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TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) AND SCIENCE TEACHERS' PERCEPTIONS OF SCIENTIFIC LITERACY AS PREDICTORS OF TEACHING COMPETENCE

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ABSTRACT
This study assessed the TPACK, scientific literacy, and teaching competence of science teachers in Santo Tomas East and Talaingod Districts. It examined TPK, TCK, and PCK levels and explored the correlation and predictive relationship between TPACK, scientific literacy, and teaching competence. Employing a descriptive-correlational research design, the study utilized validated survey instruments to collect data from science teachers. Statistical analyses included descriptive statistics, Pearson correlation, and regression analysis to determine the relationships and predictive power of TPACK and scientific literacy on teaching competence. The findings revealed that teachers exhibited very high levels of TPACK and scientific literacy, indicating strong technological integration skills and a deep understanding of scientific concepts. Science teachers also demonstrated high teaching competence, as measured by their Individual Performance Commitment and Review Form (IPCRF) ratings. Despite these high competency levels, correlation analysis revealed no significant relationship between TPACK and teaching competence ($r = 0.076$, $p = 0.571$) or between scientific literacy and teaching competence ($r = 0.161$, $p = 0.227$). Furthermore, regression analysis indicated that neither TPACK ($p = 0.800$) nor scientific literacy ($p = 0.277$) significantly predicted teaching competence, with both variables accounting for only 2.7% of the variance in teaching competence. These results suggest that while technological pedagogical content knowledge and scientific literacy skills are essential, they may not directly influence teaching competence in the measured scope. Given these findings, the study recommends continuous professional development programs focusing on advanced technology integration and scientific literacy enhancement to further support science teachers. Future research is encouraged to explore additional factors influencing teaching competence, such as pedagogical adaptability, assessment strategies, and socio-cultural awareness, to provide a more holistic understanding of effective science education.

KEYWORDS: *Science Education, Technological Pedagogical Content Knowledge, Scientific Literacy, Teaching Competence, Descriptive Statistics, Pearson Correlation, And Regression Analysis*

BACKGROUND OF THE STUDY

In the classroom, teachers encounter several challenges that call for a spectrum of skills ranging from simple to sophisticated to engage and achieve from students. For this purpose, teachers need a sound knowledge of the principles and practices of instruction, mastery over the subjects taught, and effective use of technology for instruction and assessment. Inadequate subject knowledge is one of the primary reasons behind teaching challenges and may negatively influence a teacher's proficiency (National Board for Professional Teaching Standards, 2017). Science teachers must be properly trained with required skills and competency to effectively teach their subjects (Taopan et. al., 2019). Also, with the COVID-19 pandemic and the rapid rate of technological advancement over the past few years, teachers need to be technologically savvy with the utilization of computers, ICT, mobile phones, and the internet to ensure effective teaching and learning. Technological Pedagogical Content Knowledge (TPACK), a concept to refer to the infusion of technology in the curriculum in order to support creative and applicable pedagogic practices, has been a byproduct in this regard. These skills are the essence of building science teachers' teaching capability and subsequently student performance.

In the context of global science education, Thailand and South Africa have a great challenge. In Thailand, the most important issues are the absence of teacher effectiveness, archaic teaching approaches, and shortages in training in innovative teaching methods and education technologies; only 35% of Thai teachers have training in teaching methods, and fewer than 20% in education technologies (UNESCO, 2023). Furthermore, there are acute resource limitations, as science laboratories exist in only 57% of primary schools and 86% of secondary schools, and the quality of these facilities is highly variable (Ruenwongsa, P., & Sooksawat, 2020). Meanwhile, South Africa struggles with science teacher roles and science tasks, alongside their lack of adequate training in science subjects; just 53% of educators possess a degree in science, and only 36% of them have science teaching training (Shepherd, 2022). Additionally, the inadequacy of facilities and equipment, particularly in the rural sectors, is despicable, where only a mere 34% of schools have operational science labs (Department of Basic Education, 2019). The problem in both nations impede the quality of science education and negatively impacts the readiness of students to face the demands of the modern workplace.

