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Technological, Pedagogical and Content Knowledge of Secondary Science Teachers in Santa Maria, Ilocos Sur

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Abstract
This study aimed to assess the TPACK level of Science teachers in secondary schools in Santa Maria, Ilocos Sur.
Descriptive and correlation designs were utilized in the study. The respondents involved in this study were twenty-six (26) Science teachers and three hundred and seventy-four (374) grade 10 students from the different secondary schools in Santa Maria, Ilocos Sur. Data gathered were analyzed, tabulated and presented using the frequency count, percentage, weighted mean, t-test and Spearman correlation.
Findings revealed that there is a significant difference in the perceptions of the two groups of respondents on the TPACK of science teachers specifically on the Technological and Pedagogical Knowledge but not on the Content Knowledge. A significant relationship exists between the technology usage and TPACK of science teachers. Despite of the developments in technology and other related activities provided to science teachers in order to enhance their TPACK knowledge and skills, they still encounter some constraints in their teaching like the lack of know-how of the latest technologies that can be utilized in teaching, the skill to choose and employ the appropriate methodologies in their teaching and the lack of confidence of science teachers to teach some contents outside their field of specialization.
With the above-mentioned findings, it is suggested that teachers should continuously engage themselves in trainings that would enhance their skills in technology integration. They must be provided with equal opportunities to attend seminars/trainings that would develop their TPACK level. Administrators/ school heads may also provide continuous support to teachers through development programs that would enhance their Technological, Pedagogical and Content knowledge and skills.

Keywords: Technological, Pedagogical, Content Knowledge, Science Teachers, TPACK

Introduction

Background of the Study

The era of the 21st century has certainly changed the way we live. Technological advancement is unceasingly bringing rapid changes to the different industries including education. The impact of technology is so great that it is dubbed as a vital tool in the educative process.

To sustain quality education, teachers in this era must utilize technology. The adoption and integration of technology in the teaching and learning process requires teachers to possess the 21st century teaching skills which will pave the way to the attainment of the goal of education of the present time.

A dramatic shift from the traditional method to a modern approach has taken place in the field of education. Education in this era highlights globalization and internationalization. Students and teachers alike are presented with theoretical constructs and realistic insights to develop knowledge, skills and attitudes through the advancement of technology (Abao *et al*., 2015).

The National Science Teaching Association (NSTA) recognizes the inherent and strong connection of science education with 21st century skills. Through quality science education, we can provide a rich context for enhancing 21st century skills such as critical thinking, problem solving and information literacy among students.

Quality education begins with quality teaching and learning. The prodigious variety of new technologies available today offers new landscapes for those involved in the process (Duhaney & Zemel, 2000, as cited in Boholano, 2020 [2]). Hence, quality education can be attained using technology in teaching.

Prensky (2003) mentioned that digital natives which include students born from 1980 to 1994 require the utilization of technology in the learning process for it as an essential part of their daily lives (Redecker, 2009; Noguera, 2015; Schweighofer *et al*., 2015).

Ha and Lee (2019) mentioned that students are becoming accustomed to delving into new knowledge and increasing their learning and interests through the media rather than just learning from the teacher's lectures.

Teachers play a vital role in nation building. Holistic learners equipped with 21st century skills can be developed through quality teachers. To maintain quality education, teachers are prompted to innovate their teaching practices and to adapt the imperatives of 21st century skills.

According to Altun and Akyildiz (2017), preparing societies to face a technology-oriented working environment is a main role played by the education sector.

Mishra and Koehler (2006) developed a framework for teachers' knowledge that accentuates the integration of technology known as TPACK. Technological Pedagogical and Content Knowledge or TPACK is a combination and interaction between content, pedagogy, and technology.

With the existence of various technologies, teaching in this era is becoming more challenging. It is for this reason that the researcher is prompted to conduct a study that will assess the TPACK of science teachers to determine the integration of technology in the teaching and learning process.

Framework of the Study

The following concepts and theories provide a clearer perspective of this study.

This study is grounded on the TPACK framework (Mishra & Koehler, 2006). It is a very useful model used by academic stakeholders for understanding and measuring how technology is integrated in the teaching and learning process (Mishra, 2019; Herring *et al*., 2016). Many educators and leaders have proposed various ways to measure TPACK domains through self-diagnostic questionnaires (Cacho, 2014; Chai *et al*., 2011; Baran *et al*., 2011; Archambault & Barnett, 2010; Schmidt *et al*., 2009 [19]), interviews and focused discussions, observations and/or documentary evidence (Hsu, 2012; Koh & Divaharan, 2011; Jang & Chen, 2010).

Evidence shows that certain knowledge domains of TPACK influence the teachers' overall TPACK perceptions. Several studies have shown that pedagogical knowledge (PK) and technological knowledge (TK) brought the biggest impact on TPACK development (Chai *et al*., 2010; Chai *et al*., 2011). A strong positive correlation between TPK, TCK and TPACK of pre-service teachers was revealed in the study of Koh and Sing (2011). Koh and Divaharan (2011) discovered through a qualitative study that pre-service teachers focused on issues associated with TPK.

The figure below shows the seven domains of TPACK model.

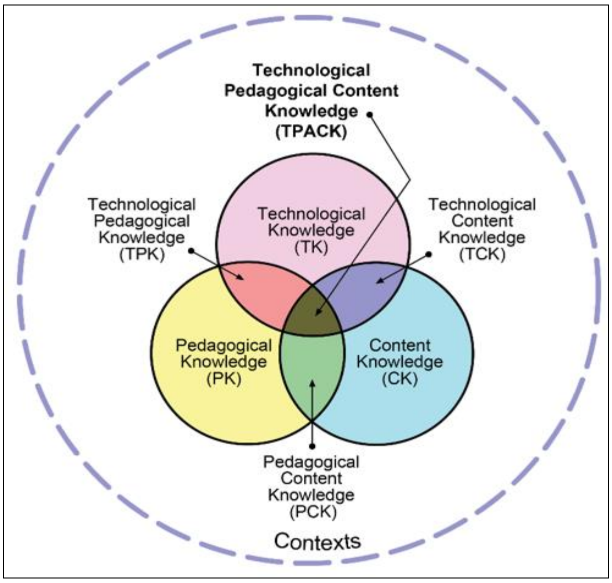

Fig 1: Dimensions of the TPACK Model

The seven domains of TPACK framework as shown in Fig 1 include the following (Mishra & Koehler, 2006; Chai *et al*., 2010):

1. Technological Knowledge (TK) which is the knowledge needed to adapt the fast development of technology;
2. Pedagogical Knowledge (PK) which is the knowledge of teaching and learning practices including classroom management, assessment and the knowledge of how students construct knowledge;
3. Content Knowledge (CK) which is the knowledge about the subject matter;
4. Pedagogical Content Knowledge (PCK) which is the knowledge needed to transform the subject matter and be able to organize conditions to make learning of certain contents easy;
5. Technological Content Knowledge (TCK) which is the knowledge of how technology and content influences one another that leads one to identify what technology can be used to a particular subject;
6. Technological Pedagogical Knowledge (TPK) which is the knowledge needed to identify what technology is appropriate to support a particular pedagogical approach.
7. Technological Pedagogical and Content Knowledge (TPACK) which is the knowledge of utilizing various technologies and pedagogical approaches in teaching different contents.

