INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 13, Issue 4, (2024) E-ISSN: 2226-6348

Exploring the Level of TPACK Mastery and its Effect on Vocational High School Teachers' Performance in Panyu District, China

Han Mingjun[1], Khairul Azhar Jamaludin[1,2,3]

[1]Faculty of Education, Universit Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [2]University Research Group on ELITEE: Enhanced Learning for Inclusive Transformation Education Experience, [3]University Research Group on Eduxcellence: Development of Innovative Curriculum &Pedagogy

Email: khairuljamaludin@ukm.edu.my

Corresponding Author Email: P132623@siswa.ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARPED/v13-i4/24068 DOI:10.6007/IJARPED/v13-i4/24068

Published Online: 13 December 2024

Abstract

The research focuses on examining the mastery of Technological Pedagogical Content Knowledge (TPACK) among vocational high school teachers in Panyu District, China, and its influence on their teaching effectiveness. TPACK is a conceptual framework that combines technological, pedagogical, and content knowledge, aiming to facilitate the effective integration of technology in education. To investigate this, the study utilized a structured survey questionnaire based on established TPACK measures, collecting data from 173 teachers. Quantitative analysis methods, including Pearson correlation and multiple regression analysis, were employed to explore the relationships between various TPACK components and teacher performance. The findings revealed that Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and Technological Content Knowledge (TCK) were significant predictors of teaching performance. These results emphasize the importance of a balanced integration of pedagogy, content, and technology in vocational education. They also underscore the necessity for ongoing professional development to bolster teachers' abilities to integrate technology into their teaching. While the study provides valuable insights, it has limitations, such as its focus on a single district and the use of self-reported data. The findings of this study offer crucial guidance for policymakers and educators on improving the quality of vocational education through targeted teacher development programs that emphasize the balanced development of pedagogical, content, and technological knowledge.

Keywords: Tpack, Vocational High School, Teaching Performance, Vocational Education, Technological Integration Skills

Introduction

The integration of technology into education has become a critical component in enhancing teaching and learning processes. In the 21st century, educators are expected to be proficient not only in their subject matter and pedagogical methods but also in their ability to integrate technology effectively into their classrooms (Singerin, 2022). The Technological Pedagogical Content Knowledge (TPACK) framework is a comprehensive model that outlines the essential knowledge teachers need to integrate technology into their teaching practices effectively. This framework highlights the interplay between three primary forms of knowledge: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) (Lyublinskaya & Kaplon-Schilis, 2022; Aktas &Ozmen, 2020).

Vocational high school teachers face unique challenges in incorporating technology into their curricula due to the practical and skill-based nature of vocational education. In China, understanding the level of TPACK mastery among these teachers is crucial for improving educational outcomes and ensuring that students are equipped with the necessary skills to thrive in a technologically advanced society. This study aims to explore the level of TPACK mastery among vocational high school teachers in Panyu District and to examine its impact on teachers' performance. The first objective of this research is to identify the levels of TPACK mastery among vocational high school teachers, focusing on each aspect of the TPACK framework: technological knowledge, content knowledge, pedagogical knowledge, technological content knowledge, technological pedagogical knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. The second objective is to determine the effect of TPACK mastery on teachers' performance in vocational high schools. By addressing these objectives, this study seeks to provide valuable insights into the professional development needs of vocational teachers and to contribute to the broader discourse on technology integration in education.

Literature Review

TPACK Model

The Technological Pedagogical Content Knowledge (TPACK) framework, developed by Mishra and Koehler in 2006, offers a holistic approach to integrating technology into teaching. Building on Lee Shulman's concept of Pedagogical Content Knowledge (PCK), TPACK recognizes that effective teaching with technology requires a deep understanding of the interplay between three primary forms of knowledge: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) (Aktas & Ozmen, 2022). These knowledge domains do not exist in isolation; rather, they intersect to form four additional areas of integrated knowledge: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and the comprehensive Technological Pedagogical Content Knowledge (TPACK). The TPACK framework emphasizes that teachers must blend their knowledge of content, pedagogy, and technology to create effective, engaging, and transformative learning experiences (Max et al., 2022). This integrated approach is essential for preparing students for the complexities of the modern world, where technology plays a pivotal role in both personal and professional spheres. The following sections will delve into each component of the TPACK model, providing a detailed understanding of their individual and collective contributions to educational practice .

Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (TPACK) represents the intersection of technological, pedagogical, and content knowledge (Choi & Paik, 2020). It is the comprehensive understanding of how to teach specific content using appropriate pedagogical strategies and technological tools. TPACK is the core of the TPACK framework, emphasizing the seamless integration of technology into teaching in a way that enhances learning outcomes. TPACK requires teachers to have a deep understanding of the content they are teaching, the pedagogical methods that are most effective for that content, and the technological tools that can support and enhance those methods (Agustini et al., 2019). For example, a science teacher using the TPACK framework might integrate interactive simulations to explain complex scientific concepts, use inquiry-based learning strategies to engage students, and leverage data collection tools for hands-on experiments. This integrated approach helps students develop a deeper understanding of scientific principles through active engagement and practical application (Ammade et al., 2020).

The development of TPACK involves continuous learning and adaptation. Teachers must stay informed about new technologies and pedagogical strategies, and be willing to experiment and reflect on their teaching practices. Professional development opportunities, such as workshops, online courses, and collaborative projects with colleagues, are essential for building TPACK (Rodriguez et al., 2019). These opportunities allow teachers to explore new tools, share best practices, and receive feedback on their integration efforts. TPACK also highlights the importance of context in teaching. Effective integration of technology, pedagogy, and content must consider the specific learning environment, student needs, and curriculum goals. Teachers with strong TPACK can adapt their instructional strategies to different contexts, ensuring that technology enhances rather than distracts from learning (Lai et al., 2022). This contextual awareness is crucial for creating inclusive and effective learning experiences. Furthermore, TPACK emphasizes the importance of assessment in the integrated teaching process. Teachers need to design assessments that measure not only content knowledge but also the ability to use technology effectively and engage in higher-order thinking (Yeh et al., 2021). These assessments provide valuable feedback on student learning and inform instructional adjustments to better meet student needs.

Effect of TPACK on Teacher's Performance

The integration of the Technological Pedagogical Content Knowledge (TPACK) framework into teaching practices has a profound impact on teacher performance. By blending technological, pedagogical, and content knowledge, teachers can enhance their instructional methods, create more engaging learning environments, and ultimately improve student outcomes (Lai et al., 2022). This section explores how TPACK influences various aspects of teacher performance and contributes to effective teaching and learning.

First, the TPACK framework empowers teachers to effectively integrate technology into their teaching. Moreover, TPACK encourages teachers to develop Technological Content Knowledge (TCK), which involves understanding how technology can support and transform the representation of specific subject matter (Omoso & Odindo, 2020). The TPACK framework also promotes the development of Technological Pedagogical Knowledge (TPK), which focuses on using technology to implement effective teaching strategies (Max et al., 2022). In addition, TPACK enhances teachers' ability to differentiate instruction and personalize learning experiences. By using adaptive learning technologies, teachers can provide customized lessons and activities that address individual student needs and learning paces (Dong et al., 2020). For instance, educational software that adjusts the level of difficulty based on student performance can help struggling students receive the support they need while allowing advanced students to progress at a faster pace. This personalized approach to teaching ensures that all students have the opportunity to succeed and reach their full potential (GomezTrigueros, 2020).

Furthermore, the comprehensive nature of TPACK encourages teachers to adopt a more holistic approach to teaching. By considering the interplay between technology, pedagogy, and content, teachers can design more coherent and cohesive lesson plans (Shi & Jiang, 2022). This integrated approach helps to create a seamless learning experience where technology is not an add-on but an integral part of the instructional process. As a result, students are more likely to see the relevance of technology in their learning and develop positive attitudes towards its use (Joshi, 2023).

