
Pedagogical Knowledge	3.64	Highly Competent
Content Knowledge	3.53	Highly Competent
Technological Knowledge	3.50	Highly Competent
Pedagogical Content Knowledge	3.60	Highly Competent
Technological Pedagogical Knowledge	3.53	Highly Competent
Technological Content Knowledge	3.34	Competent
Technological-Pedagogical- Content Knowledge	3.46	Competent
Total Mean	3.51	Highly Competent

Table 2h presents the summary table on the technological-pedagogical and content knowledge of the respondents. It can be shown from the results that they are highly competent along pedagogical knowledge, content knowledge, technological knowledge, pedagogical content knowledge, and technological pedagogical knowledge. Meanwhile, they are competent along technological content knowledge and technological-pedagogical-content knowledge. In general, elementary teachers of Rizal District of Division of Kalinga are highly competent along TPACK.

Table 3a. Significant Difference on the Technological-Pedagogical and Content Knowledge of the Respondents when Grouped According to Profile Variables

Profile Variables	Computed value	p-value	Interpretation
Gender	0.95	0.37	Not Significant
Age	2.34	0.07	Not Significant
Type of School	-0.54	0.59	Not Significant
Teaching Rank	7.95	0.00	Significant
Number of Years in Service	0.72	0.58	Not Significant
Educational Attainment	17.70	0.80	Not Significant
Number of seminars Attended	3.32	0.03	Significant

Table 3a presents the significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according to profile variables. It can be shown from the results that there is no significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according to gender, age, type of school, number of years in service, and educational attainment. These are supported by probability values of .37, .07, .59, .58, and .80, respectively. Hence, the null hypothesis is accepted.

Meanwhile, there is a significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according to teaching rank and number of seminars attended. These are supported by probability values of .00 and .03, respectively, which are both lower than .05 level of significance. Hence, the null hypothesis is rejected. This means that the technological-pedagogical and content knowledge of the respondents varies in terms of these profile variables.

Table 3b. Post- Hoc Analysis on the Significant Difference on the Technological-Pedagogical and Content Knowledge of the Respondents when grouped according to Teaching Rank

Teaching Rank	Mean	Teacher 1	Teacher II	Teacher III	Master Teacher I
Teacher 1	3.46	1			
Teacher II	3.79	0.00*	1		
Teacher III	3.45	0.91	0.00*	1	
Master Teacher I	3.49	0.73	0.00*	0.66	1

**Significant*

Table 3b presents the post-hoc analysis on the significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according to teaching rank. It can be shown from the results that a significant difference exists between Teacher I and Teacher II, and between Teacher II and Teacher III and Master Teacher I. Respondents having a Teacher II position are highly competent on their TPACK, while respondents who are Teacher I, Teacher III, and Master Teacher I are competent to TPACK.

Table 3c. Post- Hoc Analysis on the Significant Difference on the Technological-Pedagogical and Content Knowledge of the Respondents when grouped according to Number of Seminars Attended

Number of Seminars	Mean	None	1- 3	4-6	7 and above
None	3.25	1			
1-3	3.50	0.049 *	1		
4-6	3.49	0.048 *	0.89	1	
7 and above	3.48	0.04*	0.81	0.92	1

*Significant at .05

Table 3c shows the post-hoc analysis on the significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according to number of seminars attended. It can be shown from the results that there is a significant difference on the TPACK of teachers who do not have any seminars attended and those with at least one training.

Issues and Challenges of Teachers on the Attainment of TPACK

There are three major issues that respondents stressed in terms of their issues and challenges on the attainment of TPACK. These issues revolve around the following: (1) technological issues, (2) pedagogical issues, and (3) content issues. Along technological issues, respondents listed three major difficulties, which include the following: (a) lack of gadgets to use, (b) poor internet connection, and (c) lack of ICT training. Meanwhile, along pedagogical issues, there are two major issues raised by teachers, which are as follows: (a) reluctance due to previous technological problems, and (b) lack of training on pedagogy. Finally, along content issues, one difficulty has been transcribed from the responses of the respondents, which is heavy workload.