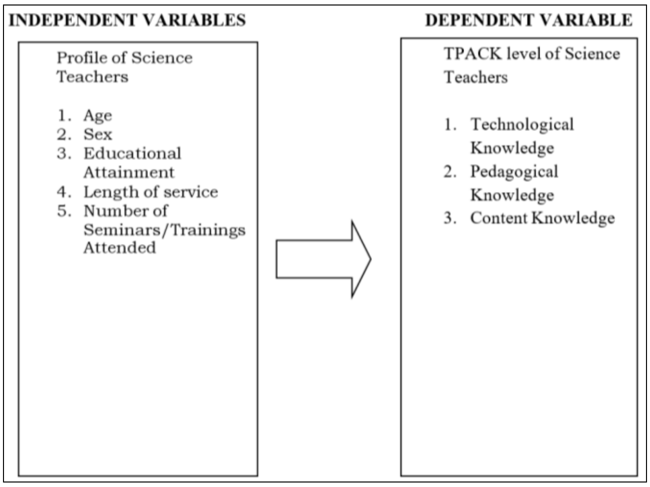

Fig 2: The Research Paradigm

Fig 2 shows the research paradigm of this study. This simplifies the study by illustrating how the study will be conducted using the Independent Variable-Dependent Variable model. An adopted questionnaire shall be administered to the respondents to measure their TPACK and to investigate if there is a significant difference between the perceptions of teachers and students on the TPACK level of science teachers specifically on the three domains namely, Technological Knowledge, Pedagogical Knowledge and Content Knowledge. In addition, this study aims to test if there is a significant relationship between the profile and TPACK level of science teachers.

Statement of the Problem

This study aimed to assess the TPACK level of science teachers in secondary schools in Santa Maria, Ilocos Sur.

Specifically, the study tried to answer the following questions:

1. What is the profile of the science teachers in terms of the following:

a. Age;
b. Sex;
c. Educational attainment;
d. Number of years in teaching science; and
e. Number of seminars and trainings attended in Science?

2. What are the available educational technologies that science teachers use in their teaching and how frequent are they using these technologies on a daily basis?

3. What is the level of TPACK of science teachers as perceived by the two groups of respondents along the following components?

a. Technological Knowledge (TK)
b. Pedagogical Knowledge (PK)
c. Content Knowledge (CK)

4. Is there a significant difference between the perceptions of teachers and students on the TPACK level of science teachers?

5. Is there a significant relationship between the profile of science teachers and their TPACK level?

Hypotheses

This study was guided by the following hypotheses.

1. There is a significant difference between the perceptions of teachers and students on the TPACK level of science teachers.
2. There is a significant relationship between the profile of the respondents and the TPACK level of science teachers.

Scope and Delimitation

The focus of this study was on the assessment of the TPACK level of science teachers.

The respondents were the science teachers and the students of the different secondary schools in Santa Maria, Ilocos Sur. A questionnaire which was adopted from Bilici *et al.*, 2013, Celik *et al.*, 2014, Lehtinen *et al.*, 2016, Muhaimin *et al.*, 2019 and Schmidt *et al.*, 2009 [19] was used in gathering data.

Importance of the Study

The result of this study will be beneficial to the following:

Science Teachers: The results of this study will serve as a motivation for science teachers to make innovation on their teaching strategies.

Administrators/Head of School: The result of this study will provide insights for the school heads and administrators in motivating teachers to develop their TPACK in teaching towards quality education.

Curriculum Planners: The result of this study will provide an insight into providing better programs/activities suited to the needs of the 21st century learners.

Future Researchers: The result of this study will serve as basis for further studies about TPACK.

Students: The study will help improve the students' academic performance in Science.

Definition of Terms

The following terms used in the study are operationally defined as follows:

Profile: This pertains to respondents' age, sex, years of teaching experience, position, number of trainings and seminars attended and educational attainment.

Age: This refers to the number of years of existence of teachers from birth.

Sex: This refers to the biological characteristics of the teachers whether male or female.

Number of Trainings and Seminars Attended: It refers to the discrete number of trainings and seminars participated by the teachers relevant to science.

Technological Knowledge (TK): This refers to the knowledge about the different technologies which include the low-tech technologies, the digital and software programs.

Pedagogical Knowledge (PK): This refers to the methods and processes involved in teaching.

Content Knowledge (CK): This refers to the knowledge about the subject matter to be learned or taught.

Pedagogical Content Knowledge (PCK): This refers to teachers' knowledge on the relationship between pedagogy and subject matter.

Technological Content Knowledge (TCK): This refers to the knowledge of creating new representations for a particular content using technology.

Technological Pedagogical Knowledge (TPK): This refers to the knowledge about teaching using various technologies.

Technological Pedagogical and Content Knowledge (TPACK): This refers to a technology integration framework that emphasizes the interactions between content, pedagogy and technology.

Review of Literature

The following literature and studies conducted were considered relevant to this study.

Profile

Mahdi and Al-Dera (2013) [10] investigated the impact of teachers' age, experience and gender on ICT in language teaching. They found out that there are no significant differences in ICT use based on age and teaching experiences by teachers. However, a significant difference between male and female teachers on the use of ICT in their teaching has been reported. Results show less use of ICT in instruction by female as compared to the male teachers.

Findings in the study of Nikolopoulou and Guialamas (2015) [15] revealed that the less the years of teaching experience (linked to younger teachers), the more the years of computer experience and the higher the confidence level of integrating technology in teaching. Implications for in-service teacher trainings is drawn from the findings.

A study conducted by Rienties *et al*. (2013) [17] indicate that after the participants have completed the twelve weeks of training, the teachers' confidence in the integration of technology in their teaching have significantly improved.

Technological Pedagogical and Content Knowledge (TPACK)

The increasingly omnipresent accessibility of digital and networked tools has fundamentally changed the teaching and learning process. Despite the availability of technologies, research on the use of instructional technology showed teachers' lack of knowledge to successfully integrate technology in their teaching hence their attempts were limited in scope, variety and depth. Technology is regarded as "efficiency aids and extension devices" (McCormick & Scrimshaw, 2001) and not as a tool for the transformation of the nature of subject matter at the most fundamental level (Mishra *et al*., 2014).

Shulman (1986) suggested that for teaching to be effective, a teacher must have a special type of knowledge which is the Pedagogical Content Knowledge (PCK) which describes the blending of content and pedagogy to understand how a specific content may be organized, represented and adapted to suit the diversity of learners' interests and abilities for instruction. The central principle of this PCK is the importance of developing instructional skills and strategies appropriate for the learners coupled with understanding the content (Mishra *et al*., 2014). Mishra and Koehler (2006) extended Shulman's (1986) framework by adding technology in it.