The impact of TPACK on teacher performance is also evident in the area of assessment. Teachers with strong TPACK skills can use technology to conduct formative and summative assessments more efficiently and effectively. Digital tools such as online quizzes, e-portfolios, and learning management systems enable teachers to track student progress, provide immediate feedback, and analyze assessment data to inform instruction (Setiawan et al., 2019). This data-driven approach to assessment helps teachers identify areas where students need additional support and adjust their teaching strategies accordingly.

Professional development is crucial for enhancing TPACK and, consequently, teacher performance. Continuous learning opportunities, such as workshops, online courses, and professional learning communities, help teachers stay updated with the latest technological advancements and pedagogical strategies (Maipita et al., 2022). Engaging in reflective practice and collaborating with colleagues also supports the development of TPACK, as teachers can share best practices and learn from each other's experiences (Istiningsih, 2022). By investing in professional development, schools can ensure that teachers have the knowledge and skills necessary to integrate technology effectively into their teaching.

Methodology

Research Design

The research design for this study is meticulously crafted to address the research objectives and answer the research questions effectively. As this study embraces a positivist paradigm, it relies on the deductive research approach and utilizes quantitative research methods. The choice of a quantitative design is informed by the need to objectively measure variables and analyze the relationships between them statistically, providing a robust and empirical foundation for the study's findings. Positivism, as a philosophical stance, underpins this research by emphasizing the importance of observable, measurable phenomena and the use of empirical evidence to generate knowledge. This paradigm is appropriate for the study as it seeks to identify the level of TPACK mastery among vocational high school teachers and determine its impact on their performance through objective measurement and analysis.

The deductive approach complements this positivist stance by starting with existing theories and frameworks, specifically, the TPACK model, and testing hypotheses derived from these theories. This method involves formulating specific hypotheses about the relationships between TPACK components and teacher performance, then collecting and analysing data to confirm or refute these hypotheses. The deductive approach ensures that the research is grounded in established theoretical constructs while allowing for empirical validation through data analysis.

Quantitative research methods are employed in this study to systematically investigate the research questions. These methods are well-suited for this type of inquiry as they allow for the collection of numerical data that can be subjected to statistical analysis. By using structured survey instruments, this study aims to quantify the levels of TPACK mastery and assess their impact on teacher performance. The primary data collection tool for this study is a structured survey questionnaire, adapted from established sources such as the measurements for TPACK developed by Schmidt, Baran, and Thompson (2009). This survey instrument is designed to capture detailed information on each of the seven components of TPACK: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK).

The survey is structured to ensure clarity and comprehensiveness, with questions tailored to measure each aspect of TPACK. The questionnaire is divided into sections corresponding to the different TPACK components, with each section containing multiple items that respondents rate on a Likert scale. This design allows for a nuanced assessment of teachers' knowledge and skills in each area. To facilitate data collection, the survey will be administered online using the Wen Juanxing platform. This platform is chosen for its user-friendly interface and capability to reach a wide audience efficiently. The online survey format is advantageous as it allows for quick distribution and collection of responses, reduces paper usage, and provides immediate data entry, minimizing the risk of errors associated with manual data handling.

Research Instrument
Data collection is conducted through a structured survey questionnaire. The survey is adapted from established instruments, specifically the TPACK questionnaire developed by Schmidt, Baran, and Thompson (2009). Data analysis is performed using SPSS version 25.

Respondent
This section presents an analysis of the respondents' gender, age, and teaching subjects.
Table 1
Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	66	38.2	38.2	38.2
	Female	107	61.8	61.8	100.0
	Total	173	100.0	100.0	

The gender distribution of the respondents indicates a higher representation of female teachers compared to male teachers. Out of the 173 respondents, 66 are male, constituting 38.2% of the total sample, while 107 are female, making up 61.8% of the respondents. This gender disparity reflects a trend often observed in educational settings, where female teachers tend to outnumber their male counterparts, particularly in vocational and general education sectors. The predominance of female teachers may have implications for how technological integration is approached in vocational education, given that previous studies have sometimes suggested gender differences in technology adoption and use in educational contexts.

