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Technological Pedagogical Content Knowledge (TPACK) Model in teaching: A Review and Bibliometric Analysis

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Abstract

TPACK (Technological Pedagogical Content Knowledge) is an entirely new teaching model in the science of education field, founded about five years ago. There is still some room for improvement and discussion to develop this model. Some studies argue that the model is irrelevant to practical context due to its vague definitions. On the other hand, some studies argue that the model is the best for learning quality in technology. Thus, it is crucial to do more comprehensive studies to investigate the factors related to the TPACK model. This article clarifies which items are relevant to TPACK. It is essential to map the database associated with TPACK. By conducting bibliometric analysis and adjusting the WoS abbreviation from Web of Science indexing filters by category, this article seeks to provide a database linked to TPACK themes published in WoS-indexed publications in the past five years. The collected findings are categorised based on metric comparisons, the top 10 publications, the top 20 journals that publish articles regarding TPACK, and visualisation using bibliometric analysis. This research contributes to developing literature regarding the determinants of TPACK model implementation. This research found that the most vital elements of the five clusters were PCK, model, technology integration, education, and framework. Moreover, this research proposes another factor, such as pre-service teachers' teaching abilities, that may impact TPACK.

Keywords: TPACK, teaching, Bibliometric Analysis.

Introduction

The needs of innovative learning models' study is vital to provide more comprehensive literature for improving educational quality. Therefore, there have been various learning models changing, mainly due to technological changes. Because technological changes have supported the growth and development of knowledge rapidly; the industrial revolution 4.0 in the field of information and communication, the speed of knowledge transfer resulting from the industrial revolution 4.0 can cause pressure on educational institutions to become more memorable, creative and innovative in this change (Shakhman et al., 2020). Thus, educational sectors need to have a strategy to cope with the rapidly changing technology and the revolution of industry 4.0. The implication is the integration of various elements such as technology, pedagogy and content in learning, known as technological pedagogical content knowledge (TPACK).

Some previous studies related to the TPACK model show that this model can improve the quality of learning outcomes (Eng & Conch, 2019; JM Santos & Castro, 2021; Absari et al., 2020). Moreover, the TPACK concept has gained attention from researchers in the educational sector because this concept provides information and knowledge on how teachers should use technology proportionally and efficiently during the learning process. Therefore, it is necessary to map the database related to TPACK to find clarity on what elements are related to TPACK. TPACK is an attractive model because it combines several elements of primacy in teaching, such as technology, pedagogy, and content (Mulbar et al., 2018; Valtonen et al., 2017; Bingimlas, 2018). As this author demonstrated in earlier articles, it is vital to comprehend the criticism and analysis of the framework's efficiency and how it has been used to develop TPACK. This paper is a full review of the available databases. Regarding the use of TPACK in empirical studies, there are 305 academic articles in 5 years from 2018 to 2022.

TPACK model is focused on bridging the pedagogical knowledge and the real-life context given the current technological use (Harris et al., 2009; Muhammad & Maat, 2020; Santos & Castro, 2021). The structure of the TPACK, however, has drawn criticism for being impractical and overly broad. According to critics, some knowledge domains' definitions are incomplete and inaccurate, especially on technological elements that still seem broad and ambiguous (Cox & Graham, 2009). Nonetheless, several articles already try to elaborate on and explain the TPACK framework clearly. Such as the differences in each element that make up the TPACK itself (Charles R. Graham 2011; C. R. Graham et al. 2012).

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In this digital era, the highest focus is still on technology. However, it is indeed technology that is in the element of pedagogy and content that is still dominant or other elements that are more dominant in the framework of TPACK. The TPACK framework in the teaching context requires many appropriate reviews. Teaching is the interaction process with all the situations around the individual student. It is seen as a process directed towards achieving goals and doing through the various experiences that the teacher creates. The mastery of TPACK owned by teachers is also different in the teaching stage. In the intermediate teaching stage, there needs to be a technological integration skill that is corroborated with pedagogical ability in the face of students with different characteristics (Li et al., 2022).

This paper is a literature review paper about the TPACK framework, which aims to find the determinants of the TPACK model. By distribution and the country of their authors, articles that have been published and indexed by the Web of Science (WoS) are examined and categorised. This analysis might reveal which research areas are the focus of more publications and potential future TPACK areas that offer prospects for additional study.

Method

The systematic and transparent methodology that underpins this bibliometric literature assessment maps ideas centred on the boundaries of knowledge. The graphic below shows the steps.

There are five stages of bibliometric analysis (see Figure 1): determining search keywords, generating initial searches, improving search results, compiling initial data statistics, and conducting data analysis. It can be detailed in the review as follows.