Technological Issues

a. Lack of Gadgets

One of the major issues of teachers along technological aspects is the lack of gadgets to be used in teaching. Despite their eagerness to learn the different new trends in educational technology, they still have no means due to the unavailability of gadgets. Some of the responses of the respondents are as follows:

> T12: *I have an issue on the lack of gadgets to be used in teaching. I only have laptop and cell phone but I do not have some educational technologies and tools to be used such as tablet and projector.*

> T15: *I do not have gadget to be used to enhance my TPACK. Today, that matters in the 21st century educational parlance because we are now in an Information Technology area.*

b. **Poor Internet Connection**

Another concern raised by teachers is the poor internet connection in their locale. According to them, internet is considered the heart of TPACK because this will make a great difference in teaching. However, many places in the locality do not have a very strong internet connection. Some of the responses of the respondents are as follows:

> T06: *I need intranet connection to fully maximize my skills, such as TPACK, but we do not have internet connection at home due to bad signal.*

> T04: *Internet is the thing now. We become great teachers because of the use of the internet. But sad to say, many places here in Rizal are not yet bounded with internet.*

c. Lack of ICT Training

Many teachers claimed that they lack training related to ICT in order to enhance and develop their TPACK, especially along technological knowledge. In most cases, most of the trainings on ICT are being attended by the ICT coordinator of the school. Some of the responses of the respondents are as follows:

> T02: *We need ICT training because only the ICT coordinator is given opportunity to attend such conferences and seminars.*
>
> T07: *ICT is very important for the successful teaching and learning. However, we are not given avenues to attend ICT trainings and seminars.*

Pedagogical Issues

d. Reluctance due to Previous Technological Problems

This issue is geared towards the reluctance of teachers in integrating some innovations in teaching due to low ICT competence. Some of the responses of the respondents are as follows:

> T18: *I am reluctant to innovate things in my class because I am not good in using technology. I might be embarrassed in the class.*
>
> T03: *I am not good in technology that is why I cannot integrate it in my pedagogy.*

e. Lack of Training on Pedagogy

Teachers stressed the need to involve themselves in different pedagogy trainings and seminars. Accordingly, pedagogy is evolving, and teachers need to be updated with the current trends on the use of instructional strategies and assessment techniques in the classroom. Some of the responses of the respondents are as follows:

> T21: *I need to participate to different CPD related activities that focus on pedagogical techniques.*
>
> T10: *I lack seminars and trainings on pedagogy.*

Content Issues

f. Heavy Workload

In order for teachers to master their field, they need to engage in different activities such as attendance to seminars and enrollment to graduate studies. However, their heavy workload impedes them to become master of their own content. Some of the responses of the respondents are as follows:

> T20: *Endless paper works and extended working hours impede me to really learn more about my topic and lesson.*
>
> T12: *Due to heavy workload, I think there is an issue now with the content of my lesson because it is too traditional and bookish.*

IV. DISCUSSION

This study was conducted to determine the Technological-Pedagogical-Content Knowledge (TPACK) of elementary teachers of Rizal District, Division of Kalinga. It can be gleaned from the results that, generally, they are highly competent on TPACK. Specifically, they are highly competent along pedagogical knowledge, content knowledge, technological knowledge, pedagogical content knowledge, and technological pedagogical knowledge. Meanwhile, they are competent along technological content knowledge and technological-pedagogical-content knowledge. Technical knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological content knowledge, and technological pedagogical knowledge are all combined to form technological pedagogical content knowledge, which focuses on how technology can be made specific to be relevant with the pedagogical needs to teach the right content in a particular context. The necessity and significance of these components in teaching are explained by each component of the knowledge field (Zainal, 2016). However, more than just each component is needed for teaching to be effective. Technology expertise, pedagogy, and content are combined by teachers with TPACK and used to create engaging learning opportunities for their pupils (Voogt & McKenney, 2017).

Specifically, teachers' PCK and PK skills were the highest among the seven sub-dimensions. TPK refers to the understanding of how to use various technologies with various educational methods. It is crucial for instructors to understand and use the latest technological advancements, as well as to select pedagogical strategies that are compatible with particular technology. PK refers to the knowledge of the teaching procedure and methods, such as the teachers' knowledge of the students' learning preferences, classroom management, lesson planning, and teaching assessment (Tanriogen, 2018). The findings show that teachers who took part in this study fared better in both TPK and PK skills. Teachers had the second-best TCK and TPACK skills at that time. For TCK, it refers to the understanding of how to express subject matter using technology. Understanding the topic content with utilizing the proper technology is advantageous for effective teaching. The capacity to use ICT correctly in accordance with teaching material and methodologies is referred to as TPACK. According to the study's findings, teachers had a good level of TPACK proficiency. The knowledge of teaching strategies with regard to subject matter content and the actual subject matter that is

to be taught came next, followed by PCK and CK. The key components for teachers are the lesson plans and instructional methods. As a result, the PCK and CK levels of the research's teachers were also fairly high. The findings, however, indicated that teachers' TK proficiency was the least strong of the TPACK framework's other components. This demonstrated that the teachers who took part in the study were unable to effectively address specific technological issues in the classroom, such as faulty hardware or software. Teachers should improve their command of technology and give more attention to gaining relevant expertise in technology usage and device management because technology is a significant part of conventional teacher-centered education (Ross & Maynard, 2021; Se et al., 2018).