Table 2
Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25 Years and Below	35	20.2	20.2	20.2
	26 to 35 Years Old	126	72.8	72.8	93.1
	36 to 45 Years Old	6	3.5	3.5	96.5
	46 to 55 Years Old	2	1.2	1.2	97.7
	56 Years Old and Above	4	2.3	2.3	100.0
	Total	173	100.0	100.0	

The age distribution of the respondents is skewed towards younger teachers, with a significant majority falling within the 26 to 35 years old age bracket. Specifically, 126 respondents, or 72.8% of the total sample, belong to this age group. Teachers aged 25 years and below constitute 20.2% of the respondents, with 35 individuals represented in this category. The remaining respondents are older, with 6 teachers (3.5%) aged between 36 and 45 years, 2 teachers (1.2%) between 46 and 55 years, and 4 teachers (2.3%) aged 56 years and above. This concentration of younger teachers may influence the overall TPACK levels within the sample, as younger educators are often more familiar with and adaptable to new technologies, having grown up in a more digitally enriched environment. However, the relatively small number of older teachers might indicate a need for targeted professional development initiatives aimed at ensuring that they are equally equipped with the necessary technological skills to integrate into their pedagogical practices.

Table 3
What is the subject you are teaching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Literacy (Chinese)	98	56.6	56.6	56.6
	Mathematics	52	30.1	30.1	86.7
	English	18	10.4	10.4	97.1
	Science (Chemistry/Physics)	5	2.9	2.9	100.0
	Total	173	100.0	100.0	

The distribution of teaching subjects among the respondents shows a predominance of teachers in literacy, particularly Chinese literacy. Out of the 173 respondents, 98 (56.6%) are literacy teachers, indicating a strong focus on language instruction within the vocational education framework in Panyu District. Mathematics teachers form the second-largest group, with 52 respondents (30.1%). English teachers account for 18 respondents (10.4%), while

Science teachers, covering subjects such as Chemistry and Physics, make up the smallest group with 5 respondents (2.9%). The dominance of literacy and mathematics subjects among the respondents may reflect the curricular priorities within vocational education in the district. This subject distribution could also affect the overall TPACK scores, as the integration of technology into literacy and mathematics instruction may differ significantly from its application in teaching English or Science. Literacy teachers, for instance, may utilize different technological tools compared to science teachers, who might rely more heavily on simulations or laboratory-based software.

Findings

Multiple regression analysis was conducted to examine the relationship between the various components of Technological Pedagogical Content Knowledge (TPACK) and teacher performance. The analysis aims to determine how well each aspect of TPACK predicts teacher performance and to identify the relative contribution of each predictor variable.

Table 4
Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.969[a]	0.938	0.936	0.15068

a: Predictors: (Constant), TPACK, TK, CK, PK, PCK, TCK, TPK.

The model summary indicates that the regression model is highly effective in explaining the variance in teacher performance. The R value of 0.969 suggests a strong correlation between the independent variables (TPACK components) and the dependent variable (teacher performance). The R Square value of 0.938 indicates that approximately 93.8% of the variance in teacher performance can be explained by the model, meaning that the predictors collectively account for a substantial proportion of the variability in teacher performance. The Adjusted R Square value of 0.936, which is very close to the R Square, confirms that the model remains robust even after adjusting for the number of predictors. The standard error of the estimate is 0.15068, suggesting that the model predicts teacher performance with a reasonable degree of accuracy.

Table 5
AVONA [a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	57.051	7	8.150	358.945	0.000 [b]
	Residual	3.746	165	0.023		
	Total	60.798	172			

a: Dependent Variable: Teacher Performance; b: Predictors: (Constant), TPACK, TK, CK, PK, PCK, TCK, TPK.

The ANOVA table provides further evidence of the model's overall significance. The F-statistic for the model is 358.945, with a significance level (p-value) of 0.000. This indicates that the model is statistically significant, meaning that at least one of the predictor variables is significantly related to teacher performance. The low residual sum of squares (3.746) compared to the regression sum of squares (57.051) further supports the model’s effectiveness in explaining the variance in teacher performance.