The TPACK framework proposes that for teachers to manage and harmonize technology, pedagogy and content into teaching, a teacher must possess a profound understanding of each of the seven components. A salient part of the TPACK framework is represented by the outer dotted circle in the TPACK diagram which means that it does not exist in a vacuum rather it is situated and grounded in a particular context. This framework has had a remarkable impact both on theory and practice in educational technology since its introduction in 2006 (Mishra *et al*, 2014). The most notable contribution of TPACK framework has been around teacher education and teacher professional development (Koehler, 2012; Mishra & Wolf *et al*., 2012).

TPACK describes the necessary knowledge that a teacher needs for an effective pedagogical practice through a technology-enhanced learning environment (Mishra & Koehler, 2006; Harris *et al* al, 2009). This framework helps teachers view what they know as teachers (Graham *et al*., 2009). To address the challenges typically faced by teachers when aligning subject content delivery with current demands in learning, the development of TPACK is used as a strategy (Olafson *et al*., 2016). Koehler and Mishra (2009) [8] asserted that teachers become competent, flexible, dynamic and adaptive in producing effective teaching with technology when they have sufficient knowledge of each TPACK domain.

Content, Pedagogy and Technology which forms the core of the TPACK framework, is the heart of good teaching with technology. The relationships between these three components are equally important. Wide variations of educational technology are seen because of the interactions between and among these components which play differently across diverse contexts (Mishra & Koehler, 2008).

The TPACK framework illustrates the multiple interactions among its three components. It encompasses understanding the use of technology to represent concepts; pedagogical strategies of using differentiated instructions to meet students' needs with the constructive application of technology; knowledge about the factors which make learning of concepts difficult or easy and how useful is technology to redress conceptual challenges; knowledge of students' prior content-related comprehension and epistemological assumptions; and knowledge of building on existing understanding through the use of technology to develop new epistemologies boost old ones (Mishra & Koehler, 2008).

Teachers' role in this digital era and 21st Century Educational Transformation era does not only focus on the transfer of knowledge but also on their ability to act as mediators/facilitators for the development of students' potentials. Both eras bring change and for teachers to address the latest learning issues and trends, they are expected to have competence on TPACK. TPACK is a framework for technology integration in teaching. This includes seven domains namely, Technological Knowledge, Pedagogical Knowledge, Content Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge and Technological Pedagogical and Content Knowledge. Technological Knowledge refers to the ability of a teacher to understand the use of computer software and hardware and other technologies in teaching. This domain also includes the ability of a teacher to adapt and learn new technologies. Pedagogical Knowledge includes the skills that a teacher needs to develop to achieve learning goals. This knowledge includes management and organization of teaching and learning activities. Content Knowledge is all about the specificity of a discipline or subject matter. A teacher is expected to be adept at this. Pedagogical Content Knowledge is the knowledge of the reciprocal influences between content and pedagogy. A teacher will identify what teaching method is most suitable for a specific content through this knowledge. Technological Content Knowledge describes the relationship between technology and content. The use of technology leads to the discovery of new content. Technological Pedagogical Knowledge is about the ability to identify what technology suits each of the pedagogical goals. Technological Pedagogical and Content Knowledge is focused on how technology can be made specific and appropriate to teach specific content while considering the most suitable pedagogical approach (Agustini *et al*., 2019).

Technology integration in the teaching and learning process is affected by several factors. The results of the study conducted by Hechter and Vermette (2013) indicated inadequate access, time, resources, training, budget, and support as leading barriers experienced by teachers in integration of technology in K-12 science classrooms. One of the main findings of this study was the uncertainty of teachers on the effective ways of integrating technology in their teaching. Varna *et al*. (2008) added that due to lack of technological literacy, teachers often use them ineffectively.

Several educational organizations accentuate the importance of teachers' training for a more effective integration of technology in their classroom (International Society for Technology in Education, 2008; Partnership for 21st Century Skills, 2010). It has been reported by in-service teachers that they feel unprepared to use ICT to support learning in the classroom. Based on the TALIS survey conducted in 2013, ICT was identified as the second highest area with "high development need" (OECD, 2014).

An efficient way of boosting confidence of teachers in the use of technology is through increasing their professional development opportunities (European Schoolnet, 2013).

Lehiste (2015) [9] revealed in his study that there is a significant increase in the in-service teachers' TPACK after participating in a training program. Significant correlations between the seven TPACK domains were also evident with the highest correlations between TPACK and TPK, and TPACK and TCK which was found consistent with the results of Schmidt *et al*. (2009) [19] and Koh & Sing (2011).

A lot of studies related to teacher preparation and technology integration have resulted in an improved pre-service teachers' expertise after modeling and carrying out a proper TPACK implementation (Lehtinen *et al*., 2016; Martin, 2015; Koh & Divaharan, 2011).

The utilization of technology is highlighted in the teaching and learning process of Science (Guzey & Roehrig, 2009). When used properly, technology has a strong positive potential to modify the teaching and learning environment (Crawford, 2000; Dilworth *et al*., 2012). The concept of integrating technology in science classroom, should be based on the principle of problem-solving and not just as a substitute for current teaching method (Ghavifekr & Athirah, 2015). The use of technology in the classroom is vital to complement the contents of science lessons and in solving problems related to teaching and learning.

The study of Mai and Hamzah (2016) [11] indicates high self-confidence in pedagogical knowledge as perceived by the primary science teachers in general. Further, there were no significant differences between the teachers' perception of TPACK with their age and gender. Results also show no difference in teachers' perception of TK, CK, TCK and TPACK according to their qualifications. However, there is a significant difference between qualifications and PK, TPK and PCK domains.

A study that measures pre-service teachers' TPACK confidence conducted by Valtonen *et al*. (2020) [21] revealed important perspectives on pre-service teachers' development of TPACK, focusing on the important position of PK and more detailed view on how pre-service teachers perceive their readiness to use ICT in teaching and learning process. The study shifted the focus to concerns and strengths as indicated and highlighted by the pre-service teachers.

Recent studies show positive attitudes of today's pre-service teachers toward the use of ICT in education. However, this task of integrating technology remains challenging.

Chatmaneerungcharoen (2019) [6] conveyed that TPACK of teachers gradually broadened through their engagement in the CO-TPACK Professional Development activities. Cooperating teachers were given many opportunities to expand their understanding and practices about concepts, pedagogy, assessment, technology integrated teaching and the nature of science.

Based on the results of the study conducted by Mercado *et al*. (2019) [12], it has been concluded that the extent of technology support to 21st Century science teaching, prompts interest and motivation among students in terms of delivery. Instructional materials on the other hand, provide accessible and up-to-date information which expand learning while content helps students to analyze and understand graphical representations easily and clearly.

Gonzales (2018) revealed in her study that there is no relationship between the self-efficacy belief of Senior High School Biology Teachers and their TPACK.