Determine search keywords

On June 23, 2022, the terms "TPACK" and "teaching" were used in the search. WoS was chosen because it currently contains more than 10,000 journals and is the oldest citation database with a broad scope of citation and bibliographic data (Aghaei Chadegani et al., 2013). WoS comprises seven citation databases and includes information from journals, conferences, reports, books, and book series. The initial search, which included the keywords "TPACK" and "teaching," was refined by topic and turned up 798 articles which used filters of language, complete article, and year count 305 academic articles.

Initial search result

Filtered out are articles that are suitable and included in the WoS database. For example, the first filter selects 2018 to 2022, resulting in 428 articles. The second filter selects the English language, resulting in 305 articles.

Refinement of search result

Articles that are appropriate and indexed in WoS are filtered. Only selected articles are not in the form of proceedings, newspapers, books, book references, and book chapters are not included in this analysis. Then to make the appropriate repairs, the file is stored in the form of a RIS file that can be used for further analysis.

Compile preliminary data statistics

The gathered information is kept in RIS form. The initial stage involves checking the elements of a complete journal article (year of publication, volume, number, page, etc.); if any missing information is discovered, we add it. Then, data analysis is done to categorise articles by year, source of publishing, and publisher.

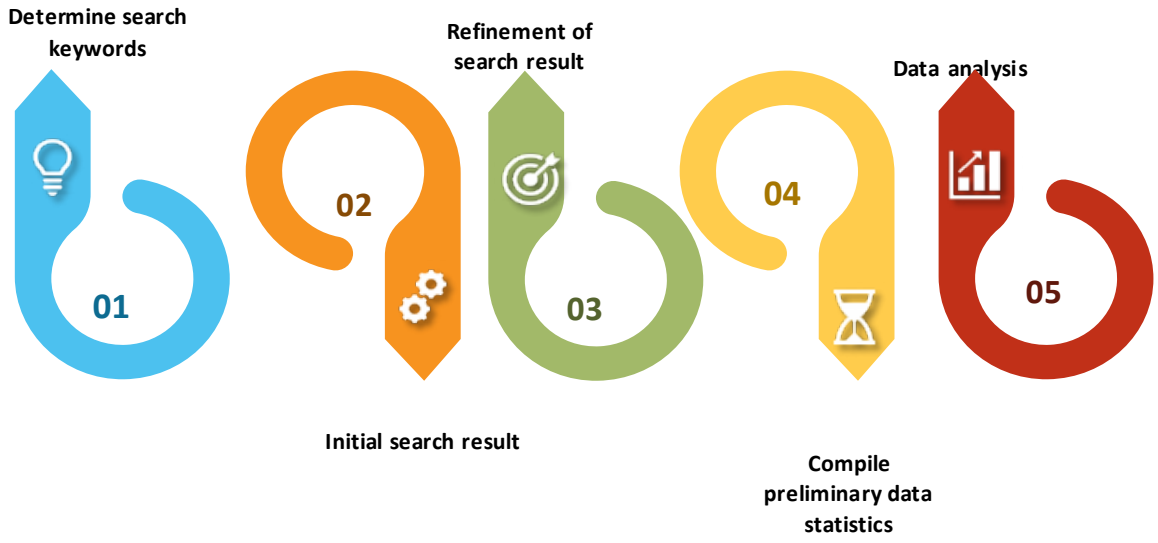

Fig. 1: Five-step method bibliometric analysis (Hudha et al., 2020)

Data analysis

VOSviewer software is used for bibliometric analysis in this study because it works effectively with big data sets and offers a variety of more intriguing visualisations, analyses, and investigations by loading publication maps, author maps, journal maps, or keyword maps based on shared networks. (van Eck & Waltman 2010; Bhattacherjee 2001; Effendy et al. 2021).

Findings

Publications and Citation Structure

The output is analysed based on VOSviewer software to determine which keywords appear most frequently. Nevertheless, the keywords that appear most often are tailored to data collection and analysis needs. Bibliometric maps that generate a network, overlay and density visualisations are viewed using VOSviewer. The table below contains the complete comparative findings (see table 1).

The author makes an effort to present the study's most pertinent contributions. The action was made by including 305 articles that had the highest citation value and the keywords "TPACK" and "teaching" (10 articles cited). Results similar to those in table 2 below can be achieved in addition to the most citations of the most pertinent publications.