There is a renewed necessity in the Philippines to make learning more inclusive through technology, mainly due to the fact that students are depending more on technology (Dizon et. al., 2022). In Davao City, recent research by Alcontin (2021) shows that although new technology has been added to instruction, teachers need to be supported to enhance their digital pedagogic capability and to include technology correctly in teaching practice. Webb and Doman (2020) also indicated that Filipino teachers suffer from great adversity in obtaining adequate digital teaching capacity, particularly with a developing nation background. It is the above findings that present the imperative to continue supporting the teachers with ongoing professional development and training in a bid to uplift the quality of science teaching as well as properly integrate technology within their classes.

Throughout the COVID-19 pandemic, different teaching-learning modalities were conducted in the Division of Davao del Norte. Teachers' capability plays a crucial role in delivering quality science education, particularly those working in remote areas, face pedagogical strategy, classroom management, and subject matter mastery challenges in imparting effective instruction. Juanico, et. al (2021) opine that gaps in teaching competence particularly in incorporating pedagogical content knowledge and effective instructional practices, hinder the building of students' scientific literacy and problem-solving skills. Because of these challenges, it is essential that science teachers undergo continuous professional development and special training programs that enhance their instructional abilities. Through the enhancement of their teaching competence, teachers can possibly create more engaging and meaningful experiences, thus promoting student performance in the science subject education.

The time and importance of this study are highlighted in the changing face of education, where there is a need to incorporate technology and scientific literacy in pedagogic approaches. No current literature explores the combined influence of technological pedagogical content knowledge and scientific literacy of teachers on the effectiveness of science education. This research tries to fill this gap, offering useful insights to improve science education. It has direct benefits to science teachers by providing them with approaches to enhance their teaching practices, thereby improving the learning process of student. The results may also inform the Department of Education in developing specialized professional development programs to equip teachers to address contemporary education challenges. In addition, this research is very valuable to science subject coordinators, offering a foundation for specific professional development activities such as Learning Action Cell (LAC) workshops. Societally, indirectly, the research helps promote scientific literacy, which is imperative towards solving global issues and making informed choices. Improved teaching methods in science education from a core aspect in the building of a scientifically literate population, which is pivotal towards promoting innovation, economic development, and technological advancement. Moreover, educating science and technology literate students promotes societal and technological development, thus enhancing the competitiveness of a country in the global world. The publication of findings at local, national, and international settings and outlets will enrich educational debate as well as inform policy and practice, determining the future of science education internationally. This multi-method strategy ensures the impact of the study goes beyond the classroom, towards a scientifically competent, well-informed society.

STATEMENT OF THE PROBLEM

The aim of the study was to assess science teachers' technological pedagogical content knowledge, scientific literacy, and teaching competence in Santo Tomas East and Talaingod District. More specifically, the study had the aim to respond to the following questions:

1. What is the level of technological pedagogical content knowledge in terms of:
   1.1 Technological Pedagogical Knowledge (TPK);
   1.2 Technological Content Knowledge (TCK); and
   1.3 Pedagogical Content Knowledge (PCK)?
2. What is the level of teachers' scientific literacy in terms of:
   2.1 thinking habits;
   2.2 character and values;
   2.3 interest and views and;
   2.4 ethics in science?
3. What is the level of science teachers' teaching competence?
4. Is there a significant relationship between:
   4.1 technological pedagogical content knowledge and teachers' teaching competence; and
   4.2 science teachers' scientific literacy and teaching competence?
   5. Do technological pedagogical content knowledge and science teachers' scientific literacy predict science teachers' teaching competence?

METHODOLOGY

RESEARCH DESIGN

This study utilized a descriptive and correlational quantitative research design to explain the interactions of Technological Pedagogical Content Knowledge with scientific literacy and teaching competence of science teachers. As an important observation here is that, as Creswell and Creswell (2018) put forward, quantitative research is called for to collect and analyze numeric data. It makes it possible for one to look for patterns in data, validate hypotheses, through statistical interference procedures, or extended outcomes form a certain population to others that are alike but found somewhere else.