It is clear that teachers are quite skilled along pedagogical knowledge (PK). When discussing classroom management, lesson design, and student evaluation, PK refers to instructors' understanding of how kids learn (Koehler & Mishra, 2009). Additionally, it implies that educators are skilled in developing conditions conducive to learning and teaching for all pupils. For educators, pedagogical skills are important because they improve the standard of instruction in the classroom (Niess, 2011; Omoso & Odindo, 2020). The learning environment is improved by effective pedagogical techniques that enhance both teaching and learning methods. As a result, it can be inferred from the study that elementary teachers assess each student's academic growth, as well as the growth of the class as a whole. Teachers who employ this method of instruction often control the classroom to create a secure, encouraging, and motivating environment for learning. In addition, along technological knowledge, it can be stressed that they already have the knowledge of the different technologies in the classroom. The findings affirm the results of previous study stressing the need for teachers to be competent, especially on the use of technology in the classroom. Teachers may use technology to boost productivity, apply practical digital tools to promote student learning opportunities, and boost engagement and support from students (Mishra, 2019). Additionally, it allows teachers to customize learning and enhance their teaching strategies. Meanwhile, for content knowledge, teachers are already considered as experts in their field. Instead of associated skills—like reading, writing, or researching—that children also learn in school, content knowledge often refers to the facts, concepts, theories, and principles taught and learned in certain academic courses. How teachers interpret the content goals they are expected to achieve with our students depends on their understanding of the subject matter. It influences how they hear their students' questions and remarks and how they respond to them. Their capacity to communicate clearly and formulate thoughtful inquiries is impacted (Krause & Lynch, 2016).

In addition, there is a significant difference on the technological-pedagogical and content knowledge of the respondents when grouped according teaching rank and number of seminars attended. Accordingly, teachers who have Teacher II positions are the highest in terms of their TPACVK competency, compared to other teaching ranks and positions. Also, teachers who attended seminars and training are more competent than those who did not attend any seminars related to TPACK. The findings affirm the results of previous studies stressing the importance of teaching position and attendance and participation to CPD activities in the development of teachers' competence, such as the TPACK (Araujo et al., 2022; Baran & Ugyun, 2006; Bos, 2011).

Finally, as they fully developed their TPACK, teachers encountered various issues and challenges. These concerns center on the following: technological issues, pedagogical problems, and content problems. Respondents highlighted three main challenges along with technology issues, including lack of ICT training, a dearth of devices to utilize, and a bad internet connection (Koehler & Mishra, 2005). Understanding the intricate web of connections between users, technologies, tools, and processes is essential for successful technology integration. Along pedagogical challenges, teachers have also brought up two other significant concerns: (a) reluctance owing to a prior technology issue, and (b) a lack of pedagogy training. Finally, a challenge related to content, namely, a hefty workload, has been identified from the respondents' responses. What should be addressed in an emergency remote classroom and what professional development support should be given priority are described in the identified issues associated with each TPACK area. Learning which technologies to use or how to use particular tools should not be the focus of professional growth. It ought to be about assisting teachers in comprehending how their understanding of subject matter, pedagogy, and technology can be effectively and efficiently synchronized to permit meaningful and interesting online distance learning within emergency remote and "better" typical teaching (Loudova, 2020).

V. CONCLUSION AND RECOMMENDATIONS

The study concludes that elementary teachers of the District of Rizal, Division of Kalinga are highly competent in their Technological-Pedagogical-Content Knowledge (TPACK). However, their full competence can only be shown along basic dimensions of TPACK, such as Pedagogical Knowledge, Content Knowledge, Technological Knowledge, Pedagogical Content Knowledge, and Technological Pedagogical Knowledge. They are competent along Technological Content Knowledge and Technological-Pedagogical-Content Knowledge. In addition, teachers' current teaching position and their attendance to seminars and training positively affect the enhancement and development of their TPACK. Finally, certain issues along technological, pedagogical, and content are considered as impediments to the development of teachers' TPACK.

