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Trend of Technological Pedagogical Content Knowledge (TPACK) for Pre-service Science Teacher: A Historical Review

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Abstract *– Technological pedagogical content knowledge (TPACK) is critical for effective technology-enhanced education and has been increasing for several years. This research aims to provide a historical overview of TPACK-related studies for pre-service teachers, particularly those in the science department. The databases held 143 papers from 2012 to 2022, which were reviewed in four steps: identification, screening, eligibility, and inclusion, yielding 44 noteworthy articles on TPACK research. The meta-analysis design was utilized in the study, with the parameters of the study's purpose, method/design, sample, data collection, and location. According to the data, most studies measure pre-service teachers' TPACK using a variety of techniques and samples. And recently, the quantitative method has grabbed the lead. TPACK studies have grown in quantity over time, with the emphasis on measuring and enhancing pre-service teachers' TPACK. Despite the fact that the trend is increasing, the Indonesian context is still rare, and this study suggests that additional research into the TPACK environment in Indonesia is essential.*

Keywords: *historical review; pre-service teacher; science education; TPACK*

I. INTRODUCTION

The world has entered the fourth industrial revolution, and technological advances are having an influence on education as technological innovations are being integrated into a variety of sectors (Ergen et al., 2019). As children who grow up in the twenty-first century face real-life difficulties (Rizal et al., 2020), schools must educate them to face a range of future events and scenarios (Efwinda & Mannan, 2021). Traditional schooling cannot simply handle these real-world difficulties (Boisandi & Alsagaf, 2021; Suganda et al., 2021). As a result, pre-service teachers' capacity toward technology (Rahmawati et al., 2021; Muchlis et al., 2018) and to combine it with pedagogy

and content, is critical (Putri et al., 2021). In this context, Mishra and Koehler (2006) established the Technological Pedagogical Content Knowledge (TPACK) model, which is based on the Pedagogical Content Knowledge model (Shulman, 1986).

The interactions among content, pedagogy and technology form the core of what has been called TPACK, a distinct type of flexible knowledge required for effective use of technology in classroom teaching (Mouza et al., 2014). Therefore, it is generally argued that pre-service teachers should acquire subject-specific professional knowledge regarding technology integration to be able to support their future students' learning. The professional knowledge related to a successful subject-specific integration of technology is commonly subsumed under the concept of technological pedagogical content knowledge (Lachner et al., 2021).

Others have used the TPACK framework to understand teachers' experiences and perceptions as they teach with technology (Bonafini & Lee, 2021). However, in an international context, the TPACK-framework has emerged as an important avenue for understanding teachers' abilities to combine diverse fields of competence. Over the years, numerous studies have explored empirically and theoretically possibilities and constraints within this framework (Tømte et al., 2015).

Recently, the definition of TPACK has been thoroughly discussed, and it has been a source of worry among teacher education academics (Haryanto et al., 2021). Previous studies have examined pre-service teachers' technology pedagogical and content knowledge (Canbazoglu Bilici et al., 2016; Irwanto et al., 2022; Nordin et al., 2013; Tondeur et al., 2017; Tyarakanita, 2020). Other researchers have also considered creating of measures to evaluate pre-service teachers' TPACK (Alharbi, 2019; Kabakci Yurdakul et al., 2012; Lyublinskaya & Tournaki, 2015).

This study aimed to discuss the trend of pre-service teachers' TPACK. Research on TPACK, especially for pre-service science teachers, has not been widely applied in Indonesia. This study is focused on reviewing articles about pre-service teachers' TPACK, considering that this ability is an important skill in the 21st-century and has become the basis for world progress and development (Nasar et al., 2020; Bancong et al., 2021). For the previous decade, little study has been conducted on the trajectory of pre-service teachers' TPACK. Therefore, the purpose of this work is to conduct a historical meta-analysis of TPACK-related research from 2012 to 2022. Our findings map out the TPACK tendency among pre-service science teachers, which has been a source of consternation in earlier theoretical studies on the subject.

II. METHODS

The meta-analysis approach was used in this study. This method tries to integrate statistical analysis of quantitative findings from separate and related investigations, as well as study outcomes, in a logical and consistent manner (Demirel & Dağyar, 2016; Suganda et al., 2021). The sample for this study was chosen after reviewing the findings of research publications on pre-service teachers' TPACK.

The research articles were determined by browsing the Scopus and SINTA (Science and Technology Index) databases using the keyword "pre-service teachers' TPACK". 143 articles from 2012-2022 were chosen based on the keyword and assessed in four stages: identification, screening, eligibility, and inclusion. Figure 1 depicts the various stages of this investigation.