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At the core of our methodological framework is descriptive design, and it aims to provide an authentic representation of phenomena under study. Descriptive methodology enables effective data collection in terms of variables of interest, in this case, the elements of TPACK, dimensions of teachers' scientific literacy and teaching competence factors. Highlighted in prevailing literature, descriptive research is the identification of the typical frequencies and distributions that exist within a population and, in the process, provides a comprehensive benchmark against which further analysis can continue. A framework of such methodology is at the heart not only for an understanding of prevailing educational competencies and practice but also in the identification of areas which are amenable to intervention and development.

After establishing a strong descriptive framework, the study then employs a correlation design. The design is employed to measure the size and direction of the correlations between TPACK, scientific literacy, and teaching competence among science teachers. Correlational research, with its absence of interventionism in the measurement of variables, is important in uncovering the interactions between constructs in education. Through the investigation of the way the variables interact in the educational setting, the study seeks to determine potential casual relationships and predictors of effective teaching, hence improving understanding of the variables that best impact educational outcomes.

The integration of descriptive and correlational approaches provides advanced ways of addressing the complex nature of science education. The descriptive component of the investigation will initially systematically list the TPACK, scientific literacy and teaching competence among science teachers. Subsequently, this categorized list serves as the basis for correlational analysis later on, detailing the correlational and predictive effectiveness of such variables to effective teaching. Combined, two approaches not only advance our professional understanding of such educational variables of interest, but also lay the groundwork for informed, data gathering strategies created to maximize, not just instructional quality, but also students' learning achievements.

Finally, in summary, the purpose of this research is to shed light on the salient factors influencing the effectiveness of instruction in the context of science education through systematic use of correlational descriptive research approaches. By a thorough analysis of TPACK, scientific literacy and how they contribute to teaching competence, the research aims to gain valuable insights into the process that has the capability of facilitating learning and thereby opening doors to more informed and effective education policy and practice.

STATISTICAL TREATMENT OF DATA

Data relative to this research was thoroughly discussed and interpreted based on a wide range of statistical indicators, Mean, standard deviation, Pearson correlation coefficient, and Multiple Regression Analysis. Such indicators are highly significant in establishing the level of educators' Technological Pedagogical Content Knowledge (TPACK), Science Literacy, and teaching competence and in enhancing how these variables influence each other.

Mean. This statistical parameter is a statistical measure that is commonly used to determine the average mark of a data set. In this study, the Mean was used to measure the level of Scientific Literacy, TPACK, and teaching ability of the teachers. through the Mean, the researcher can find the middle point of the data, which can give information about the level of knowledge and competence of the teachers in the sample.

Standard Deviation. This statistical indicator is used to measure the extend to which scores are spread in relation to the Mean. In the context of this study, Standard Deviation was used to measure the spread of scores in relation to TPACK, Scientific Literacy, and teaching competence. This indicator of analysis helps the researcher identify the extent to which the scores of the teachers are clustered around the Mean or are highly spread.

Pearson's moment Correlation Coefficient (Pearson-r). It is a statistical method used in the determination of the intensity and direction of the relationship between two variables. Pearson-r in this research were used to examine the correlations of the levels of teachers' Scientific Literacy, TPACK and teaching competence. This indicates whether and the degree to which these variables co-vary.

Multiple Regression Analysis. This statistical tool is a collection of statistical methods applied to define the nature of the relationship between a dependent variable and or multiple dependent variables and one or more independent variables. Multiple Regression Analysis was applied for this research to investigate the correlations between the level of instructors' Technological Pedagogical Content Knowledge (TPACK), Science Literacy, and teaching competence. Through the application of this tool, the researcher is able to determine which among these variables exerts the greatest impact on teaching competence and the degree to which the impact exists.

Finally, the statistical tools utilized were needed for the examination of the information collected in this study. With the assistance of these tools, the researcher can gain information regarding the level of TPACK and Science literacy of the teachers, and their impact on teaching competence.