Since the release of TPACK framework in the year 2006, a lot of researchers have developed numerous survey instruments to measure TPACK. The plethora of instruments and articles makes it difficult for many researchers to choose which survey is best for their study. An analysis of study instrument lineage was undertaken by Scott (2021) to determine which survey instruments were mostly used in the literature. Results show that more than any other instrument, the 47-item survey instrument by Schmidt *et al*., accounts for 27.0% of articles. It is widely used in literature, is appropriate for elementary school teachers and provides a generic view of technology. However, disadvantages of this instrument include its CK-related constructs which use single item being customized for the four subject area being measured, its TK-related constructs which utilized excessively simple items and numerous failed factor analytic studies. The second highest is the survey instrument made by Chai *et al*. (2010-2019), which accounts for 12.9% of articles. Researchers are encouraged to use their survey instruments because they have undergone extensive studies using factor analysis. The 7-factor structure was obtained by eight studies using an instrument made by this research team. Sahin (2011) [18] and Yurdakul *et al*. (2012) surveys both account for 8.2 % of the literature. Sahin (2011) [18] survey is composed of 47 items with a 5-point Likert scale with TK items using common technologies, suitable for any discipline and is pedagogically agnostic. Potential advantages of this survey instrument include its lack of validity and reliability studies in geographically broad samples and its TK-items which are specific and thus may become outdated and will eventually need some revisions. Yurdakul *et al* (2012) survey on the other hand, is a 33-item instrument with 5-point Likert scale but was not designed to measure the seven domains of TPACK but TPACK as a whole entity. Disadvantages of this survey instrument include not being able to measure the 7-factors and its lack of studies in geographically diverse populations (Scott, 2021).

Investigating the Self-assessment TPACK instruments from January 2006- March 2020, findings show that 50.6% of

TPACK literature focused on pre-service teachers. Several studies account for 6.4% of literature which used both pre-service and in-service teachers. Less than 1.0% of studies did not report the status of teachers. The majority of the study participants did not report on teaching discipline which accounts for 43.8% of the literature. English (20.0%) and Science (15.4%) were most of the teaching disciplines reported in mixed studies while most studies included multiple disciplines (16.1%) in empirical research. Among the empirical studies with reports on specific discipline, Science is mostly reported which accounts for 11.3% (Scott, 2021).

Teaching with technology is not an easy thing to do. To successfully teach with technology, one must unceasingly create, maintain and re-establish a dynamic balance among all components. As explained in this paper, TPACK components have roles to play individually and together. The TPACK framework aims to aid the development of better approaches for discovering and describing how professional knowledge related to technology is manifested in practice. Through TPACK, educators can have better understanding about variance in levels of technology integration occurring. It also offers possibilities for promoting research in teacher education, teacher professional development and teachers' use of technology. In addition, it allows teachers, researchers as well as teacher educators to move beyond techniques that regard technology as an "add-on" and instead focus on the connections of technology, pedagogy and content as interrelated knowledge needed to achieve teaching and learning goals (Koehler & Mishra, 2009) [8].

Methodology

This chapter presents the research design, population, data gathering instrument and procedure, statistical treatment of data and data categorization used in the study.

Research Design

This study made use of the descriptive research design. It determined the TPACK level of secondary science teachers of Santa Maria, Ilocos Sur.

Descriptive research design is a scientific method which involves describing individuals, events or conditions by studying them as they are and not trying to manipulate any of the variables (Siedlecki, 2020) [20]. Thus, the profile of the teacher-respondents in terms of age, sex, educational attainment, years of teaching experience and number of seminars attended and their TPACK level were described in this study.

In addition, the study also used correlational design to determine the significant associations between the profile and TPACK level of the science teachers.

Population of the Study

The respondents of this study were the Science teachers and the students of the different High Schools in Santa Maria, Ilocos Sur. These include Santa Maria National High School, Saint Mary's College, Ilocos Sur Polytechnic State College - Laboratory High School, and Ag-agrao National High School.

Table 1: Distribution of Respondents of the Study

School	Number of Science Teachers	Number of Grade 10 Students
Ag-agrao National High School	2	37
Ilocos Sur Polytechnic State College	6	20
St. Mary's College	2	52
Santa Maria National High School	16	265
Total	26	374

Stratified sampling was used to determine the number of student respondents in each participating school. Of the 374 student respondents, 37 were from Ag-agrao National High School, 20 from Ilocos Sur Polytechnic State College, 52 from St. Mary's College and 265 from Santa Maria National High School.

Research Instrument and Procedure

This study focused on the Technological, Pedagogical and Content Knowledge of secondary science teachers in Santa Maria, Ilocos Sur. An adopted questionnaire was used to gather data specifically on the three components of TPACK namely, Technological Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK). It also includes the profile of the science teachers in terms of age, sex, educational attainment, years in teaching, number of relevant seminars/trainings attended and the usage of available technologies in the classroom. It is a descriptive research design employing correlation.

To gather the data needed in the study, the researcher submitted a letter of request to the office of the Schools Division Superintendent to ask permission to gather data from the different secondary schools in Santa Maria, Ilocos Sur. Upon the receipt of the approved letter, the researcher asked permission from the principal to conduct the study in their respective schools through a request letter. Upon approval, the researcher personally administered the questionnaires to the respondents to measure the TPACK level of science teachers.

Statistical Treatment of Data

The following statistical tools were used in analyzing the data gathered in the study:

Frequency Count and Percentage: These are the statistical tools used to collect data on the profile of science teachers.

Weighted Mean: This is the statistical tool used to describe the data on the usage of available technologies utilized by the science teachers and the TPACK level of science teachers specifically on the three components namely Technological Knowledge, Pedagogical Knowledge and Content Knowledge.

T-test: This statistical tool was used to determine if there is a significant difference between the perceptions of the two groups of respondents on the TPACK level of science teachers.

Spearman Correlation: This tool was used to determine the significant relationship between the profile of science teachers and their TPACK level.

Data Categorization

The following range and descriptive ratings were used to interpret the data that were gathered in this study.

A. TPACK Components

Rating	Range	Descriptive Rating
5	4.21- 5.00	Strongly Agree
4	3.41- 4.20	Agree
3	2.61- 3.40	Neither Agree/Disagree
2	1.81- 2.60	Disagree
1	1.00- 1.80	Strongly Disagree

B. Available technologies Used in Science

Range	Descriptive Rating
3.21-4.00	Very High (VH)
2.41-3.20	High (H)
1.61-2.40	Moderate (M)
0.81-1.60	Low (L)
0.01-0.80	Very Low (VL)

C. Strengths and Weaknesses of Teachers in TPACK

Range	Descriptive Rating
3.41- 5.00	Strength (S)
1.00- 3.40	Weakness (W)

Results and Discussion

This chapter includes the presentation, interpretation and analysis of significant findings of the current study. This also contains the conclusions and recommendations of the study.

Findings

Profile of the Respondents

Fig 2 shows the distribution of respondents in terms of age.