REFERENCES

Araújo Filho, R., & Gitirana, V. (2022). Pre-service Teachers' Knowledge: Analysis of teachers' education situation based on TPACK. *The Mathematics Enthusiast*, *19*(2), 594-631.

Araújo, I., & Carvalho, A. A. (2022). Enablers and Difficulties in the Implementation of Gamification: A Case Study with Teachers. *Education Sciences*, *12*(3), 191.

Arredondo-Trapero, F. G., Vázquez-Parra, J. C., & González-Martínez, M. D. J. (2021). Teachers' perceptions of ICT issues in education: an approximation by gender and region in Mexico. *On the Horizon*.

Azhari, B., Ma'awiyah, A., Hamid, M., Ridhwan, M., & Bahri, S. (2020, February). E-Learning as connector among education institution in the 4th industrial revolution. In *Journal of Physics: Conference Series* (Vol. 1471, No. 1, p. 012024). IOP Publishing.

Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian journal of educational technology*, *32*(2).

Bos, B. (2011). Professional development for elementary teachers using TPACK. *Contemporary Issues in Technology and Teacher Education*, *11*(2), 167-183.

Castéra, J., Marre, C. C., Yok, M. C. K., Sherab, K., Impedovo, M. A., Sarapuu, T., ... & Armand, H. (2020). Self-reported TPACK of teacher educators across six countries in Asia and Europe. *Education and Information Technologies*, *25*(4), 3003-3019.

Cheng, S. L., & Xie, K. (2018). The relations among teacher value beliefs, personal characteristics, and TPACK in intervention and non-intervention settings. *Teaching and Teacher Education*, *74*, 98-113.

Clausen, J. M., Finsness, E. S., Borthwick, A. C., Graziano, K. J., Carpenter, J. P., & Herring, M. (2019). TPACK leadership diagnostic tool: Adoption and implementation by teacher education leaders. *Journal of Digital Learning in Teacher Education*, *35*(1), 54-72.

Durdu, L., & Dag, F. (2017). Pre-service teachers' TPACK development and conceptions through a TPACK-based course. *Australian Journal of Teacher Education (Online)*, *42*(11), 150-171.

Figg, C., & Jaipal, K. (2012, March). TPACK-in-Practice: Developing 21st century teacher knowledge. In *Society for Information Technology & Teacher Education International Conference* (pp. 4683-4689). Association for the Advancement of Computing in Education (AACE).

Finger, G., Romeo, G., Lloyd, M., Heck, D., Sweeney, T., Albion, P., & Jamieson-Proctor, R. (2015). Developing graduate TPACK capabilities in initial teacher education programs: Insights from the Teaching Teachers for the Future Project. *The Asia-Pacific Education Researcher*, *24*(3), 505-513.

Gómez-Trigueros, I. M., & Yáñez de Aldecoa, C. (2021). The digital gender gap in teacher education: the TPACK framework for the 21st Century. *European Journal of Investigation in Health, Psychology and Education*, *11*(4), 1333-1349.

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: systematic review. *Sustainability*, *14*(3), 1493.

Graziano, K. J., Herring, M. C., Carpenter, J. P., Smaldino, S., & Finsness, E. S. (2017). A TPACK diagnostic tool for teacher education leaders. *TechTrends*, *61*(4), 372-379.

Gur, H. (2015). A short review of TPACK for teacher education. *Educational Research and Reviews*, *10*(7), 777-789.

Habowski, T., & Mouza, C. (2014). Pre-service teachers' development of technological pedagogical content knowledge (TPACK) in the context of a secondary science teacher education program. *Journal of Technology and Teacher Education*, *22*(4), 471-495.

Herring, M. C., Meacham, S., & Mourlam, D. (2016). TPACK development in higher education. In *Handbook of technological pedagogical content knowledge (TPACK) for educators* (pp. 217-234). Routledge.

Hulya, G., & Ay? en, K. (2015). A short review of TPACK for Teacher Education. *Educational Research and Reviews*, *10*(7), 777-789.

Krause, J. M., & Lynch, B. M. (2016). Preparing 21st-century educators: TPACK in physical education teacher education. *Research Quarterly for Exercise and Sport*, *87*(S2), A131.

Loudova, I. (2020, August). Continuing Professional Development in ICT for Primary School Teachers, Reflections and Issues. In *International Conference on Blended Learning* (pp. 326-337). Springer, Cham.

Manda, M. I., & Ben Dhaou, S. (2019, April). Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries. In *Proceedings of the 12th international conference on theory and practice of electronic governance* (pp. 244-253).