RESEARCH RESPONDENTS

This research on science teachers at public junior high school under the division of Davao del Norte, two of which are varied districts namely District A (Sto. Tomas East) and District B (Talaingod District). There is a total of fifty-eight science teachers in these two districts, thirty-three in district A and twenty-five in District B.
Following respondent identification, the next step is determining the sample size for the study, using the Yamane formula and including a five percent margin considering the population of fifty-eight educators, the sample size is approximately fifty-one. This sample size is sufficient enough to deliver the representativeness and reliability of the findings of the study.

After the sample size was established, the study performed the stratified sampling technique. The method prescribed the segmentation of the entire population into two strata corresponding to the two districts and the enrolling participants from the two strata proportionally. Described below are how the sample size allocation will proceed.

Of the teachers in District A (Sto. Tomas East), there were about twenty-nine teachers covered by the study. Of the teachers in District B (Talaingod District), there were about twenty-two teachers covered by the sample. Proportional allocation guarantees that all districts are well represented in the sample to facilitate even and comprehensive analysis of the research variables across education contexts.

Through the judicious selection of an adequate sample size and the implementation of stratified sampling techniques, this research aims to conduct a comprehensive and balanced inquiry into the science teachers' teaching methods, experiences, and views in the Division of Davao del Norte. The research design is such a nature that it can provide insights representative of the diverse teaching environments in District A and B hence contribute to an understanding of science education in the region.

RESULTS AND DISCUSSION

The following are the results of the study.

Table 1
Summary of the Level of Technological Pedagogical Content Knowledge

Indicators	Mean	SD	Description
1. Technological Pedagogical Knowledge (TPK)	4.61	0.55	Very High
2. Technological Content Knowledge (TCK)	4.16	0.85	High
3. Pedagogical Content Knowledge (PCK)	4.56	0.66	Very High
Overall Mean	**4.44**	**0.69**	**Very High**

The findings in Table 1 presents an overview of the level of Technological Pedagogical Content Knowledge (TPACK) for three main indicators. The highest mean score was allocated for Technological Pedagogical Knowledge (TPK) (M=4.61), reflecting teachers' exceptional ability to integrate technology with pedagogical strategies. Second in a very close range, Pedagogical Content Knowledge (PCK) exhibited a mean score of 4.56, which, although in the ''High'' range, reflects a relatively lower confidence in using technology to support specific content areas. The overall mean score was attained at 4.44, with a standard deviation of 0.69, which is in the ''Very High'' category and thus exhibit a high overall ability in TPACK among the teachers.

The overall results indicate that the teachers are aware of integrating pedagogy and technology with subject-matter knowledge, which demonstrates well-rounded potential in facilitating instructional activities. The slightly less that optimal score in TCK indicates that while teachers effectively utilize technology for pedagogical purposes, they can improve in embracing technology tools in support of learning activities in specific subject matters. Providing specifically targeted professional training in technology tools according to the subject matter may further optimize the potential of the teachers in developing subject-specific web-based learning environments.

The findings are consistent with previous research that underscores the significance of Technological Pedagogical Content Knowledge (TPACK) in improving instructional effectiveness. Koehler and Mishra (2018) asserted that TPACK empowers educators to design engaging lessons by integrating technology, pedagogy, and content knowledge, as evidence by the elevated proficiency levels across the various indicators. Vivian and Falkner (2019) elaborated on how TPACK can facilitate enhancing new styles of teaching to address 21st-century learning requirements alongside "Very High" ratings in Technological Pedagogical Knowledge (TPK) and Pedagogical Content Knowledge (PCK). Spiteri and Rundgren (2020) also highlighted TPK's contribution to facilitating flexible pedagogies for educators through the use of diverse technological tools, thus supporting this study's robust TPK results. Meanwhile, lower TCK scores are consistent with Fowler and Leonard's (2021) argument that TCK enables subject-specific technology-activated activities to be designed by teachers, again showing future potential for enhancement in technology integration across content-specific learning.