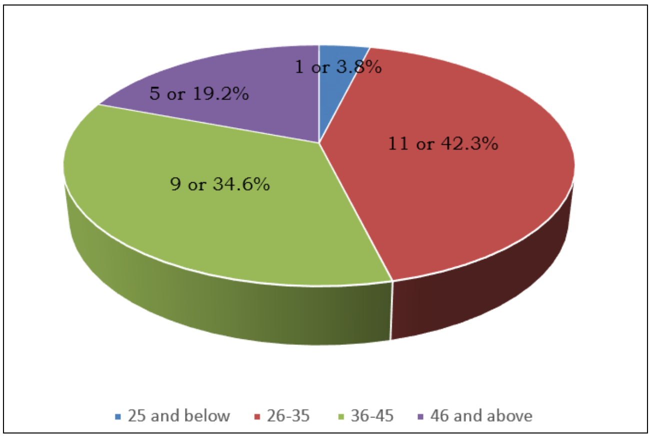

Fig 2: Distribution of Respondents by Age

The figure shows the age distribution of science teachers, highlighting that 42% fall within the 26-35 age group, indicating a significant portion of the teaching workforce in this demographic. The 36-45 age bracket accounts for 35%, while teachers aged 46 and above constitute 19% of the total. Notably, only 4% of teachers are 25 years old or younger, emphasizing a relatively lower representation in this age category. This implies that the science teachers are generally of the middle age groups and still very energetic.

Fig 3 shows the distribution of teacher respondents by sex.

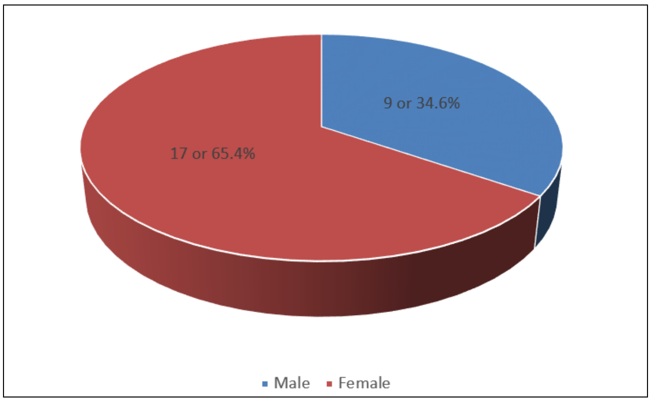

Fig 3: Distribution of Respondents by Sex

The figure distinctly conveys that 65% or 17 of the teacher respondents are female and 35% or 9 are male. The female outnumbered the male by 30%. The World Bank's data, accentuating that 71.29% of secondary teachers in the Philippines are female in 2021, indeed suggests a dominance of women in the teaching profession. This sex distribution in the education sector reflects a noteworthy trend, indicating a higher representation of females in teaching roles.

Fig 4 shows the distribution of respondents in terms of educational attainment.

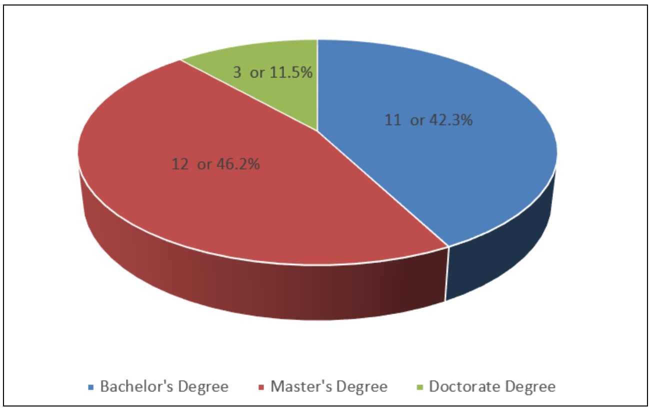

Fig 4: Distribution of Respondents by Educational Attainment

The figure reveals a diverse academic landscape. A substantial 46% holding master's degree signifies a considerable number of individuals with advanced education, while the 42% with the bachelor's degree represent a substantial portion of the sample. The lower percentage of 12% with doctorate degree suggests that a smaller but notable fraction has attained the highest academic qualification. The distribution reflects a varied educational background among the surveyed population, with a majority having master's or bachelor's degree.

The distribution of respondents in terms of number of years in teaching is presented in Fig 5.

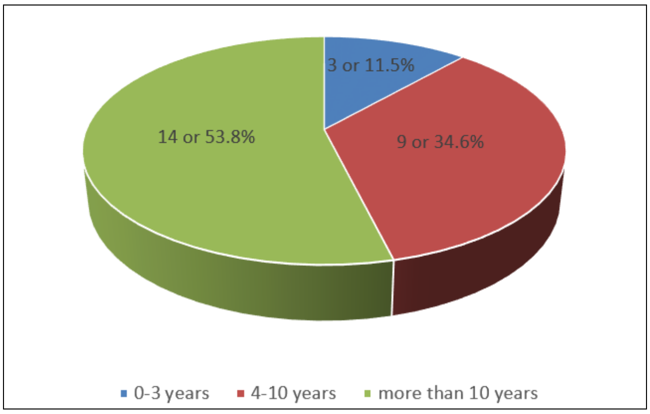

Fig 5: Distribution of Respondents by Number of Years in Teaching Science

The figure clearly shows that a substantial 53.8% with more than 10 years in service suggests a majority of experienced individuals, possibly bringing extensive knowledge and expertise to their roles. The 34.6% falling within the 4-10 years category indicates a significant portion with a mid-range level of service, contributing a balance of experience and potential for further growth. Meanwhile, the 11.5% with 0-3 years in service represents a smaller but notable part of relatively new entrants to the field. This distribution reflects a diverse mix of experience levels among the surveyed group contributing to a dynamic and varied professional landscape.

The distribution of respondents in terms of number of seminars and trainings attended related in science is presented in Fig 6.

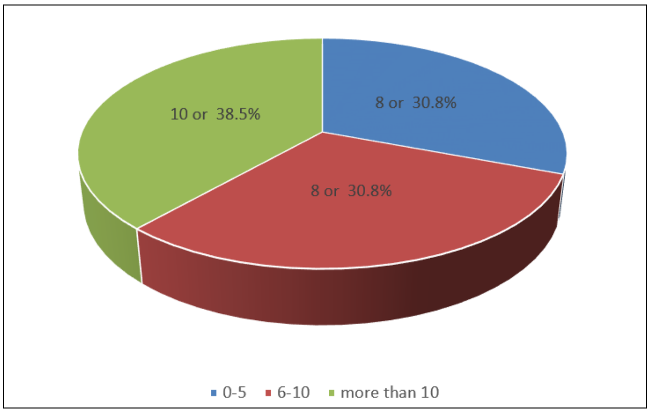

Fig 6: Distribution of Respondents by Number of Relevant Seminars and Trainings Attended

It appears on the figure that a significant portion of teacher respondents have diverse experiences, with 30.8% having attended 0-5 relevant seminars/trainings, another 30.8% who attended 6-10, and a noteworthy 38.5% indicating participation in more than 10 seminars/trainings. The result suggests a varied level of engagement and expertise within the surveyed group, potentially influencing their perspectives and knowledge in the field.