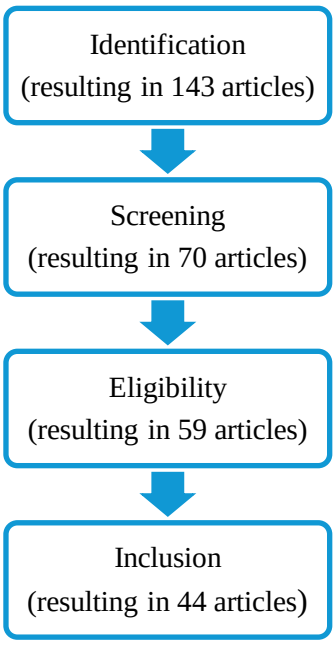

Figure 1. The flow diagram of the study

The first stage was identification, during which the researchers searched the Scopus and SINTA databases for papers related to the problem under consideration. The second stage was screening, in which the researcher selected relevant papers from a pool of 143 articles on pre-service teachers' TPACK research published in journals that are still indexed in Scopus and SINTA until 2022. Even after applying the keyword, the results were still too wide, such as studies that assessed in-service teachers' TPACK and building TPACK-based modules or courses. The third step was to determine eligibility. The researchers examined and evaluated the articles that would be used as evidence in the argument, omitting studies that did not focus on pre-service teachers and their TPACK competence. Only researchers with samples of pre-service teachers were chosen. The researchers detailed their findings from the article analysis in the conclusion step. Finally, 44 studies were included in the meta-analysis, as shown in Table 1.

Table 1. Summary of study

No	Database	n
1	Scopus	40
2	SINTA	4
Total		**44**

The research was classified and tagged using four parameters: the objective of the studies, the participants, the method/design, data collection, and the location of the study, and it was sorted by publication year. The

papers were then examined by parameter to determine the trend in each year during the previous ten years. The purpose of the studies was divided into scaling TPACK, scaling TPK, scaling PCK, and instrument development. The sample of the studies was divided into six groups: pre-service science teachers, pre-service physics teachers, pre-service chemistry teachers, pre-service mathematics teachers, non-science pre-service teachers, and pre-service teachers (from various programs). The methods of the studies were divided into qualitative, quantitative, and mixed methods. Data collection for the studies was divided into several types: questionnaire, document, interview, performance assessment, observation sheet, and open-ended questions. The last parameter is the locations of the study, which were divided between foreign countries and Indonesia.

III. RESULTS AND DISCUSSION

Table 2 displays the purposes contained in four different codes. These codes identify how the purposes of the TPACK-related studies variates within the year. During 2012 – 2016 little has been done to examine pre-service teachers' TPACK, although there was also an attempt at developing TPACK instruments. As the year goes by, many researchers have tried to explore pre-service teachers' TPACK and the other intersection domains as well such as TPK and PCK. New instrument development also has been done in the recent years.

Table 2. Frequencies of the purpose of the study

Year	Code	n
2012	Scaling TPACK	2
	Instrument development	1
2013	Scaling TPACK	2
2014	Scaling TPACK	1
2015	Scaling TPACK	1
2016	Scaling TPACK	2
2017	Scaling TPACK	5
2018	Scaling TPACK	5
2019	Scaling TPACK	1
	Scaling TPK	1
	Instrument development	1
2020	Scaling TPACK	9
	Scaling TPK	1
2021 - now	Scaling TPACK	10
	Scaling PCK	1
	Instrument development	1
	Total	**44**

Table 3 displays the variation of samples in these researches along the year. For the first 5 years, researchers seem to not aim for pre-service teachers in a certain field for the reason that many samples that taken were pre-service teachers whose fields were not specified or pre-service teachers from many different fields. In the recent years, many studies have specified their samples, especially in the science field, such as pre-service physics and mathematics teachers.

Table 3. Frequencies of the sample of the study

Year	Code	n
2012	Pre-service science teacher	2
	Pre-service teachers	1
2013	Pre-service teachers	2
2014	Non-science pre-service teachers	1
2015	Pre-service teachers	1
2016	Pre-service teachers	1
	Pre-service science teachers	1
2017	Pre-service teachers	4
	Pre-service chemistry teachers	1
	Pre-service science teachers	2
	Pre-service physics teachers	1
2018	Pre-service mathematic teachers	1
	Non-science pre-service teachers	1
2019	Pre-service teachers	3
2020	Pre-service science teachers	3
	Pre-service physics teachers	1
	Pre-service mathematic teachers	1
	Non-science pre-service teachers	3
	Pre-service teachers	2
2021 – now	Pre-service science teachers	2
	Pre-service physics teachers	3
	Pre-service mathematic teachers	2
	Non-science pre-service teachers	2
	Pre-service teachers	3
	Total	**44**

Table 4 displays the variation of method or design used in the studies. From three different methods, which were quantitative, qualitative, and mixed methods, stems many different designs. During 2012-2016, there seemed to be a lot of studies that used mixed methods, but along the year, more designs have been used especially the qualitative approach, which has a positive trend and becoming more common in the recent years.