Table 2
Summary of the Level of Teachers' Scientific Literacy

Indicators	Mean	SD	Description
1. Thinking Habits	4.53	0.40	Very High
2. Character and Values	4.51	0.40	Very High
3. Interest and Views	4.58	0.43	Very High
4. Ethics in Science	4.45	0.46	Very High
Overall Mean	4.52	0.42	Very High

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Table 2 displays the findings measuring the scientific literacy of teachers with four broad indicators: Thinking Habits, Character and Values, Interests and Views and Ethics in Science. The highest mean score was recorded for the Interest and Views category (M=4.58), which indicates that teachers highly respect the usefulness and relevance of scientific inquiry. This was closely followed by Thinking Habits (M=4.53), reflecting the teachers' capability in applying critical thinking in scientific contexts. The lowest mean score was recorded in the Ethics in Science category (M=4.45), which, though slightly less, still reflected a very high level of sensitivity in ethical practice in science-related matters.

The overall results show that teachers possess and even profile of scientific literacy with high interest in the science subject, critical thinking ability, ethical awareness, and values conducive to quality science teaching. Their passion for science also indicates their willingness to involve students in meaningful scientific discussions, and their strong thinking styles show their capability to scrutinize and evaluate scientific evidence. Although Ethics in Science had the lowest mean score, the high score still suggests a strong commitment to ethical and responsible scientific inquiry.

The results of this research concur with the current literature that emphasizes the complex and multi-faceted nature of scientific literacy. Wang et. al. (2010) highlighted the pivotal role of cognitive habits, critical analysis to effective science teaching, which is in line with the high scores in Thinking Habits. Oosterheert et. al. (2010) highlighted the character and values role in building positive student-teacher relationships, which is in line with the high ratings in Character and Values. Moreover, Reiss (2020) emphasized the ethical sensitivity role in teaching science, thereby confirming the high degrees of ethics among the teachers in this study. In total, these results imply that scientific literacy among teachers is a factor that should be considered in facilitating effective science instruction, with the call for ongoing support and professional development to maintain and enhance these competences.

Table 3
Level of Science Teachers' Teaching Competence

IPCRF Rating	SD	Description
4.494	.190	Very satisfactory

The findings reflect the ability of science teachers to maintain quality pedagogic practice and professionalism. Their ability to demonstrate daily high instructional competency points towards strong content knowledge base and pedagogic knowledge, determines that underpin pupil attainment and the overall quality of learning. The reliability of the findings further indicates that the teaching profession is typically well-prepared and in accordance with set standards.

Recent studies have highlighted the importance of pedagogical competence in enhancing learning outcomes, specifically the introduction of modern pedagogy, i.e., technology and inquiry-based learning. Ibrahim and Mahmud's (2020) extensive review highlighted a high level of correlation between teaching competence and the ability for inquiry-based science teaching, the requirement for teachers to have profound knowledge of inquiry methods in order to maximize students' scientific knowledge. In the same manner, Sukini (2025) discovered that inquire-based instruction, technology infusion, and peer mentoring in general were accountable for a notable disparity in the professionalism of teachers, hence the need for a comprehensive plan for teacher development. Moreover, a survey conducted by Ibrahim and Mahmud (2020) revealed that teachers' awareness of inquiry-based science pedagogy has a strong impact on their proficiency in applying these methods, citing the pressing the need for ongoing professional development regarding these topics.

The research indicates that through traditional skills form the center the incorporation of technological tools and inquiry-based practices is vital in achieving teaching excellence in modern contexts. Hence, ongoing professional development courses in these areas are vital in maintaining and improving teaching capability in modern learning environments.