Table 2 shows the available technologies used by science teachers.

Table 2: Available Technologies used by Science Teachers

Software	Mean	Descriptive Rating
Microsoft Word	1.62	M
Microsoft Excel	1.27	L
Microsoft Powerpoint Presentation	2.08	M
Microsoft Teams	0.38	VL
Google Meet	0.46	VL
Zoom	0.38	VL
Google Classroom	0.42	VL
Edmodo	0.12	VL
Schoology	0.08	VL
Google Forms	0.54	VL
Kahoot	0.12	VL
Quizlet	0.04	VL
Adobe Premier Pro	0.08	VL
Wondershare Filmora	0.04	VL
Capcut	0.19	VL
Paint	0.08	VL
Canva	0.42	VL
Email	0.69	VL
Messenger	1.77	M
Youtube	1.08	L
Hardware		
Computer/Laptop	2.46	H
Digital Camera	0.19	VL
Printer	1.31	L
Scanner	0.77	VL
Projector	0.65	VL
Mobile Phone	2.12	M
Flash Drive, CD, DVD	1.19	L
TV	1.88	M
Anycast	0.46	VL
Speakers	1.15	L

Legend:

3.21-4.00 Very High (VH)
2.41-3.20 High (H)
1.61-2.40 Moderate (M)
0.81-1.60 Low (L)
0.01-0.80 Very Low (VL)

As can be gleaned in Table 2, the data indicates that teachers predominantly utilize Microsoft PowerPoint presentations as reflected by the moderate mean of 2.08. Following this, Messenger and Microsoft word are also utilized, though to a lower extent, with means of 1.77 and 1.62 respectively. Conversely, Quizlet and Wondershare Filmora show minimal usage among teachers with the lowest means of 0.04. The results suggest a preference for traditionally utilized softwares, possibly due to their familiarity and ease of integration into the teaching process.

Data on hardware category reveals that teachers mainly rely on computer/laptop, reflected by a high mean of 2.46. Mobile phones and TVs are also moderately used, with means of 2.12 and 1.88 respectively. In contrast, the usage of digital camera is notably low, indicated by the lowest mean of 0.19. This suggests a strong dependence of teachers on computers/laptops for educational activities while mobile phones and TVs play moderately significant roles. The minimal use of digital cameras may imply their limited relevance in the context of teaching for the surveyed group.

TPACK of Science Teachers

This part presents the TPACK level of science teachers as perceived by the two groups of respondents.

Table 3 reveals the mean ratings on technological knowledge of Science Teachers as perceived by the two groups of respondents.

The result as reflected in Table 3a describes that students agree to most of the statements in the technological knowledge. TK10 statement "Science teachers can use strategies that combine technology and teaching approaches in the classroom" stands out with the highest mean of 4.39. Conversely, TK7 statement "Science teachers can facilitate students to use technology to plan and monitor their own learning" with the lowest mean of 3.87, still reflects a generally positive sentiment but comparatively less agreement than other technological knowledge statements.

Table 3a: Teachers' Technological Knowledge as perceived by the students

Indicators	Mean	Descriptive Rating
TK1. Science teachers can use technologies that enhance the teaching approaches for a lesson.	**4.38**	**SA**
TK2.Science teachers can choose technologies that enhance students' learning for a lesson.	**4.26**	**SA**
TK3. Science teachers can use technologies in various teaching activities.	**4.16**	**A**
TK4. Science teachers can think critically about the most appropriate technology that they can use in the classroom.	**4.14**	**A**
TK5. Science teachers can use technology to introduce the students to real-world scenarios.	**4.13**	**A**
TK6. Science teachers can facilitate students to use technology to find more information on their own.	**4.02**	**A**
TK7. Science teachers can facilitate students to use technology to plan and monitor their own learning.	**3.87**	**A**
TK8. Science teachers can facilitate students to collaborate with each other using technology.	**4.03**	**A**
TK9. Science teachers can utilize technological tools to make teaching processes more productive.	**4.17**	**A**
TK10. Science teachers can use strategies that combine technology and teaching approaches in the classroom.	**4.39**	**SA**
Overall mean	**4.16**	**SA**

Legend:

4.21-5.00 - Strongly Agree (SA)

3.41-4.20 – Agree (A)

Table 3b: Teachers' perception on their Technological Knowledge

Indicators	Mean	Descriptive Rating
TK1. Science teachers can use technologies that enhance the teaching approaches for a lesson.	**4.92**	**SA**
TK2.Science teachers can choose technologies that enhance students' learning for a lesson.	**4.85**	**SA**
TK3. Science teachers can use technologies in various teaching activities.	**4.77**	**SA**
TK4. Science teachers can think critically about the most appropriate technology that they can use in the classroom.	**4.54**	**SA**
TK5. Science teachers can use technology to introduce the students to real-world scenarios.	**4.69**	**SA**
TK6. Science teachers can facilitate students to use technology to find more information on their own.	**4.54**	**SA**
TK7. Science teachers can facilitate students to use technology to plan and monitor their own learning.	**4.46**	**SA**
TK8. Science teachers can facilitate students to collaborate with each other using technology.	**4.42**	**SA**
TK9. Science teachers can utilize technological tools to make teaching processes more productive.	**4.54**	**SA**
TK10. Science teachers can use strategies that combine technology and teaching approaches in the classroom.	**4.69**	**SA**
Overall mean	**4.64**	**SA**

Table 3b indicates a strong consensus among respondents, with a notable inclination towards technological knowledge statements. TK1 statement "Science teachers can use technologies that enhance the teaching approaches for a lesson" with the highest mean of 4.92 stands out. Even the lowest mean attributed to TK8 statement "Science teachers can facilitate students to collaborate with each other using technology" at 4.42, still signifies a substantial level of agreement, reinforcing the overall positive sentiment towards the technological knowledge aspects assessed.

The overall mean of 4.40 in technological knowledge signifies a widespread and robust consensus among respondents. The high mean suggests that, on average, individuals strongly agree with the various technological statements assessed in Table 3c. This positive overall sentiment underscores a collective affirmation from the two groups of respondents that science teachers possess the technological knowledge covered in the survey.