Table 6
Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.189	0.092		2.054	0.042
	TK	-0.031	0.047	-0.035	-0.652	0.515
	CK	0.289	0.039	0.369	7.435	0.000
	PK	0.406	0.040	0.442	10.058	0.000
	PCK	0.303	0.054	0.347	5.628	0.000
	TCK	0.325	0.047	0.371	6.885	0.000
	TPK	-0.340	0.068	-0.393	-4.968	0.000
	TPACK	0.001	0.010	0.001	0.059	0.253

a: Dependent Variable: Teacher Performance.

The coefficient analysis reveals distinct contributions of each component of TPACK to teacher performance. Starting with Technological Knowledge (TK), the coefficient for TK is negative (-0.031) and statistically insignificant (p = 0.515). This suggests that TK, while necessary, does not significantly influence teacher performance when considered in isolation from other factors. This finding indicates that merely having technological knowledge may not directly translate to better teaching performance, emphasizing the need for effective integration with other knowledge domains. In contrast, Content Knowledge (CK) shows a strong positive impact on teacher performance, with a coefficient of 0.289 and a highly significant p-value (p < 0.000). The standardized coefficient (Beta = 0.369) further underscores CK's importance, highlighting that a deep understanding of the subject matter is crucial for effective teaching. Teachers who possess strong content knowledge are better equipped to deliver lessons with clarity and confidence, directly enhancing student learning outcomes.

Pedagogical Knowledge (PK) emerges as the most substantial predictor of teacher performance in this model. The coefficient for PK is 0.406, with a highly significant p-value (p < 0.000) and a Beta value of 0.442. This suggests that pedagogical expertise understanding how to teach effectively is paramount in influencing teacher performance. Teachers with strong pedagogical skills can design and deliver instruction that meets diverse student needs, making PK a critical area for professional development. Pedagogical Content Knowledge (PCK) also significantly contributes to teacher performance, with a coefficient of 0.303 and a p-value of less than 0.000. The Beta value of 0.347 indicates that PCK, which reflects the ability to integrate pedagogy with content, is a crucial determinant of teaching effectiveness. This result underscores the importance of teachers not only knowing their subject matter but also understanding the best ways to teach it, bridging the gap between knowledge and pedagogy. The role of Technological Content Knowledge (TCK) is similarly significant, with a positive coefficient of 0.325 and a p-value below 0.000. The Beta value of 0.371 suggests that TCK is a strong predictor of teacher performance, emphasizing the importance of integrating technology with content knowledge to enhance instructional delivery. This finding highlights that teachers who effectively use technology to support and transform the teaching of specific content areas are likely to achieve better performance outcomes. Interestingly, Technological

Pedagogical Knowledge (TPK) shows a negative coefficient (-0.340) with a significant p-value ($p < 0.000$). The negative Beta value (-0.393) suggests an inverse relationship with teacher performance, which may reflect the challenges or potential pitfalls of overemphasizing technological pedagogical strategies without sufficiently integrating them with content knowledge. This finding suggests that while TPK is essential, its effectiveness may be contingent on its balanced integration with other TPACK components.

Finally, the overall Technological Pedagogical Content Knowledge (TPACK) construct shows a near-zero coefficient (0.001) and is not statistically significant ($p = 0.253$). This result implies that the combined effect of TPACK, as measured by the model, does not significantly predict teacher performance beyond the individual contributions of its components. It highlights that while TPACK as a framework is valuable, the isolated impacts of its constituent parts including TK, CK, PK, PCK, TCK, and TPK may offer more practical insights for enhancing teacher performance.

Discussion

The findings of this study provide important insights into the relationship between Technological Pedagogical Content Knowledge (TPACK) components and teacher performance among vocational high school teachers in Panyu District. The multiple regression analysis reveals significant correlations between specific TPACK components and teacher performance, with Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and Technological Content Knowledge (TCK) emerging as the most influential factors. In contrast, Technological Pedagogical Knowledge (TPK) displayed a negative association with teacher performance, while Technological Knowledge (TK) and the overall TPACK construct did not significantly predict teacher performance. These findings align with and contribute to the existing literature on TPACK, particularly within the vocational education context.