Table 4
Relationship between the Technological Pedagogical Content Knowledge, Science Teachers' Scientific Literacy and Teachers' Teaching Competence

Independent Variables	Teachers' Teaching Competence		Decision on H_o	Decision on Relationship
	r	p-value		
Technological Pedagogical Content Knowledge	0.076	.571	Accept	Not Significant
Science Teachers' Scientific Literacy	0.161	.227	Accept	Not Significant

The results of this study varied from prevailing literature, which tends to document a positive association between these competencies and effective teaching. For example, Yawman and Appiah-Kubi (2018) maintained that Technological Pedagogical Content Knowledge (TPACK) is essential in effective teaching as it combines technological, pedagogical, and content knowledge to enhance classroom practice. Similarly, Sari and Kurniawati (2023) established that scientific literacy enhances teaching effectiveness by facilitating teachers to encourage inquiry-based learning and critical thinking. In addition, Ke et. al. (2021) maintained that scientific literacy enables teachers to make appropriate pedagogical decisions, hence enhancing their science education competence. However, the failure to document significant relationship in this study could imply that other, unobserved variables could have a larger effect on teaching competence.

Results tabulated in Table 11 reflect that there is no significant correlation between Technological Pedagogical Content Knowledge (TPACK) and teaching competence and between Science Teachers' Scientific Literacy and teaching competence. This finding opposes prior scholarly literature that often suggests a significant association between these competences and teaching accomplishment. Many studies have studied other variables that will affect teaching competence regardless of the effect of TPACK and scientific literacy. Guskey (2020) and Opfer et al. (2021) in one of their studies revealed teachers' continuous professional growth and expansive support system enomously enhance teachers' teaching effectiveness. Similarly, Priyanto et. al. (2021) reflected in one of their research studies that variables of teaching experience, training, and availability of facilities have a positive effect on the development of TPACK, which in turn have an effect on teaching competence.

Teachers' belief in their own capability, self-efficacy, and intrinsic motivation have been viewed as the key factors that affect their technological capability as well as their willingness to adopt technology in the pedagogic process. Fidan and Tuncel (2022) believe that innovativeness in terms of willingness to facilitate new ideas enhances a high impact on facilitating Technological Pedagogical Content Knowledge (TPACK) and teaching competence (Fidan and Tuncel, 2022). In addition, the affective component that represents teachers' feelings, beliefs, and attitude towards technology has also impacted the integration of technology into pedagogic practice. Ma et. al. (2023) proposed the addition of affect (TPACK) to the TPACK model, citing that an optimistic affective perception towards technology would facilitate the adaption of its integration into pedagogic practice (Ma et. al., 2023).

The impact of the learning environment and mentoring practices has been significantly linked to teaching competence. Masri and Rahim (2023) argue in a study that a positive school climate combined with efficient mentoring foretells teachers' competence development, thus demonstrating that organizational culture and peer support are essential in the development of teaching competence. The absence of significant correlations in this research may suggest that these other variables; professional development, self-efficacy, affective orientation, and environmental support may have a greater impact on teaching competence than has been understood. Future research must examine these variables to develop a more comprehensive image of the variables that impact teaching competence.

Table 5

Influence of the Technological Pedagogical Content Knowledge and Science Teachers' Scientific Literacy to the Science Teachers' Teaching Competence

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value	Decision on Ho
	B	SE	Beta			α=0.05
(Constant)	4.129	.354		11.651	.000	
Technological Pedagogical Content Knowledge	-.023	.090	-.044	-.255	.800	Accept
Science Teachers' Scientific Literacy	.103	.094	.189	1.099	.277	Accept
Model Summary: R=0.165; R^2 = 0.027; F = .767; p=.469						

The results as reflected in Table 12 show that neither Technological Pedagogical Content Knowledge (TPACK) nor Scientific Literacy of Science Teachers has a statistically significant influence on the Teaching Competence of Science Teachers. The constant for the model is 4.129, p-value 0.000, showing a statistically significant base for teaching competence. For TPACK, the unstandardized coefficient (B) is -0.023 with the standard error 0.90 and the standardized beta -0.044. The t-value is -0.255 with a p-value of 0.800, resulting in the acceptance of the null hypothesis, which shows that TPACK does not predict teaching competence significantly. Likewise, for Scientific Literacy for Science Teachers, unstandardized coefficient (B) is 0.103 and its standard error is 0.094 with a standardized beta of 0.189. the t-value is 1.099 with a p-value of 0.277, leading to the acceptance of the null hypothesis and showing no significant predictive effect on teaching competence. The model summary yielded and R of 0.165, which was a weak correlation, and an R^2 of 0.027, showing that 2.7% of teaching competence variation was explained by TPACK and scientific literacy. The F-statistic was 0.767 and the p-value was 0.469, again confirming that the overall model was not statistically significant.