Based on table 2 above, there are 10 article titles with the highest number of citations originating from 2017, as many as one article, 2018 as many as six articles and in 2020, as many as three articles with the highest number of citations, as many as 69 articles from Springer publishers and at least 32 citations also from Springer. Of the 10 article titles, it is generally done to prospective teachers. In addition, it examines TPACK, which is expanded with other knowledge, such as digital competencies possessed by teachers or the International Society for Technology in Education (ISTE), whose estuary is how TPACK is (Falloon, 2020; Nelson et al., 2019). The research also examined various factors such as technological knowledge, institutional support, pedagogical content knowledge, teacher technostress, computer self-efficacy, administrative support, and collegial support, which builds the TPACK and clarifies what variables make up the TPACK (Brinkley-Etzkorn, 2018; Willermark, 2018a; Tseng et al., 2019; Schmid et al., 2020; Dong et al., 2020). In addition, table 3.9 also discusses the design framework for implementing TPACK in learning and how the parties play a role in implementing the TPACK (Baran et al., 2017; Taimalu & Luik, 2019; Admiraal et al., 2017). The top 10 publishers who publish TPACK and teaching topics can be seen in table 3.

Table 1:Comparison Metrics

Metrics data	*Initial search*	*Refinement search*
Source	"TPACK" and "teaching."	"TPACK" and "teaching."
Publication year	all	2018 – 2022
Language	all	English
Papers	789	305

Source: Analysed by the authors

Table 3 shows that the ten highest publishers are Springer, with 18.033%, and the least published TPACK and teaching is Sage, with a percentage of 2.295%. The top 20 journals that publish TPACK and teaching topics can be seen in table 4.

The 20 top publications that frequently publish works on TPACK and education are listed in Table 4. The highest journal is Education and Information Technologies, with 6.557% published articles. Meanwhile, the fewest journals that contain articles about TPACK and teaching are the International Journal of Instruction at 1.311%. The 20 countries with relevant keywords TPACK and teaching can be seen in chart two below.

Figure 2 describes the country of origin of the article's author on TPACK and teaching the most. The highest country is the USA, and South Korea is the least discussing this topic. Figure 3 shows the presentation of data network visualisations on WoS data connected to the terms "TPACK" and "teaching," which have been refined in search, together with figure 4 and figure 5 below, which provide overlay and density visualisations.

Figure 3 describes keywords related to TPACK and teaching consisting of 1045 networks and 5 clusters. Furthermore, if it is clarified, will appear a greater connection to the unique colours and the magnitude of the circles in each keyword, as seen in figures 4, 5 and 6 below.

The close relationship between TPACK, the framework, and pedagogical subject knowledge is shown in Figure 4. (PCK). Figure 5 below shows how these clusters are related to one another.

Figure 5 shows the relationship between TPACK in one cluster (green) with technology, education, and technology integration. For other clusters, it can be seen in figure 6 below.

Figure 6 reviews that keywords related to TPACK and teaching also come from teacher education and technology integration.

Figure 7 describes the novelty of keywords seen from the year of publication, as 2019 with blue and 2020 with yellow, which indicates keywords most relevant to the topic of TPACK and teaching.

The visualisation's Figure 8 includes keywords that can be utilised as sources for additional research. Additionally, the visualisation alludes to TPACK, which is connected to yellow-coloured variables or technologies. These results are compiled from titles, keywords, and abstracts, with the minimum number of events set at 5. A total of 67 things met the criteria for 87 items. The term "common" is not used in this sentence. The size of the node identifies each item as an additional term. In other words, the node size reveals how often the keywords are used together. Here, five groups are named. The table 6

Table 2: Top 10 Articles Cited

No	*Publication Year*	*Author*	*Title*	*Journal*	*Cites*	*Publisher*	*Result*
1	2020	Falloon, Garry (Falloon, 2020)	From digital literacy to digital competence: the digital teacher competency (TDC) framework	Education Tech Research Development	69	Springer	This article presents a conceptual framework that introduces an expanded view of teacher digital competencies (TDC). In addition, this article recommends more complex frameworks and skills students require ethically, safely, and productively in a multi- and digitally dimensional environment.
2	2018	Brinkley-Etzkorn, Karen E. (Brinkley-Etzkorn, 2018)	Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens	The Internet and Higher Education	62	ELSEVIER SCIENCE INC	This research reveals a significant change in the TPACK model because there is an amalgamation of elements and a redesign of the syllabus, which shows an improvement in teaching effectiveness.

No	Publication Year	Author	Title	Journal	Cites	Publisher	Result
3	2018	Willermark, Sara (Willermark, 2018a)	Technological Pedagogical and Content Knowledge: A Review of Empirical Studies Published From 2011 to 2016	Journal of Educational Computing Research	53	SAGE Journal	This article describes a literature study of 107 articles from 2011 to 2016 that added the latest framework factors of the characteristics of the TPACK and the contribution of an analysis of the framework that has been applied to identify TPACK teachers. The existing findings to identify TPACK are generally carried out through self-reporting, and there is still a rare evaluation of the performance of teaching activities.
4	2018	Nelson, Michael J.; Voithofer, Rick; Cheng, Sheng-Lun (Nelson et al., 2019)	Mediating factors that influence the technology integration practices of teacher educators	Computers and Education	51	ELSEVIER	Research conducted on 806 teachers across the United States showed significant differences in the alignment of TPACK and International Society for Technology in Education (ISTE) standards across subject areas. However, that level of experience positively predicted the alignment of ISTE standards. A significant factor is that technical knowledge and institutional support in implementing TPACK are aligned with ISTE. So, this study recommends that institutions provide targeted support to cross-disciplinary teacher

