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The Impact of Technological Pedagogical Content Knowledge (TPACK) on Learning Outcomes: A Bibliometric Review

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Abstract

This study aims to analyze the research landscape regarding Technological Pedagogical Content Knowledge (TPACK) which is related to learning outcomes, using the bibliometric analysis method. The data used comes from the Scopus database. After going through the four stages of the process (identification, screening, eligibility, and inclusion), 41 relevant data were obtained. The results showed that the most publications related to TPACK and learning outcomes occurred in 2022 with a total of 6 publications. Meanwhile, the most cited publication occurred in 2017 with 267 citations. The United States has had a major influence on TPACK research and study outcomes. The research focus is divided into three main parts, namely 1) engineering and curriculum; 2) teaching and student; and 3) technology integration. Several new themes in this field include self-regulation, children learning, self-assessment, teaching strategies, learning activities and educational computing. However, the TPACK keywords which were the most dominant in the three research focuses were not directly connected with the three new theme keywords, namely self-regulation, children learning, and teaching strategies. By understanding the trends and research focus related to TPACK and learning outcomes, researchers and education practitioners can obtain useful guidance for developing innovative and effective teaching strategies, as well as designing curricula that match students' learning needs.

Keywords: *bibliometrics, learning outcomes, TPACK*

I. INTRODUCTION

Research on learning outcomes has been carried out since the 19th century, where several previous studies have examined factors related to learning outcomes. For example, Bourner, (1997); Purdie & Hattie, (1999); Underwood & Underwood, (1998) conducted research on the effect of teaching methods, learning skills, and students' interactions with interactive talking books on student learning outcomes. Until now, this problem is still

the focus of research, as was done by Sarumaha et al., (2022); Supit et al., (2023); Yuliana et al., (2023) who examined the effect of articulation learning models, teacher digital literacy and learning environments, as well as visual, auditory, kinesthetic learning styles on student learning outcomes.

Learning outcomes refer to the abilities possessed by students after experiencing the learning process (Irawan, 2022). According to Muhammad, Marchy, et al., (2023), learning outcomes can be observed in the form of changes in student behavior that can be measured through changes in knowledge, attitudes, and skills. This change indicates an improvement and better development than before (Ahmed & Kumalasari, 2023; Darmayanti et al., 2023; Nasiha et al., 2023; Pradana & Uthman, 2023). There are several objectives of learning outcomes as stated by Irawan, (2022) providing information about students' progress in achieving learning goals through various activities; 2) provide information that can be used to further develop student learning activities; 3) provide information that can be used to evaluate student abilities, provide a basis for encouraging student learning motivation by recognizing their own progress, and encouraging improvement efforts; and 4) provide relevant information to assist students in choosing a school or career that suits their abilities, interests, and talents. Thus, learning outcomes are a measure of student progress which includes changes in knowledge, attitudes, and skills, and has the aim of providing information, encouraging learning motivation, and assisting students in self-development and decision making.

There are two factors that affect learning outcomes, namely endogenous factors and exogenous factors. Endogenous factors are factors that come from within students, while exogenous factors come from students' external environment such as parents, teachers, and the surrounding environment (Angraini et al., 2022). In the 21st century education era, teachers need to have the ability to integrate technological knowledge, facilitate learning, and improve student learning outcomes (Rahmadi, 2019). The combination of knowledge about material, pedagogy, and the use of technology is known as TPACK (Technological Pedagogical Content Knowledge) (Koehler et al., 2013). TPACK is a framework introduced by Mishra and Koehler that understands and describes the type of knowledge required by a teacher to integrate technology effectively in a learning context (Mustika & Temarwut, 2022). The TPACK model consists of three main components and four combined components. Its main components include technological knowledge (Technological Knowledge -TK), pedagogical knowledge (Pedagogical Knowledge -PK), and content knowledge (Content Knowledge -CK). In addition, there are four combined components consisting of Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK) (Mishra & Koehler, 2006). Thus, endogenous and exogenous factors affect student learning outcomes, and in the context of 21st century education, it is important for teachers to have TPACK knowledge which involves the integration of technology, pedagogy, and content knowledge in order to improve learning effectiveness and student learning outcomes.