Martin, B. (2015). Successful implementation of TPACK in teacher preparation programs. *International Journal on Integrating Technology in Education*, *4*(1), 17-26.

McKenney, S., & Voogt, J. (2017). Expert views on TPACK for early literacy: Priorities for teacher education. *Australasian Journal of Educational Technology*, *33*(5).

Meyer, M. W., & Norman, D. (2020). Changing design education for the 21st century. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 13-49.

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

Mishra, P., & Koehler, M. J. (2008, March). Introducing technological pedagogical content knowledge. In *annual meeting of the American Educational Research Association* (Vol. 1, p. 16).

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of educational computing research*, *44*(3), 299-317.

Oke, A., & Fernandes, F. A. P. (2020). Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th industrial revolution (4IR). *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2), 31.

Omoso, E., & Odindo, F. (2020). TPACK in teacher education: Using pre-service teachers' self-reported TPACK to improve pedagogic practice.

Peña-Ayala, A. (2021). A learning design cooperative framework to instill 21st century education. *Telematics and Informatics*, *62*, 101632.

Rets, I., Rienties, B., & Lewis, T. (2020). Transforming pre-service teacher education through virtual exchange: a mixed-methods analysis of perceived TPACK development. *Interactive Learning Environments*, 1-13.

Reyes Jr, V. C., Reading, C., Doyle, H., & Gregory, S. (2017). Integrating ICT into teacher education programs from a TPACK perspective: Exploring perceptions of university lecturers. *Computers & Education*, *115*, 1-19.

Ross, P., & Maynard, K. (2021). Towards a 4th industrial revolution. *Intelligent Buildings International*, *13*(3), 159-161.

Sabiri, K. A. (2020). ICT in EFL teaching and learning: A systematic literature review. *Contemporary Educational Technology*, *11*(2), 177-195.

Sen, C., Ay, Z. S., & Kiray, S. A. (2018). STEM skills in the 21st century education. *Research highlights in STEM education*, 81-101.

Shahroom, A. A., & Hussin, N. (2018). Industrial revolution 4.0 and education. *International Journal of Academic Research in Business and Social Sciences*, *8*(9), 314-319.

Singh, B. (2019). Character education in the 21st century. *Journal of Social Studies (JSS)*, *15*(1), 1-12.

Skilton, M., & Hovsepian, F. (2018). *The 4th industrial revolution*. Springer Nature.

Stein, H., Gurevich, I., & Gorev, D. (2020). Integration of technology by novice mathematics teachers–what facilitates such integration and what makes it difficult?. *Education and Information Technologies*, *25*(1), 141-161.

Tanriogen, Z. M. (2018). The possible effects of 4th industrial revolution on Turkish educational system. *Eurasian Journal of Educational Research*, *18*(77), 163-184.

Thomas, T., Herring, M., Redmond, P., & Smaldino, S. (2013). Leading change and innovation in teacher preparation: A blueprint for developing TPACK ready teacher candidates. *TechTrends*, *57*(5), 55-63.

Valtonen, T., Leppänen, U., Hyypiä, M., Sointu, E., Smits, A., & Tondeur, J. (2020). Fresh perspectives on TPACK: pre-service teachers' own appraisal of their challenging and confident TPACK areas. *Education and Information Technologies*, *25*(4), 2823-2842.

Voogt, J., & McKenney, S. (2017). TPACK in teacher education: Are we preparing teachers to use technology for early literacy?. *Technology, pedagogy and education*, *26*(1), 69-83.

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

Warr, M., Mishra, P., & Scragg, B. (2019, March). Beyond TPACK: Expanding technology and teacher education to systems and culture. In *Society for Information Technology & Teacher Education International Conference* (pp. 2558-2562). Association for the Advancement of Computing in Education (AACE).

Wetzel, K., & Marshall, S. (2011). TPACK goes to sixth grade: Lessons from a middle school teacher in a high-technology-access classroom. *Journal of Digital Learning in Teacher Education*, *28*(2), 73-81.

Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' use of technology and the impact of Covid-19. *Irish Educational Studies*, *40*(2), 235-246.

Young, J. R., Young, J. L., & Hamilton, C. (2013). The use of confidence intervals as a meta-analytic lens to summarize the effects of teacher education technology courses on preservice teacher TPACK. *Journal of Research on Technology in Education*, *46*(2), 149-172.

Zainal, N. F. (2016). TPACK Development in Teacher Education Programs: Malaysian Context. *International Journal of Academic Research in Business and Social Sciences*, *6*(12), 237-244.