Table 3c: Technological Knowledge of Science Teachers Based on the Perceptions of the Two Groups of Respondents

Indicators	Mean	Descriptive Rating
TK1. Science teachers can use technologies that enhance the teaching approaches for a lesson.	**4.65**	**SA**
TK2.Science teachers can choose technologies that enhance students' learning for a lesson.	**4.56**	**SA**
TK3. Science teachers can use technologies in various teaching activities.	**4.47**	**SA**
TK4. Science teachers can think critically about the most appropriate technology that they can use in the classroom.	**4.34**	**SA**
TK5. Science teachers can use technology to introduce the students to real-world scenarios.	**4.41**	**SA**
TK6. Science teachers can facilitate students to use technology to find more information on their own.	**4.28**	**SA**
TK7. Science teachers can facilitate students to use technology to plan and monitor their own learning.	**4.17**	**A**
TK8. Science teachers can facilitate students to collaborate with each other using technology.	**4.23**	**SA**
TK9. Science teachers can utilize technological tools to make teaching processes more productive.	**4.36**	**SA**
TK10. Science teachers can use strategies that combine technology and teaching approaches in the classroom.	**4.54**	**SA**
Overall mean	**4.40**	**SA**

Legend:
4.21-5.00 - Strongly Agree (SA)
3.41-4.20 – Agree (S)

Table 4a: Students' perception on Science Teachers' Pedagogical Knowledge

Indicators	Mean	Descriptive Rating
PK1. Science teachers know how to assess student performance in the classroom.	**4.40**	**SA**
PK2. Science teachers can adapt their teaching based on what students currently understand or do not understand.	**4.16**	**A**
PK3. Science teachers can adapt their teaching styles to different types of learners.	**4.09**	**A**
PK4. Science teachers can assess student learning in multiple ways.	**4.18**	**A**
PK5. Science teachers can use a wide range of teaching approaches in a classroom setting.	**3.92**	**A**
PK6. Science teachers are familiar with common student understandings and misconceptions.	**4.02**	**A**
PK7. Science teachers can manage their classroom effectively.	**4.11**	**A**
PK8. Science teachers can recognize individual differences in students.	**4.06**	**A**
PK9. Science teachers can guide the students adopt appropriate learning strategies.	**4.20**	**A**
PK10. Science teachers can help the students monitor their own learning.	**4.14**	**A**
Overall mean	**4.13**	**A**

Table 4a reveals a notable level of agreement among student-respondents regarding pedagogical knowledge, with an overall mean of 4.13 PK1 statement "Science teachers know how to assess student performance in the classroom" is the highest rated statement with a mean of 4.40, suggesting that respondents agree on almost all of the statements. On the other hand, PK5 statement "Science teachers can use a wide range of teaching approaches in a classroom setting" with the lowest mean of 3.92, still reflects a generally positive attitude, albeit with comparatively less agreement than other pedagogical knowledge statements. Overall, the data indicates a favorable perception of pedagogical knowledge among respondents, with varying degrees of agreement across specific statements.

Table 4b: Teachers' perception on Science Teachers' Pedagogical Knowledge

Indicators	Mean	Descriptive Rating
PK1. Science teachers know how to assess student performance in the classroom.	**4.73**	**SA**
PK2. Science teachers can adapt their teaching based on what students currently understand or do not understand.	**4.73**	**SA**
PK3. Science teachers can adapt their teaching styles to different types of learners.	**4.65**	**SA**
PK4. Science teachers can assess student learning in multiple ways.	**4.5**	**SA**
PK5. Science teachers can use a wide range of teaching approaches in a classroom setting.	**4.42**	**SA**
PK6. Science teachers are familiar with common student understandings and misconceptions.	**4.5**	**SA**
PK7. Science teachers can manage their classroom effectively.	**4.65**	**SA**
PK8. Science teachers can recognize individual differences in students.	**4.62**	**SA**
PK9. Science teachers can guide the students adopt appropriate learning strategies.	**4.5**	**SA**
PK10. Science teachers can help the students monitor their own learning.	**4.58**	**SA**
Overall mean	**4.59**	**SA**

Table 4b clearly reflects a remarkable consensus among the respondents regarding pedagogical knowledge, as all statements received a descriptive rating of "strongly agree". The overall mean of 4.59 further emphasizes the high level of agreement across all pedagogical knowledge aspects. This consistent and strong affirmation suggests a unified and positive perception among participants, highlighting the effectiveness of teachers on all the pedagogical knowledge elements covered in the survey.

Table 4c reveals that pedagogical knowledge has an overall mean of 4.36 which means that most of the respondents strongly agree to almost all the statements with 4.565 as the highest mean received by PK1 statement "Science teachers know how to assess student performance in the classroom" and the lowest is PK5 with a mean of 4.17.

Table 4c: Pedagogical Knowledge of Science Teachers Based on the Perceptions of the Two Groups of Respondents

Indicators	Mean	Descriptive Rating
PK1. Science teachers know how to assess student performance in the classroom.	**4.565**	**SA**
PK2. Science teachers can adapt their teaching based on what students currently understand or do not understand.	**4.445**	**SA**
PK3. Science teachers can adapt their teaching styles to different types of learners.	**4.37**	**SA**
PK4. Science teachers can assess student learning in multiple ways.	**4.34**	**SA**
PK5. Science teachers can use a wide range of teaching approaches in a classroom setting.	**4.17**	**A**
PK6. Science teachers are familiar with common student understandings and misconceptions.	**4.26**	**SA**
PK7. Science teachers can manage their classroom effectively.	**4.38**	**SA**
PK8. Science teachers can recognize individual differences in students.	**4.34**	**SA**
PK9. Science teachers can guide the students adopt appropriate learning strategies.	**4.35**	**SA**
PK10. Science teachers can help the students monitor their own learning.	**4.36**	**SA**
Overall mean	**4.36**	**SA**

Table 5a: Students' perception on Science Teachers' Content Knowledge

Indicators	Mean	Descriptive Rating
CK1. Science teachers have sufficient knowledge about science.	**4.46**	**SA**
CK2. Science teachers can use and apply scientific ways of thinking.	**4.32**	**SA**
CK3. Science teachers have various ways and strategies of developing their understanding of science.	**4.29**	**SA**
CK4. Science teachers can think about the content of science like a subject matter expert.	**4.25**	**SA**
CK5. Science teachers have a deep and wide understanding of biology.	**4.37**	**SA**
CK6. Science teachers have a deep and wide understanding of chemistry.	**4.43**	**SA**
CK7. Science teachers have a deep and wide understanding of earth science.	**4.45**	**SA**
CK8. Science teachers have a deep and wide understanding of physics.	**4.37**	**SA**
CK9. Science teachers are following up-to-date resources (e.g., books, journals) in their content area.	**4.12**	**A**
CK10. Science teachers are following recent developments and applications in their content area.	**4.27**	**SA**
Overall mean	**4.33**	**SA**

The results as reflected on Table 5a reveals a strong consensus among the student-respondents, with all statements receiving a "strongly agree" descriptive rating except for CK9 statement "Science teachers are following up-to-date resources (e.g., books, journals) in their content area", which has a mean of 4.12. The overall mean of 4.33 suggests that almost all students has a strong positive perception of their science teachers. However, some of the respondents have deviated from the general perception which means that their view on their teachers' use of up-to-date resources is not that high.

Table 5b conveys that science teachers perceived themselves as effectively possessing each of the content knowledge as indicated above. The overall mean of 4.64 clearly shows that science teachers are confident in their content knowledge.