The study found that Technological Knowledge (TK) and the overall TPACK construct did not significantly predict teacher performance. TK, which refers to the basic understanding of how to use technological tools, may not directly impact performance unless it is effectively integrated with pedagogical and content knowledge. This finding is consistent with the idea that technological proficiency alone is insufficient for improving teaching outcomes; it must be coupled with strong pedagogical and content knowledge to be effective. The lack of significance for the overall TPACK construct may indicate that the individual contributions of TK, CK, PK, PCK, TCK, and TPK are more critical than the combined effect captured by TPACK. This suggests that teacher training programs should focus on strengthening each component of TPACK rather than relying solely on the integrated framework.

Implications of Findings

The findings from this study have significant implications for educational practice, particularly within vocational high schools. The strong positive correlation between Pedagogical Knowledge (PK) and teacher performance underscores the critical importance of focusing on pedagogy in teacher professional development. Teachers with strong pedagogical skills are better equipped to create engaging and effective learning environments, which is particularly important in vocational education where hands-on learning and practical application are key. This suggests that teacher training programs should place a high priority on developing pedagogical skills, ensuring that teachers can effectively manage classrooms, design instructional strategies, and assess student learning to improve educational outcomes.

Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) were also found to significantly impact teacher performance, highlighting the necessity for teachers to not only master their subject matter but also to understand the best methods for teaching that content. In vocational education, where alignment with industry standards is crucial, this suggests that professional development should equally focus on deepening teachers' content knowledge and enhancing their ability to integrate that knowledge with pedagogical techniques. This dual approach will enable teachers to present complex content in ways that are both accessible and engaging for students, ultimately improving learning outcomes.

The significant role of Technological Content Knowledge (TCK) in teacher performance emphasizes the need for professional development that goes beyond basic technological proficiency. Teachers need to learn how to effectively integrate technology into their specific content areas to create interactive and impactful learning experiences. In vocational education, this could involve training on the use of industry-specific software, simulations, and virtual labs, which can enhance the practical, hands-on nature of vocational training. This approach ensures that technology is not just an add-on, but a meaningful component of the teaching and learning process.

The negative association between Technological Pedagogical Knowledge (TPK) and teacher performance suggests caution in how technology is integrated into pedagogy. Overemphasis on technology without proper integration with content and pedagogical strategies may detract from effective teaching. This finding highlights the importance of a balanced approach, where technology is used to complement rather than overshadow traditional teaching methods. Curriculum designers and policymakers should therefore focus on creating guidelines for the appropriate use of technology in education, ensuring that it enhances rather than hinders the learning process.

Conclusion

This study explored the relationship between TPACK components and teacher performance among vocational high school teachers in Panyu District, China. The findings revealed that Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and Technological Content Knowledge (TCK) are significant predictors of teacher performance, emphasizing the importance of a balanced integration of pedagogy, content, and technology in teaching. The negative association between Technological Pedagogical Knowledge (TPK) and teacher performance highlights the complexities of technology integration, suggesting that overemphasis on technology without proper alignment with pedagogy and content may hinder teaching effectiveness.

References

Agustini, K., Santyasa, I. W., & Ratminingsih, N. M. (2019). Analysis of competence on "TPACK": 21st century teacher professional development. *Journal of Physics: Conference Series*, *1387*(1), 012035.

Aktaş, I., & Özmen, H. (2020). Investigating the impact of TPACK development course on pre-service science teachers' performances. *Asia Pacific Education Review*, *21*(4), 667-682.

Aktaş, I., & Özmen, H. (2022). Assessing the performance of Turkish science pre-service teachers in a TPACK-practical course. *Education and Information Technologies*, *27*(3), 3495-3528.

Ammade, S., Mahmud, M., Jabu, B., & Tahmir, S. (2020). TPACK Model Based Instruction in Teaching Writing: An Analysis on TPACK Literacy. *International Journal of Language Education*, *4*(1), 129-140.

Benedicto, M. T., Sala, A. M. V., Carascal, I. C., & Mutya, R. C. (2023). Development and Utilization of Online Teacher Professional Development Program to Improve Private e-Tutors' TPACK Skills. *Jurnal Pendidikan Progresif*, *13*(2), 736-750.