Table 4. Frequencies of the method of the study

Year	Code		n
2012	Qualitative	Case study	2
2013	Quantitative	Research & development	1
	Mixed methods		1
2014	Mixed methods		1
2015	Mixed methods		1
2016	Quantitative	Research & development	1
	Qualitative	Case study	1
2017	Quantitative	Descriptive	1
		Correlational research	1
		Research & development	3
2018	Quantitative	Descriptive	1
		Survey research	1
		Regression Analysis	1
	Qualitative	Descriptive	1
		Case study	1
2019	Quantitative	Correlational research	1
		Research & design	1
	Qualitative	Other (not specified)	1
2020	Quantitative	Correlational research	1
		Research & development	3
	Qualitative	Correlational research	1
		Case study	2
	Mixed methods		3
2021 – now	Quantitative	Descriptive	2

		Quasi experimental	3
		Research & development	1
	Qualitative	Descriptive	2
		Case study	2
		Iterative categorization	1
		Other (not specified)	1
	Mixed methods		1
Total			**44**

Table 5 shows the variation of data collection tools in the studies. For the past ten years, the questionnaire has been the most frequently produced and used instrument to assess pre-service teachers' TPACK since self-assessment instruments are simple to use and allow for a large number of participants to be reached. Although the participants' capacity to appraise their own knowledge limits their precision in gauging pre-service teachers' genuine TPACK (Abbitt, 2011). Thus, in recent years, many studies have also used different data collection tools, such as performance assessment (Nasar et al., 2020; Putri et al., 2021) and documentation (Haryanto et al., 2021; Koh, 2013; Srisawasdi, 2012; Valtonen et al., 2017). Researchers have also attempted to employ several instruments in a single study to gain a better understanding of TPACK (Assadi & Hibi, 2020; Deng et al., 2017; Gonzales & Gonzales, 2021; Hofer & Grandgenett, 2012), resulting in more codes than the total number of studies.

Table 5. Frequencies of the data collection of the study

Year	Code	n
2012	Questionnaire	2
	Document	2
2013	Questionnaire	1
	Document	1
	Interview	1
2014	Questionnaire	1
	Performance assessment	1
2015	Questionnaire	1
2016	Questionnaire	1
	Document	1
	Performance assessment	1
2017	Questionnaire	5
	Document	1
2018	Questionnaire	5
	Observation sheet	2
	Performance assessment	1
2019	Questionnaire	2
	Open-ended questions	1
	Interviews	1
2020	Questionnaire	8
	Open-ended questions	1
	Document	4
	Interview	1
	Performance assessment	2
2021-now	Questionnaire	5
	Document	5
	Interview	2
	Performance assessment	4
Total		**63**

Table 6 shows the location of the studies. Given that SINTA was employed as one of the databases for this study, it demonstrates that few Indonesian academics have attempted to investigate technology pedagogical and content knowledge, particularly in teacher education. Nonetheless, numerous Indonesian-based TPACK research

has increased in recent years, indicating a promising trend.

Table 6. Frequencies of the location

Year	Code	n
2012	Foreign country	3
2013	Foreign country	2
2014	Foreign country	1
2015	Foreign country	1
2016	Foreign country	2
2017	Foreign country	5
2018	Indonesia	1
	Foreign country	4
2019	Foreign country	3
2020	Indonesia	2
	Foreign country	8
2021-now	Indonesia	6
	Foreign country	6
Total		**44**

As seen in the tables, TPACK related research has grown in number. The purpose of the still have the same focus for years, which is the measurement of TPACK (Setiawan et al., 2019). Although, several researchers have attempted on making new instruments recently (Yeh et al., 2021). The sample has also been growing in variety, coming from large numbers of pre-service teachers of different programs to specific ones like pre-service physics or chemistry teachers. In recent years, many TPACK related studies have been done quantitatively with different data collection tools. But the most instrument used throughout the years is the self-assessment questionnaire (Wang et al., 2018). In Indonesia, studies exploring pre-service teachers' TPACK were still rare, considering out of 44 articles analyzed, only 9 were done by Indonesian scholars.