Many studies have been conducted on TPACK and learning outcomes by (Cahya Yolanda et al., 2021; Nusa et al., 2021; Safitri et al., 2021). Therefore, it is important to analyze the results of these studies. One method that can be used to analyze major research publications is bibliometric analysis (Soraya et al., 2023). Bibliometric analysis uses statistical methods to analyze the results of publications in certain fields (Muhammad, Darmayanti, et al., 2023; Triansyah et al., 2023). This method has

been widely used in educational research (Angraini & Muhammad, 2023; Dwi et al., 2023; Maryanto et al., 2023; Muhammad, 2023; Muhammad, Triansyah, et al., 2023; Muhammad & Juandi, 2023; Samosir et al., 2023; Siahaan et al., 2023). Thus, bibliometric analysis is a useful approach for analyzing and understanding research results related to TPACK and learning outcomes that have been conducted, and has been used extensively in educational research.

II. RESEARCH METHODS

The method used in this research is descriptive bibliometric analysis. The data obtained came from the Scopus database related to TPACK's research on learning outcomes from 2009 to 2023. The data collection process was carried out in several stages such as identification, screening, eligibility and inclusion (Moher et al., 2009).

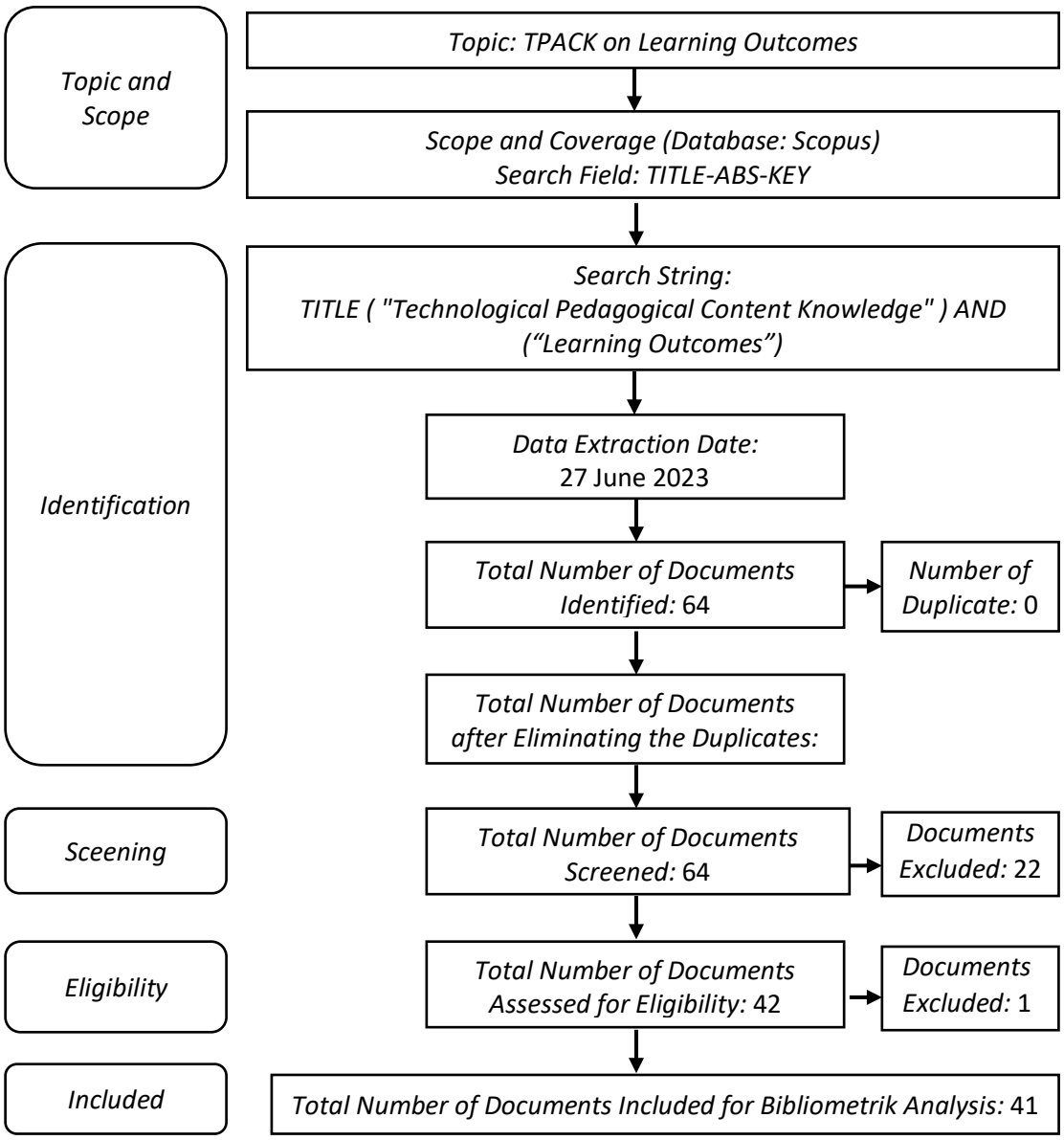

Figure 1. Data collection process

In Figure 1, it can be seen that the first step in data collection begins with identification. This step is done by entering keywords in the database used. In this study, the researchers entered the keywords "Technological Pedagogical Content Knowledge" AND "Learning Outcomes" in the Scopus database.

Based on the search, 64 publications were found that met the criteria at this stage. The second step is filtering. At this step the researcher sets several criteria, namely publication in the form of articles published in reputable journals or conference proceedings. After the screening process, 42 publications that match these criteria were obtained. In the third step, researchers manually checked the titles and abstracts of the 42 publications. The criteria used are whether the TPACK is related to learning outcomes and whether the articles use English. Publications that meet these criteria will be further analyzed at a later stage. At this feasibility stage, there was 1 publication that did not meet the set criteria, so that the number of publications that entered the inclusion stage was 41 documents.