No	Publication Year	Author	Title	Journal	Cites	Publisher	Result
4							educators and adopt a coherent technological framework for their programs.
5	2017	Evrim Baran,Sedef Canbazoglu Bilici,Aylin Albayrak Sari,Jo Tondeur (Baran et al., 2017)"	Investigating the impact of teacher education strategies on pre-service teachers' TPACK	British Journal of Educational Technology	45	BERA (British Educational Research Association)	The study was conducted on 215 pre-service teachers in three Turkish universities with the findings of a very positive relationship between teacher Education strategies (teachers as role models, reflecting on the role of Technology in Education, technology design, cooperation with peers, conducting ongoing feedback) and TPACK pre-service teachers.
6	2018	Taimalu, Merle; Luik, Piret (Taimalu & Luik, 2019)	The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis	Teaching and Teacher	44	ELSEVIER	This study aims to identify the impact of teacher educators' professional beliefs and knowledge on technology integra tion in 54 teachers. Its results show that the advantages of technology and its integration directly affect the integration of technology. Furthermore, beliefs about technology's value affect technology's integration indirectly, and pedagogical knowledge significantly affects technology integration. These results can be helpful for in-service training for teacher

No	Publication Year	Author	Title	Journal	Cites	Publisher	Result
6	2018	Taimalu, Merle; Luik, Piret (Taimalu & Luik, 2019)	The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis	Teaching and Teacher	44	ELSEVIER	educators and professional development programs for the university's teaching staff.
7	2017	Admiraal, Wilfried; van Vugt, Felix; Kranenburg, Frans; Koster, Bob; Smit, Ben; Weijers, Sanne; Lockhorst, Ditte (Admiraal et al., 2017)	Preparing pre-service teachers to integrate Technology into K-12 instruction: evaluation of a technology-infused approach	Technology, Pedagogy and Education	44	Informa UK Limited, trading as Taylor & Francis Group	This study aims to evaluate the courses taken by prospective teachers and how to integrate technological knowledge with pedagogical knowledge and content. The result of the research is that this integration still requires further development through collaboration between class teachers and prospective teachers about the knowledge and skills possessed by prospective teachers.
8	2018	Tseng, Jun-Jie; Cheng, Yuh-Show; Yeh, Hsi -Nan (Tseng et al., 2019)	How pre-service English teachers enact TPACK in the context of web-conferencing teaching: A design thinking approach	Computers & Education	35	ELSEVIER	This study examines how six aspiring English teachers designed the TPACK design and implemented it in a 14-week web conference teaching. Through quantitative content analysis of coded post-teaching discussions and qualitative analysis interview, it was found that while the teacher's discussion was prominently

No	Publication Year	Author	Title	Journal	Cites	Publisher	Result
8	2018	Tseng, Jun-Jie; Cheng, Yuh-Show; Yeh, Hsi -Nan (Tseng et al., 2019)	How pre-service English teachers enact TPACK in the context of web-conferencing teaching: A design thinking approach	Computers & Education	35	ELSEVIER	displayed orientation towards Pedagogical Content Knowledge, as opposed to technology-based Knowledge, their discussions are mainly not related to technology Pedagogical Knowledge. In addition, two contextual factors were found to influence web conferencing teaching: technical problems related to voice quality are identified as: micro -level contextual factors while teachers worry about their students' priorities knowledge and short attention spans are seen as student-centred contextual factors.
9	2020	Mirjam Schmid Eliana Brianza Dominik Petko (Schmid et al., 2020)which beside their inherent methodological limitations present constraints related either to the validity, reliability, or practical applicability of existing instruments. Furthermore, the i 1	Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK.xs) and comparing the factor structure of an integrative and a transformative model	Computers and Education	33	ELSEVIER	This study aims to develop a short questionnaire that is valid and reliable for measuring TPACK. In addition, this instrument is used to assess TPACK's internal relationships about whether the framework reflects an integrative or transformative view of how the TPACK knowledge domain interacts. Research involving pre-service high school teachers with 42 question items showed that the final TPACK.