The result of this research contradicts the literature, which primarily indicates a positive impact of TPACK and scientific literacy on teaching effectiveness. Kim et. al. (2021) presumed that TPACK improves the quality of teaching by allowing teachers to combine technology, content and pedagogy effectively. Likewise, Sari and Kurniawati (2019) also hypothesized that scientific literacy plays a significant role in the design of inquiry-based science education that can enhance teaching effectiveness. Koehler and Mishra (2018) further stressed that thorough knowledge structures such as TPACK are essential in the development of teachers to handle the varied needs of the classrooms. Nevertheless, the fact that this study failed to identify any significant influence implies that other determinants can have an even greater impact on the development of teaching competency among science teachers.

One of the possible reasons for the lack of strong correlation between Technological Pedagogical Content Knowledge (TPACK) and teaching effectiveness could be the level of technology integration in actual classrooms. While teachers have learned TPACK knowledge, it can be limited by contextual factors such as insufficient access to technology, poorly designed training, or school policy without support for digital integration in science instruction. A study by Pather and Bayaga (2023) shows that even when teachers have technology integration knowledge, such as administrative support, availability of infrastructure, and individual-level confidence in technology use.

Another possible contributor would be the pedagogical emphasis adopted by science teachers. a majority of the teachers might concentrate on mastering the content and traditional pedagogy rather than on the incorporation of technology, particularly in environments where experiential learning and student participation are perceived as more useful than the application of digital aids. Darling-Hammond et. al. (2020) argue that effective instruction is largely a function of experience, reflective pedagogy, and adaptability in the teaching of lessons, as opposed to excessive reliance on a single model like TPACK. As such, while TPACK might be theoretically superior, its practical impact on pedagogical competence might be surpassed by other pedagogical factors.

Furthermore, teacher motivation and self-efficacy can also act as moderators of the TPACK, scientific literacy and teaching competence relationship. Highly self-efficacious teachers might invoke their problem solving and adaptability skills instead of technological or scientific literacy to increase their competence. Bandura (1997) argued that self-efficacy plays a significant role in how people translate their knowledge into practice, and that teacher confidence and belief in teaching ability might be a more accurate predictor of competence than technical knowledge.

The results also provide potential avenues for future research to examine other variables that significantly affect teaching effectiveness. Future research may explore the influence of classroom management skills, professional development experience, and mentoring relationship on teachers' instructional competence. Similarly, organizational support structures such as curriculum planning, access to instructional resources, and inter-teacher collaboration are potential mediators in the TPACK, scientific literacy and teaching competence link that could be explored. Scaling up studies in these areas might shed light on the variables that actually enhance science teachers' instructional competence above and beyond the technological and scientific knowledge they bring into the classroom.

These findings underscore the imperative for education policy and training programs to increase teachers' technological and scientific literacy and resolve the practical issues that can impede its application. Schools' administrators can consider offering extra formal support mechanism, such as periodic workshops, mentoring, and infrastructure, to enable teachers apply their knowledge in the classroom in a practical way. Policymakers and curriculum specialists will also need to rethink current teacher education models to add a more balanced model that combines technology with practical, and based on experience pedagogy.

The findings of the study indicate that both Science Teachers' Scientific Literacy and Technological Pedagogical Content Knowledge (TPACK) do not make significant contributions to Science Teachers' Teaching Competence, in contrast to existing literature in their defense of their decisive significance in increasing teaching competence. The failure to produce a substantive result suggest that other variables such as the inability to make full technological use within the classroom setting as a result of limitations on infrastructure and training, content proficiency over technological utilization taking priority, and the teacher's motivational and self-efficacy effects which could possibly be a larger contributing factor in terms of competence of instruction. The results demand follows up research that assesses an array of various predictors such as classroom management, training as a professional, and a school level support infrastructure that may have significant influence in helping achieve effective teaching strategies. Further, teacher preparation programs must also undergo reconsideration to facilitate an inclusive strategy encompassing technological and scientific literacy with adaptive pedagogies. Guided by these findings, schools and policymakers should implement interventions like systematic training interventions, mentorship programs, and school wide composite support system directed towards teaching competence. Future research should further examine these broader influences to design an improved science teacher education model where teachers would have access to both theoretical content and transferable instructional competence.