Research data will be analyzed with the help of several applications. Publication trends related to TPACK's research on learning outcomes from 2009 to 2023 are displayed with the help of the Microsoft Excel application, which are grouped by year of publication. Publish or Perish application used to calculate total citations, total citations per year, h-inde x and g-index values. The Vosviewer application is used to see patterns of relations between countries related to TPACK's research on learning outcomes from 2009 to 2023, namely by network visualization. This application is also used to see the focus of research in this field and see the novelty of the research.

III. RESULTS AND DISCUSSION

Presentation of research results and discussion is organized based on research questions, starting with publication trends, citation trends, geographic distribution, patterns of relations between countries, research focus, and research novelty. The research found that the first publication in this field was found in 2009, and research is continuing into 2023.

What are the publication trends and citation trends regarding TPACK's research on learning outcomes from 2009 to 2023?

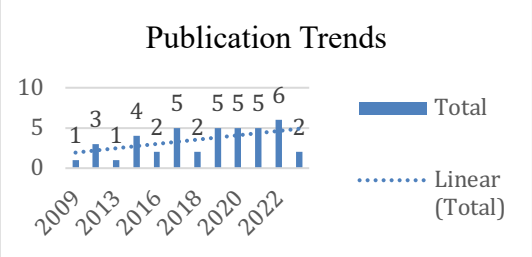

Figure 2. Publication trends (2009-2023)

Publications related to TPACK's research on learning outcomes from 2009 to 2023 are separated by year of publication. A total of 41 publications spread over the last few years. The number of publications in 2022 is the largest compared to other years. The trend of publications in this field has increased from year to year, this can be seen from the trend line (linear total) in Figure 2 below. on. Publications in recent years have seen a large increase in numbers. This is in accordance with what was stated by Zou et al., (2022) that research related to TPACK continues to increase every year. The biggest increase occurred from 2018 to 2019. In 2018 there were 2 published articles and increased to 5 publications the following year.