No	Publication Year	Author	Title	Journal	Cites	Publisher	Result
		nternal structure of the TPACK framework is a topic of debate. The two goals of this study were					Furthermore, the internal relationships of the knowledge component support a transformative view of the TPACK mode.
10	2020	Yan Dong Chang Xu Ching Sing Chai Xuesong Zhai (Dong et al., 2020)	Exploring the Structural Relationship Among Teachers' Technostress, Technological Pedagogical Content Knowledge (TPACK), Computer Self-efficacy and School Support	*The Asia-Pacific Education Researcher*	32	Springer Link	This research built a structural model that considered teachers' technostress, TPACK, computer self-efficacy, administration support, and collegial support. Composite apparatus modified from earlier research. Data were gathered from 366 Chinese K–12 in-service teachers. Following the confirmatory factor analysis and exploratory, the factor analysis results revealed that the adapted.

Source: Analysed by the authors

shows the keywords displayed on each cluster representing the TPACK and instructional study flow.

With 1045 linkages and 3540 total strong links, Table 6 analyses around 67 items distributed throughout 5 clusters.

Discussion

The quantity of citations is the study's most important contribution. They were considering data from table 2 of the article with the most citations, specifically (Falloon, 2020) a variety of frameworks, models and literacies have been developed to guide teacher educators in their efforts to build digital capabilities in their students, that will support them to use new and emerging technologies in their future classrooms. Generally, these focus on advancing students' skills in using 'educational' applications and digitally-sourced information, or understanding effective blends of pedagogical, content and technological knowledge seen as supporting the integration of digital resources into teaching, to enhance subject learning outcomes. Within teacher education institutions courses developing these capabilities are commonly delivered as standalone entities, or there is an assumption that they will be generated by technology's integration in other disciplines or through mandated assessment. However, significant research exists suggesting the current narrow focus on subject-related technical and information skills does not prepare students adequately with the breadth of knowledge and capabilities needed in today's classrooms, and beyond. This article presents a conceptual framework introducing an expanded view of teacher digital competence (TDC, which examines the conceptual framework that introduces an expanded view of the digital competence of teachers (TDC) which turns out that the result is the need to expand the understanding of teacher education students about the kind of competencies necessary to function productively, safely and ethically in diverse and increasingly mediated environments digitally. It highlights this importance concerning the role of their future classes, educating young people to help them build the capacity to utilise the advantages of digital resources and information safely, securely, and sustainably. The second most citations were writings (Brinkley-Etzkorn, 2018) that published articles to analyse one method of instructing new online educators, evaluate their proficiency in teaching techniques, and assess how well they incorporated their expertise with what they had learned: Their aspects were included in the course syllabus

Table 3: 10 Publishers who Publish TPACK and Teaching Topic

Number	*Publishers*	*Record Count*	*%*
1	Springer Nature	55	18.033
2	Taylor & Francis	54	17.705
3	Elsevier	27	8.852
4	Mdpi	23	7.541
5	Emerald Group Publishing	12	3.934
6	Wiley	11	3.607
7	Frontiers Media Sa	9	2.951
8	Kassel Univ Press Gmbh	9	2.951
9	Igi Global	7	2.295
10	Sage	7	2.295

Source: Analysed by the authors

Table 4: lists the top 20 journals with publications on TPACK and pertinent teaching topics.

Number	*Journal*	*Record Count*	*%*
1	Education and Information Technologies	20	6.557
2	Computers Education	10	3.279
3	Education Sciences	10	3.279
4	British Journal of Educational Technology	8	2.623
5	International Journal of Emerging Technologies in Learning	8	2.623
6	Technology Pedagogy and Education	8	2.623
7	Sustainability	7	2.295
8	Journal of Research on Technology in Education	6	1.967
9	Australasian Journal of Educational Technology	5	1.639
10	Computer-Assisted Language Learning	5	1.639
11	Computers In Human Behavior	5	1.639
12	ETR D Educational Technology Research and Development	5	1.639
13	Frontiers in Psychology	5	1.639
14	Interactive Learning Environments	5	1.639
15	International Journal of Information and Communication Technology Education	5	1.639
16	Techtrends	5	1.639
17	Educational Technology Society	4	1.311
18	Frontiers in Education	4	1.311
19	International Journal for Technology in Mathematics Education	4	1.311
20	International Journal of Instruction	4	1.311

Source: Analysed by the authors

and after training. Overall, teachers' efficacy of instruction only slightly improved.

Furthermore, the third citation (Willermark, 2018b), which investigates how the framework has been used to demonstrate why TPACK is essential for teachers. In this study, the use of TPACK in empirical studies was examined in 107 peer-reviewed journal publications published between 2011 and 2016. The results show various of techniques and tools for TPACK teachers to consider. For example, self-reporting is the most popular method of determining instructors' TPACK; however, assessing how well teaching activities are performed is still not ideal. Additionally, the operationalisation of TPACK as a measuring instrument is frequently implicit and facilitates the comparison of challenging outcomes that serve as recommendations for the course of further research.