IV. CONCLUSION AND SUGGESTION

According to the study, measuring pre-service teachers' TPACK has dominated the goals of TPACK-related studies during the previous ten years. However, to delve deeper into TPACK, more researchers have created new tools such as performance assessments, interviews, and documentation. There is also a propensity to employ the mixed methods approach used in earlier research. Nonetheless, as academics seek a larger sample size, the quantitative method has recently taken the lead. For example, many recent studies have also included pre-service teachers from certain fields, such as physics and mathematics.

The findings of this study have to be seen in the light of some limitations. There are many journals that the researchers do not have access to, and the TPACK-related articles published in reputational Indonesian journals were also short in number, resulting in limited articles to be analyzed. For future research, it is suggested to have a larger quantity of articles in order to see the trend more clearly. Despite their growing numbers, few Indonesian researchers have been interested in TPACK, much alone published their work in recognized publications that Scopus or SINTA may index. It is advised that the TPACK of Indonesian pre-service

teachers be investigated further to improve education in Indonesia.

REFERENCES

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education*, *43*(4), 281–300. https://doi.org/10.1080/15391523.2011.10782573

Alharbi, H. E. (2019). An Arabic assessment tool to measure technological pedagogical and content knowledge. *Computers and Education*, *142*. https://doi.org/10.1016/j.compedu.2019.103650

Assadi, N., & Hibi, W. (2020). Developing pre-service teachers' mathematics TPACK through an integrated pedagogical course. *Creative Education*, *11*(10), 1890–1905. https://doi.org/10.4236/ce.2020.1110138

Bancong, H., Putra, D. P., & Nurazmi. (2021). The purposes of students in conducting thought experiments while solving physics problem. AIP Conference Proceedings, 2330(1), 050032. https://doi.org/10.1063/5.0043195

Boisandi, B., & Alsagaf, S. L. H. (2021). Developing Electrical Magnetic Textbook Based On Technological Pedagogical Content Knowledge (TPCK). *Jurnal Pendidikan Fisika*, *9*(1), 14–24. https://doi.org/10.26618/jpf.v9i1.4379

Bonafini, F. C., & Lee, Y. (2021). Investigating prospective teachers' TPACK and their use of mathematical action technologies as they create screencast video lessons on ipads. *TechTrends*, *65*, 303–319. https://doi.org/10.1007/s11528-020-00578-1/Published

Canbazoglu Bilici, S., Guzey, S. S., & Yamak, H. (2016). Assessing pre-service science teachers' technological pedagogical content knowledge (TPACK) through observations and lesson plans. *Research in Science and Technological Education*, *34*(2), 237–251. https://doi.org/10.1080/02635143.2016.1144050

Demirel, M., & Dağyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(8), 2115–2137. https://doi.org/10.12973/eurasia.2016.1293a

Deng, F., Chai, C. S., So, H.-J., Qian, Y., & Chen, L. (2017). Examining the validity of the technological pedagogical content knowledge (TPACK) framework for preservice chemistry teachers. In *Australasian Journal of Educational Technology*, 33(3). https://doi.org/10.14742/ajet.3508

Efwinda, S., & Mannan, M. N. (2021). Technological pedagogical and content knowledge (TPACK) of prospective physics teachers in distance learning: Self-perception and video observation. *Journal of Physics: Conference Series*, *1806*(1), 1–7. https://doi.org/10.1088/1742-6596/1806/1/012040

Ergen, B., Yelken, T. Y., & Kanadli, S. (2019). A meta-analysis of research on

technological pedagogical content knowledge by gender. *Contemporary Educational Technology*, *10*(4), 358–380. https://doi.org/10.30935/cet.634182

Gonzales, G. G., & Gonzales, R. R. (2021). Introducing IWB to preservice mathematics teachers: An evaluation using the TPACK framework. *Cypriot Journal of Educational Sciences*, *16*(2), 436–450. https://doi.org/10.18844/CJES.V16I2.5619

Haryanto, Z., Sulaeman, N. F., Nuryadin, A., Putra, P. D. A., Putri, S. A., & Rahmawati, A. Z. (2021). Learning how to plan a science lesson: An exploration of preservice science teacher reflection in online microteaching. *Journal of Physics: Conference Series*, *2104*(1). https://doi.org/10.1088/1742-6596/2104/1/012017

Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary M.A.Ed. program. *Journal of Research on Technology in Education*, *45*(1), 83–106. https://doi.org/10.1080/15391523.2012.10782598

Irwanto, I., Redhana, I. W., & Wahono, B. (2022). Examining perceptions of technological pedagogical content knowledge (TPACK): A perspective from Indonesian pre-service teachers. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 142–154. https://doi.org/10.15294/jpii.v11i1.32366