Choi, K., & Paik, S. H. (2020). The difference of measurement results between the questionnaire and performance assessment of Pre-service teacher's TPACK competency. *Journal of the Korean Association for Science Education*, *40*(4), 437-449.

Dong, Y., Xu, C., Chai, C. S., & Zhai, X. (2020). Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support. *The Asia-Pacific Education Researcher*, *29*, 147-157.

Gómez-Trigueros, I. (2020). Digital teaching competence and space competence with TPACK in social sciences. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(19), 37-52.

Hapsari, N., Subali, B., & Astuti, F. E. C. (2020). Teaching Performance of High School Biology Teachers in Applying TPACK: A Descriptive Study. In *International Conference on Educational Research and Innovation (ICERI 2019)* (pp. 95-99). Atlantis Press.

Istiningsih, I. (2022). Impact of ICT integration on the development of vocational high school teacher TPACK in the digital age 4.0. *World Journal on Educational Technology: Current Issues*, *14*(1), 103-116.

Joshi, S. C. (2023). TPACK and teachers' self-efficacy: A systematic review. *Canadian Journal of Learning and Technology*, *49*(2), 1-23.

Kim, H. J. (2022). Importance-Performance Analysis of Pre-Service Elementary School Teachers' TPACK in English Education. *MEESO 2022*, 104.

Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., ... & Thomas, P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers & Education*, *174*, 104304.

Lai, C., Wang, Q., & Huang, X. (2022). The differential interplay of TPACK, teacher beliefs, school culture and professional development with the nature of in-service EFL teachers' technology adoption. *British Journal of Educational Technology*, *53*(5), 1389-1411.

Lai, D., Lew, S. L., & Ooi, S. Y. (2022). Modified TPACK Framework for Teachers' Efficiency, Students' Performance and Students' Engagement. In *Proceedings of Sixth International Congress on Information and Communication Technology: ICICT 2021, London, Volume 1* (pp. 827-835). Springer Singapore.

Li, S., Liu, Y., & Su, Y. S. (2022). Differential analysis of teachers' technological pedagogical content knowledge (TPACK) abilities according to teaching stages and educational levels. *Sustainability*, *14*(12), 7176.

Long, T., Zhao, G., Li, X., Zhao, R., Xie, K., & Duan, Y. (2022). Exploring Chinese in-service primary teachers' Technological Pedagogical Content Knowledge (TPACK) for the use of thinking tools. *Asia Pacific Journal of Education*, *42*(2), 350-370.

Lyublinskaya, I., & Kaplon-Schilis, A. (2022). Analysis of differences in the levels of TPACK: Unpacking performance indicators in the TPACK levels rubric. *Education Sciences*, *12*(2), 79.

Mailizar, M., Hidayat, M., & Al-Manthari, A. (2021). Examining the impact of mathematics teachers' TPACK on their acceptance of online professional development. *Journal of Digital Learning in Teacher Education*, *37*(3), 196-212.

Maipita, I., Dongoran, F. R., Syah, D. H., & Sagala, G. H. (2022). TPACK Knowledge Mastery of Pre-Service Teacher Students in the Faculty of Economics Universitas Negeri Medan. In *2nd International Conference of Strategic Issues on Economics, Business and, Education (ICoSIEBE 2021)* (pp. 120-125). Atlantis Press.

Maipita, I., Rahman, D. F., Husrizal, S. D., & Sagala, G. H. (2023). TPACK, organizational support, and technostress in explaining teacher performance during fully online learning. *Journal of Information Technology Education: Research*, *22*, 41-70.

Max, A. L., Lukas, S., & Weitzel, H. (2022). The relationship between self-assessment and performance in learning TPACK: Are self-assessments a good way to support preservice teachers' learning? *Journal of Computer Assisted Learning*, *38*(4), 1160-1172.

Ning, Y., Zhou, Y., Wijaya, T. T., & Chen, J. (2022). Teacher education interventions on teacher TPACK: A meta-analysis study. *Sustainability*, *14*(18), 11791.