According to bibliometric research, there are five clusters for the keywords "TPACK" and "teaching," with Pedagogical

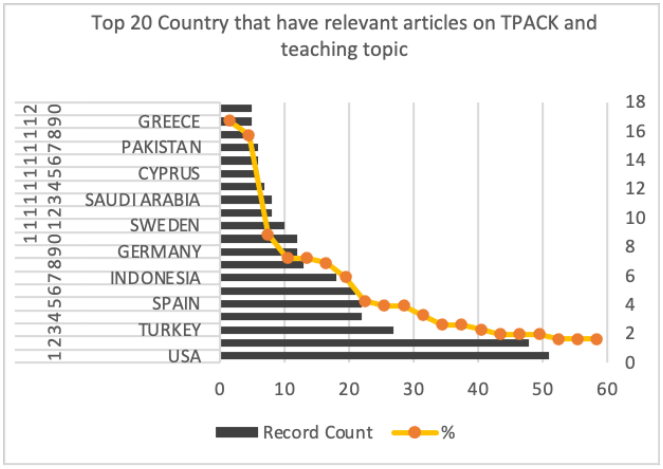

Fig. 2: Top 20 Countries that have relevant articles on TPACK and teaching topic
Source: Analysed by the authors

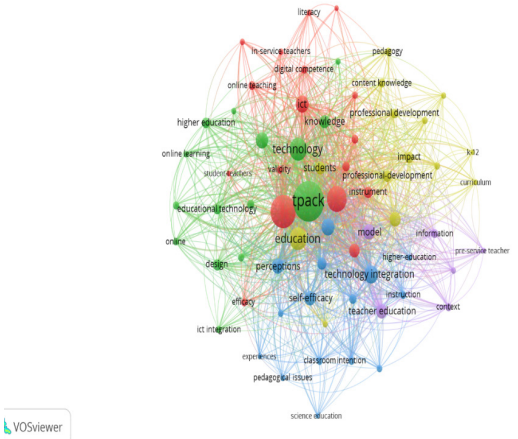

Figure 3: Network Visualization on a WoS database
Source: Analysed by the authors

Content Knowledge being the first cluster with the most links and highest occurrences (PCK). This indicates that most of the TPACK article's conversation has focused on PCK. This finding relates to the elements that meet the TPACK criteria, which is a complex relationship of knowledge about technology, pedagogy, and content in teaching, especially in teaching practice activities by utilising various types of software or learning media to improve learning performance carried out where PCK includes knowledge of students' learning difficulties, knowledge of Instructional Strategies, Knowledge of Program, Knowledge of Assessment, subject knowledge, etc. (Habibi et al., 2022subjective norms (SN;

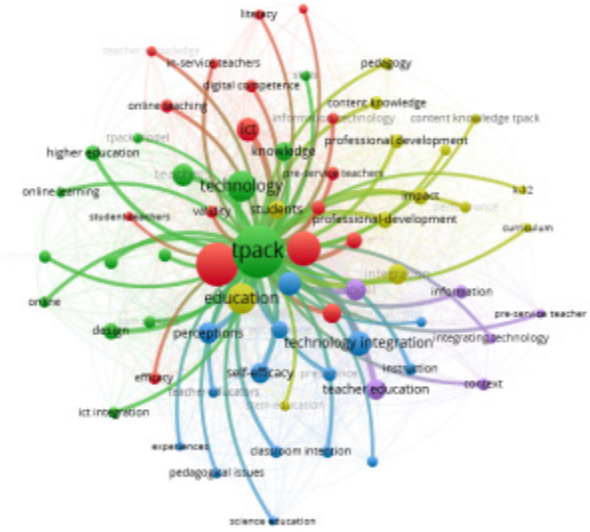

Fig. 4: Visualisation of a more specific database network
Source: Analysed by the authors

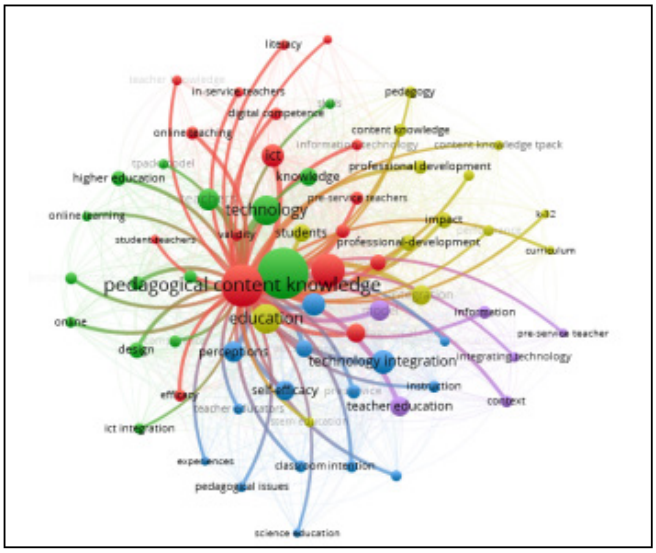

Fig. 5: Visualisation of a more specific database network
Source: Analysed by the authors