Kabakci Yurdakul, I., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers and Education*, *58*(3), 964–977. https://doi.org/10.1016/j.compedu.2011.10.012

Koh, J. H. L. (2013). A rubric for assessing teachers' lesson activities with respect to TPACK for meaningful learning with ICT. *Australasian Journal of Educational Technology*, *6*, 29. https://doi.org/10.14742/ajet.228

Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., Küchler, U., Paravicini, W., Randler, C., & Thomas, P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers and Education*, *174*. https://doi.org/10.1016/j.compedu.2021.104304

Lyublinskaya, I., & Tournaki, N. (2015). Examining the relationship between self and external assessment of TPACK of pre-service special education teachers. *Society for Information Technology & Teacher Education International Conference*, 3331–3337.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Muchlis, F., Sulisworo, D., & Toifur, M. (2018). Pengembangan alat peraga fisika berbasis internet of things untuk praktikum hukum newton II. *Jurnal Pendidikan Fisika*, *6*(1), 13–20. https://doi.org/10.26618/jpf.v6i1.956

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Yilmaz Ozden, S., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers and Education*, *71*, 206–221. https://doi.org/10.1016/j.compedu.2013.09.020

Nasar, A., Kaleka, M. B. U., & Alung, H. v. (2020). Applying the learner-centered micro teaching model for improving teaching confidence, attitudes toward teaching profession, and pedagogical content knowledge (PCK) of physics education students. *Jurnal Pendidikan Fisika*, *8*(3), 235–248. https://doi.org/10.26618/jpf.v8i3.3607

Nordin, H., Davis, N., & Ariffin, T. F. T. (2013). A case study of secondary pre-service teachers' technological pedagogical and content knowledge mastery level. *Procedia - Social and Behavioral Sciences*, *103*, 1–9. https://doi.org/10.1016/j.sbspro.2013.10.300

Putri, S. A., Sulaeman, N. F., Damayanti, P., & Putra, P. D. A. (2021). Fostering TPACK in pre-service physics teachers during the covid-19 pandemic. *Journal of Physics: Conference Series*, *2104*(1). https://doi.org/10.1088/1742-6596/2104/1/012006

Rahmawati, A. Z., Haryanto, Z., & Sulaeman, N. F. (2021). Digital literacy of indonesian prospective physics teacher: Challenges beyond the pandemic. *Journal of Physics: Conference Series*, *2104*(1). https://doi.org/10.1088/1742-6596/2104/1/012004

Rizal, R., Rusdiana, D., Setiawan, W., & Siahaan, P. (2020). The digital literacy of the first semester students in physics education. *Jurnal Pendidikan Fisika*, *8*(2), 101–110. https://doi.org/10.26618/jpf.v8i2.3293

Setiawan, H., Phillipson, S., Sudarmin, & 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). https://doi.org/10.1088/1742-6596/1317/1/012213

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Research*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Srisawasdi, N. (2012). The role of TPACK in physics classroom: case studies of preservice physics teachers. *Procedia - Social and Behavioral Sciences*, *46*, 3235–3243. https://doi.org/10.1016/j.sbspro.2012.06.043

Suganda, E., Latifah, S., Irwandani, Sari, P. M., Rahmayanti, H., Ichsan, I. Z., & Rahman, M. M. (2021). STEAM and environment on students' creative-thinking skills: A meta-analysis study. *Journal of Physics: Conference Series*, *1796*(1). https://doi.org/10.1088/17426596/1796/1/012101

Tømte, C., Enochsson, A. B., Buskqvist, U., & Kårstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK-framework goes online. *Computers and Education*, *84*, 26–35.

https://doi.org/10.1016/j.compedu.2015.01.005

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2017). A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap! *Australasian Journal of Educational Technology*, *33*(3). https://doi.org/10.14742/ajet.3504

Tyarakanita, A. (2020). A case study of pre-service teachers' enabling TPACK knowledge: lesson design projects. *ELS Journal on Interdisciplinary Studies in Humanities*, *3*(2), 158–169. https://doi.org/10.34050/els-jish.v3i2.10006

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, *33*(3), 15–31. https://doi.org/10.14742/ajet.3518

Wang, W., Schmidt-Crawford, D., & Jin, Y. (2018). Preservice teachers' TPACK development: A review of literature. *Journal of Digital Learning in Teacher Education*, *34*(4), 234–258. https://doi.org/10.1080/21532974.2018.1498039

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 and Education*, *171*. https://doi.org/10.1016/j.compedu.2021.104238