Putry, A. R. A., Astuti, P., & Sakhiyya, Z. (2022). The manifestation of EFL teachers' self-efficacy and TPACK with their teaching performance. *English Education Journal*, *12*(2), 151-161.

Qiu, C. A., He, H. X., Chen, G. L., & Xiong, M. X. (2022). Pre-service teachers' perceptions of technological pedagogical content knowledge in mainland China: A survey of teachers of Chinese as a second language. *Education and Information Technologies*, *27*(5), 6367-6391.

Rahmawati, A., Suryani, N., Akhyar, M., & Sukarmin, S. (2021). Vocational teachers' perspective toward technological pedagogical vocational knowledge. *Open Engineering*, *11*(1), 390-400.

Rodríguez Moreno, J., Agreda Montoro, M., & Ortiz Colon, A. M. (2019). Changes in teacher training within the TPACK model framework: A systematic review. *Sustainability*, *11*(7), 1870.

Setiawan, H., Phillipson, S., & Isnaeni, W. (2019). Current trends in TPACK research in science education: a systematic review of literature from 2011 to 2017. *Journal of Physics: Conference Series*, *1317*(1), 012213.

Shi, L., & Jiang, L. (2022). How EFL teachers perceive and self-evaluate the knowledge components in forming Technological Pedagogical Content Knowledge (TPACK). *English Language Teaching Educational Journal*, *5*(1), 1-15.

Singerin, S. (2022). The Effect Supervision on Teacher Performance through TPACK as Mediating Variable. *Scholars Journal of Arts, Humanities and Social Sciences*, *10*(2), 39-51.

Soler-Costa, R., Moreno-Guerrero, A. J., López-Belmonte, J., & Marín-Marín, J. A. (2021). Co-word analysis and academic performance of the term TPACK in web of science. *Sustainability*, *13*(3), 1481.

Tosuntaş, Ş. B., Çubukçu, Z., & Beauchamp, G. (2021). A new model for the factors that affect interactive whiteboard usage of teachers and its effect on performance. *Education and Information Technologies*, *26*(3), 3575-3592.

Tosuntaş, Ş. B., Cubukcu, Z., & Beauchamp, G. (2021). Teacher performance in terms of technopedagogical content knowledge competencies. *Kastamonu Education Journal*, *29*(1), 63-83.

Tseng, J. J., Chai, C. S., Tan, L., & Park, M. (2022). A critical review of research on technological pedagogical and content knowledge (TPACK) in language teaching. *Computer Assisted Language Learning*, *35*(4), 948-971.

Kotzebue, L. (2022). Beliefs, self-reported or performance-assessed TPACK: What can predict the quality of technology-enhanced biology lesson plans? *Journal of Science Education and Technology*, *31*(5), 570-582.

Wang, Y., Gu, X., & Liu, S. (2020). The investigation and analysis of pre-service teachers toward TPACK competencies. *Open Journal of Social Sciences*, *08*(12), 327-339.

Wu, Y. T., Chai, C. S., & Wang, L. J. (2022). Exploring secondary school teachers' TPACK for video-based flipped learning: The role of pedagogical beliefs. *Education and Information Technologies*, *27*(6), 8793-8819.

Xiong, X. B., Ching Sing, C., Tsai, C. C., & Liang, J. C. (2022). Exploring the relationship between Chinese pre-service teachers' epistemic beliefs and their perceptions of technological pedagogical content knowledge (TPACK). *Educational Studies*, *48*(6), 750-771.

Yeh, Y. F., Chan, K. K. H., & Hsu, Y. S. (2021). Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process. *Computers & Education*, *171*, 104238.

Zhang, S., Liu, Q., & Cai, Z. (2019). Exploring primary school teachers' technological pedagogical content knowledge (TPACK) in online collaborative discourse: An epistemic network analysis. *British Journal of Educational Technology*, *50*(6), 3437-3455.

Zhang, W., & Tang, J. (2021). Teachers' TPACK development: A review of literature. *Open Journal of Social Sciences*, *9*(7), 367-380.