RECOMMENDATIONS

The study's findings and conclusions lead to the following recommendations:

1. According to the results and conclusion of this study, the following suggestions are given:
1. Students need to be encouraged by scientific literacy and technology support to participate in the learning process. Utilizing digital tools and interactive materials, students can sufficiently understand complicated science topics and understand more with better interest. This method not only makes learners excel academically but also creates wonder, analytical skills, and everlasting scientific curiosity in them.
2. Science teachers were advised to assess their technological pedagogical content knowledge and scientific literacy competencies on a regular basis to identify areas for growth. Through attendance at professional development courses for technology

integration enhancements and or scientific literacy, teachers are able to enhance teaching practices to optimize the performance of their classrooms. Teachers may maintain teaching journals or share with colleagues their feel for how these competencies are enacted in their own classroom. Looking back on how they do science instruction leads them to modify their practices continually and improve.

3. Master Teachers were urged to consider the insights from this study in their evaluations of science teachers using the Class Observation Tool (COT). Master Teachers will be able to provide targeted and specific feedback to science teachers as they identify what TPACK and scientific literacy aspects impact teaching competence, allowing science teachers to craft these skills and find features in these areas. Using this study as a touchstone, Master Teachers can target individual needs to support ongoing improvement in their proficiencies and classroom methods.

4. School heads are recommended to create dedicated programs, workshops, and seminars on TPACK and scientific literacy to enhance the professional development of science teachers. these activities will further enable teachers to strengthen their skills in these aspects, improving the teaching learning processes for students. thus, school supervisors must develop context specific support programs that facilitate effective quality science teaching under these peculiar challenges to improve the school's quality of science education.

5. The study's findings will assist in designing specific training pathways and teacher professional development initiatives, considering TPACK and scientific literacy needs of teachers in the Department of Education Officials. Updating curriculum guidelines with these competencies as a focus and providing funding to support teachers in delivering high quality science education are also essential. Help give science teachers the skills, experiences, and knowledge they need to create a broad, impactful science education.

6. Future researchers were urged to do this study up to other factors that can impact teaching competence, such as classroom management skills, sociocultural awareness, and institutional support. Research beyond TPACK, scientific literacy, or pedagogical knowledge in different subjects and educational levels would help advance the knowledge around more generic teaching methods. This research will not only affect the science education community but also affect scientific fields in history, thereby affecting various pedagogical methods and the efficacy of learning outcomes in various settings.

CONCLUSIONS

Based on the findings of the study, the subsequent conclusions have been derived:

1. The results showed that teachers have an extremely high TPACK level with high ability in applying technology to enhance pedagogy and knowledge of content. This implied that teachers were in good position to apply technology in enhancing learning and personalizing instruction.
2. Teachers exhibited a very high level of scientific literacy across various dimensions, including critical thinking habits, character and values, interest and views and ethics in science. This level of scientific literacy reflected a dedication to creating a comprehensive and ethical method in science education, one that was needed to motivate and direct students toward scientific inquiry.
3. Teachers' high competence, as indicated by their IPCRF ratings, showed a high level of instructional performance consistently. This indicated teachers' ability to perform to educational standards and provide quality science teaching.
4. The fact that there was no high correlation between TPACK, scientific literacy, and teaching competence signified that, while TPACK and scientific literacy are skills of highest importance, this also signified that they may not necessarily influence teaching competence directly within the context of the present study. This finding suggest that teaching competence might be influenced by other factors than in the current study, e.g., classroom management competencies or organizational support.

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