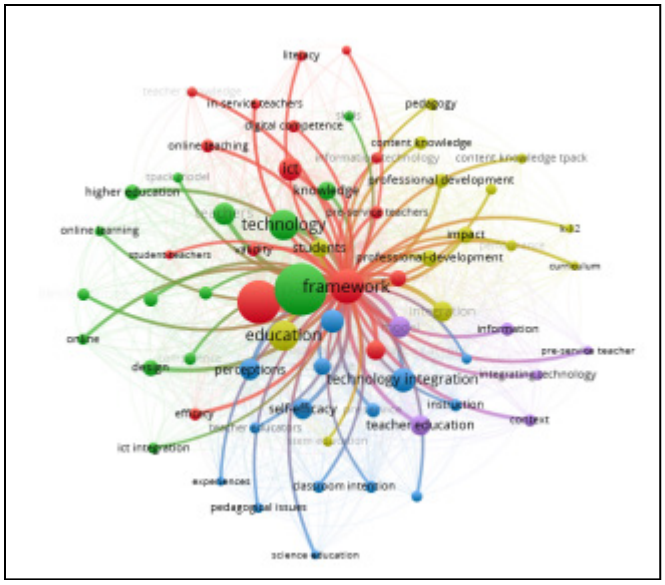

Fig. 6: Visualisation of a more specific database network

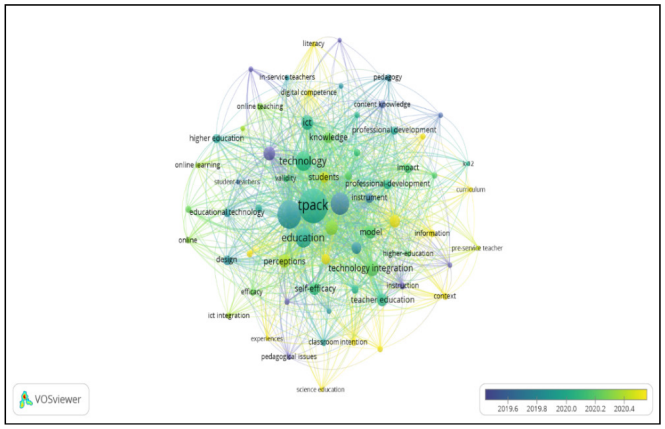

Fig. 7: Overlay Visualisation in the WoS database
Source: Analysed by the authors

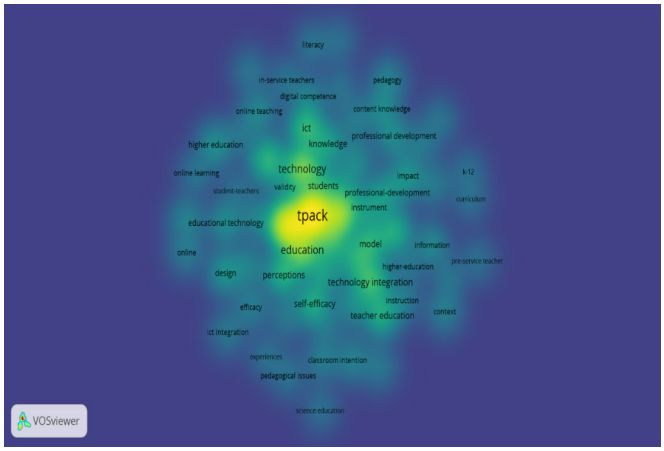

Fig. 8: Visualisation of density in the WoS database
Source: Analysed by the authors

Bardakcı & Alkan, 2019pedagogical framework, and integrated model. Within this scope, preservice teachers' behavioral

Table 6: VOSviewer TPACK

No	*Cluster*	*Link*	*Total Strenght*	*Occurrences*
	Cluster 1 (Red)			
1	Attitudes	32	71	13
2	Digital competence	31	56	9
3	Efficacy	21	45	9
4	framework	65	444	90
5	IT	50	199	38
6	in-service teachers	16	31	6
7	information technology	22	40	8
8	instrument	36	95	18
9	Literacy	18	25	6
10	online teaching	26	48	12
11	PCK	66	661	145
12	pre-service teachers	28	48	11
13	student-teachers	18	28	5
14	teacher knowledge	18	33	6
15	TK	14	19	5
16	TPACK	41	133	27
17	Validity	27	53	9
	Cluster 2 (Green)			
1	blended learning	20	42	10
2	competence	22	43	10
3	Design	31	85	17
4	educational Technology	31	61	14
5	higher education	26	65	15
6	ICT integration	17	25	7
7	Knowledge	38	99	23
8	Online	25	42	8
9	online learning	20	32	6
10	Skills	18	27	6
11	teacher training	20	44	11
12	Teachers	45	156	36
13	technology	60	327	69
14	TPACK	66	908	215
15	TPACK model	18	26	6
	Cluster 3 (Blue)			
1	acceptance	39	116	20
2	classroom	26	49	9
3	experiences	21	30	5
4	higher-education	21	32	6
5	instruction	35	60	9