Table 5b: Teachers' perception on Science Teachers' Content Knowledge

Indicators	Mean	Descriptive Rating
CK1. Science teachers have sufficient knowledge about science.	**4.92**	**SA**
CK2. Science teachers can use and apply scientific ways of thinking.	**4.85**	**SA**
CK3. Science teachers have various ways and strategies of developing their understanding of science.	**4.77**	**SA**
CK4. Science teachers can think about the content of science like a subject matter expert.	**4.54**	**SA**
CK5. Science teachers have a deep and wide understanding of biology.	**4.69**	**SA**
CK6. Science teachers have a deep and wide understanding of chemistry.	**4.54**	**SA**
CK7. Science teachers have a deep and wide understanding of earth science.	**4.46**	**SA**
CK8. Science teachers have a deep and wide understanding of physics.	**4.42**	**SA**
CK9. Science teachers are following up-to-date resources (e.g., books, journals) in their content area.	**4.54**	**SA**
CK10. Science teachers are following recent developments and applications in their content area.	**4.69**	**SA**
Overall mean	**4.64**	**SA**

Table 5c: Content Knowledge of Science Teachers Based on the Perceptions of the Two Groups of Respondents

Indicators	Mean	Descriptive Rating
CK1. Science teachers have sufficient knowledge about science.	**4.69**	**SA**
CK2. Science teachers can use and apply scientific ways of thinking.	**4.585**	**SA**
CK3. Science teachers have various ways and strategies of developing their understanding of science.	**4.53**	**SA**
CK4. Science teachers can think about the content of science like a subject matter expert.	**4.395**	**SA**
CK5. Science teachers have a deep and wide understanding of biology.	**4.53**	**SA**
CK6. Science teachers have a deep and wide understanding of chemistry.	**4.485**	**SA**
CK7. Science teachers have a deep and wide understanding of earth science.	**4.455**	**SA**
CK8. Science teachers have a deep and wide understanding of physics.	**4.395**	**SA**
CK9. Science teachers are following up-to-date resources (e.g., books, journals) in their content area.	**4.33**	**SA**
CK10. Science teachers are following recent developments and applications in their content area.	**4.48**	**SA**
Overall mean	**4.485**	**SA**

The overall mean of 4.485 for content knowledge based on the perceptions of the two groups of respondents show that both the students and the science teachers themselves are confident about the content knowledge of the teachers.

Table 6: Overall Mean of TPACK Levelof Science Teachers Based on Students' and Teachers' Point of view

	Student		**Teacher**		**Overall**	
	Mean	**DR**	**Mean**	**DR**	**Mean**	**DR**
Technology Knowledge	4.16	A	4.64	SA	4.40	SA
Pedagogy Knowledge	4.13	A	4.59	SA	4.36	SA
Content Knowledge	4.33	SA	4.45	SA	4.39	SA
Overall	4.21	SA	4.56	SA	4.39	SA

Legend

4.21-5.00 - Strongly Agree (SA)
3.41-4.20 – Agree (S)

The results in Table 6 illustrates a notable comparison between students' and teachers' perceptions of TPACK level. Technological and Pedagogical Knowledge have 4.16 and 4.13 mean respectively and both were given a descriptive rating of "Agree" while Content knowledge received a mean of 4.33 with a descriptive rating of "Strongly Agree".

In contrast, teachers rated themselves consistently higher across all components- technological, pedagogical and content knowledge. The overall mean of 4.39 indicates a positive and harmonious agreement between the two perspectives. This alignment suggests a shared positive perception of teachers' abilities as seen through the lens of both students and the science teachers themselves.

Table 7: Difference between Students' and Teachers' perceptions on the TPACK Level of Science Teachers

	t-value	p-value	Interpretation
Technology Knowledge	-7.418	0.000	Significant
Pedagogy Knowledge	-5.575	0.000	Significant
Content Knowledge	-1.518	0.139	Not Significant
Overall	-5.525	0.000	Significant

Tabel 7 highlights a substantial difference in the perception of students and teachers regarding the technological knowledge (TK) and pedagogical knowledge (PK) of science teachers. The significant difference suggests that students and teachers diverge in their views on these aspects.

Conversely, the p-value of 0.139 for content knowledge (CK) indicates an insignificant difference in the perceptions of students and teachers. This suggests a relatively consistent alignment on how both groups perceive the content knowledge of science teachers, with the lack of statistical significance implying a similarity in their perceptions.

The overarching conclusion is that while there's congruence in the perceptions of students and teachers regarding content knowledge, there is a noteworthy discrepancy in their technological and pedagogical knowledge. This underscores the importance of addressing and bridging these perceptual gaps for a more comprehensive and effective educational strategies tailored to the specific needs of each group.

Table 8: Relationship between Profile and TPACK level of Science Teachers

	Technology		Pedagogy		Content		Overall	
	rho	p-value	rho	p-value	rho	p-value	rho	p-value
Age	0.003	0.987	0.164	0.424	-0.13	0.527	-0.016	0.936
Sex	0.016	0.936	0.235	0.248	0.195	0.34	0.151	0.461
Educ	0.287	0.155	0.31	0.123	0.282	0.162	0.334	0.096
Years in teaching	-0.008	0.968	0.06	0.773	-0.097	0.636	-0.037	0.869
Seminars/Trainings	0.153	0.455	0.383	0.054	0.276	0.172	0.336	0.093
Software	0.431*	0.028	0.473*	0.015	0.479*	0.013	0.558*	0.003
Hardware	0.289	0.216	0.439	0.053	0.665**	0.001	0.582**	0.007

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 8. Indicates that demographic factors such as age, sex, educational attainment, years in teaching and number of relevant seminars/trainings attended are not significantly correlated with the teachers' TPACK. However, there is a noteworthy relationship between software usage and teachers' TPACK, with significance at the 0.05 level. This suggests that the extent to which teachers use software is associated with their technological, pedagogical and content knowledge.

Furthermore, hardware usage is significantly linked with content knowledge with significance at the 0.01level. This implies that the utilization of hardware is specifically associated with the content knowledge of science teachers.

Overall, the results emphasize that technology use, both in terms of software and hardware, is significantly related to the overall TPACK of teachers. This accentuates the importance of integrating technology, including both software and hardware in enhancing teachers' proficiency in technological, pedagogical and content knowledge.

Conclusion

Based on the salient findings of the study, the following can be concluded.

1. The teacher-respondents are dominated by female. Most of them exhibit high levels of energy, enthusiasm and adaptability because they are generally young. The wealth of experience and continuous professional development emphasizes their effort of leveraging their expertise to enhance the quality of teaching and adapt to evolving educational trends.
2. Most of the Science teachers utilize computer/laptop, mobile phone and Microsoft PowerPoint presentations in their teaching.
3. Students and science teachers have similar views on content knowledge of science teachers while their views on the technological and pedagogical knowledge diverge.
4. The Science teachers' profile has no influence on their TPACK.
5. The correlation between technology use and TPACK of science teachers underscores the significance of technology integration in modern science education.

Recommendations

With the conclusions drawn from the study, the following recommendations are forwarded.

1. Science teachers shall continue graduate studies to enhance their competencies and skills in teaching. Participation to seminars and trainings are also encouraged.
2. The DepEd should continuously provide opportunities to teachers to attend trainings related to technology use as it affects their TPACK level.
3. The results of this study shall be disseminated to the science teacher respondents.

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