No	*Cluster*	*Link*	*Total Strenght*	*Occurrences*
6	Intention	25	60	10
7	pedagogical issues	20	29	6
8	perceptions	49	186	32
9	pre-service	32	66	14
10	pre-service teachers	56	232	39
11	science education	19	30	5
12	self-efficacy	42	145	29
13	teacher educators	22	45	7
14	teacher professional development	23	37	7
15	technology integration	53	243	42
	Cluster 4 (Yellow)			
1	Content knowledge	26	49	12
2	Content knowledge TPACK	20	26	6
3	Curriculum	17	30	5
4	Education	61	359	67
5	Impact	32	86	17
6	Integration	49	172	30
7	K-12	16	24	5
8	mathematics education	19	31	7
9	pedagogy	21	37	10
10	performance	26	37	8
11	professional development	30	68	14
12	Professional -development	44	122	18
13	STEM Education	21	36	6
14	Student	49	118	23
	Cluster 5 (Purple)			
1	Context	25	50	9
2	Information	33	70	12
3	Integrating Technology	18	32	6
4	Model	53	186	32
5	Pre-service Teacher	15	28	5
6	Teacher Education	46	148	29

Source: Analysed by the authors

Study 1 (N = 284. Model innovations carried out to integrate TPACK, such as by using Virtual Reality that is based on interactive spherical video and the use of models such as the Technological Acceptance Model (TAM), are also able to be a solution for the implementation of TPACK (Geng et al., 2021; Liu et al., 2019) based on data from a sample of 198 in-service college-level foreign-language teachers in China. Its sequential explanatory research design involved, firstly, a quantitative approach to examine the structural relations among the TAM's variables, using path analysis on survey data; and secondly, qualitative interviews with a purposive sub-sample of 16 of the same teachers, aimed at identifying potential influences on the intention-behavior gap in their student-centered technology use. Analysis of the quantitative data indicated a significant relationship between the teachers' intention to use technology and their teacher-centered technology use of technology, but a non-significant relationship between intention to use technology and their student-centered technology use. The qualitative data revealed that facilitating conditions, prior experience with technology and technological pedagogical content knowledge (TPACK all of which focuses on quality education.

Conclusion

To develop educational quality needs to be supported by more comprehensive literature regarding innovative learning model such as TPACK model. This research contributes to developing literature regarding the determinants of TPACK model implementation. Moreover, this article laso aims to provide a database linked to TPACK themes published in WoS-indexed articles in the last five years by doing bibliometric analysis and altering the WoS—Web of Science—indexing filters by category. The findings indicate that there is a growing study in last five years in this theme and it is generally conducted to prospective teachers. In addition, this study found that the highest country is the USA, and South Korea is the least discussing this topic. According to bibliometric research, there are five clusters for the keywords "TPACK" and "teaching," with Pedagogical Content Knowledge being the first cluster with the most links and highest occurrences (PCK). Therefore, in order to map the database related to TPACK, it is crucial to identify the items pertinent to TPACK.. Through bibliometric analysis, it was found that the most vital elements of the five clusters were PCK, model, technology integration, education, and framework. Additional findings factors such as teacher training, higher education, and professional development also build a framework and can further strengthen the implementation of better TPACK. From the visualisation of overlay bases carried out through bibliometric analysis, it can be seen that studies associated with TPACK include elements of literacy, professional development, curriculum, intention, context and experience. Moreover, this research also recommends that another factor that affect TPACK such as pre-service teachers' teaching abilities. Thus, there are still a lot of determinants to be investigated to develop more literature regarding TPACK model. In addition, research studies related to TPACK and pre-service teachers can also be carried out by subsequent research. Further research is more towards TPACK, associated with elements that lead to pre-service teachers developing the skills and talents in applying TPACK.

Suggestion

Considering limitation of this study, it is suggested to involve various databases, such as Scopus, ProQuest to reach a more remarkable finding. Additionally, further research is forwarded to more towards TPACK, associated with elements that lead to pre-service teachers developing the skills and talents in applying TPACK. This paper also suggests proposing that another factor, such as pre-service teachers' teaching abilities, may impact TPACK.

Limitation

This article solely involved articles using Web of Science (WoS) database linked with TPACK in learning and it is purposed in the last five years. In addition, the selection of years is based on the latest and up-to-date elements of the studies discussed TPACK in learning.

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