Table 1. Citation Analysis of Publications

year	TP	NCP	tc	C/P	h	g
2023	2	1	2	1	1	1
2022	6	4	41	6,83	2	6
2021	5	5	24	4.80	3	4
2020	5	4	267	53,40	3	5
2019	5	4	33	6,60	3	5

year	TP	NCP	tc	C/P	h	g
2018	2	2	11	5.50	2	2
2017	5	5	141	28,20	4	5
2016	2	2	19	9.50	2	2
2015	-	-	-	-	-	-
2014	4	3	44	11	3	4
2013	1	-	-	-	-	-
2012	3	2	74	24,67	2	3
2011	-	-	-	-	-	-
2010	-	-	-	-	-	-
2009	1	1	64	64	1	1

Notes. TP=total of publications, NCP=number of cited publications, TC=total citations, C/P=average citations per publication, h=h-index, g=g-index

Publications related to TPACK's research on learning outcomes were analyzed based on the number of citations per year from 2009 to 2023. Table 1 shows that the highest NCP scores were in 2021 and 2017 with 5 publications each citing at least 1 time out of the total publications in that year (TP = 5). Meanwhile, the highest total citations were in the 2020 publication with a total of 267 citations. The highest h-index value was in 2017 with h-index = 4. The h-index is an indicator of which publications in a particular year have a strong influence on this field. This means that publications in 2017 have had a very large influence on TPACK's research on learning outcomes. In 2017 there were 5 publications that had been cited at least 28 times as can be seen in Table 2.

Table 2. Articles published in 2017

No	Author (year)	title	Sources	Citation
1	Koh et al. (2017)	Teacher Professional Development for TPACK-21CL: Effects on Teacher ICT Integration and Student Outcomes	Journal of Educational Computing Research	97
2	Thomas & Munge (2017)	Innovative outdoor fieldwork pedagogies in the higher education sector: Optimizing the use of technology	Journal of Outdoor and Environmental Education	24
3	Mckenney & Voogt (2016)	Expert views on TPACK for early literacy: Priorities for teacher education	Australasian Journal of Educational Technology	12
4	Moundridou & Papanikolaou (2017)	Educating engineer educators on technology enhanced learning based on TPACK	IEEE Global Engineering Education Conference (EDUCON)	5
5	Hannaway & Steyn (2017)	Teachers' experiences of technology-based teaching and learning in the Foundation Phas	Early Child Development and Care	3

The study conducted by Koh et al. (Koh et al., 2017)was recorded as having the highest number of citations, namely 97 times. This research highlights the importance of teacher professional development focusing on improving TPACK for 21st century learning through engagement with peers and researchers in design teams. The results of this study indicate that the process has a positive effect on teachers' beliefs and practice of learning design, as well as improving student learning outcomes. Nevertheless, this study also has some limitations which can be the focus of future research. First, this research was conducted on teachers at an elementary school in Singapore. Future studies can confirm these findings by involving other primary schools, as well as involving secondary schools, colleges and other higher education institutions. In addition, it is important to pay attention to the school's leadership culture and its influence on the implementation of the professional development process. Second, in this study, the design team only completed one lesson design cycle. Future research could examine the long-term effects of this development process on teacher TPACK, design confidence, and student performance over multiple design cycles. Third, the construct validation of the survey instrument used is limited because the number of respondents is only 27. Therefore, only reliability statistics can be reported. Therefore, it is suggested that the survey instrument can be validated with a larger sample in future studies.

How does the geographic distribution of publications and the pattern of relations between countries relate to TPACK's research on learning outcomes?

The geographical distribution of countries and patterns of relations between countries are seen based on the origin of the authors of published documents related to TPACK on learning outcomes from 2009 to 2023. Figure 3 shows the geographical distribution of authors of publications related to TPACK on learning outcomes. The country with the highest number of publications is Indonesia, with 6 publications. In second place is the United States, with 5 publications, which is a country from the Americas. Furthermore, the country of Australia, from the continent of Australia, has a total of 4 publications. The geographic distribution of this publication covers almost all continents, including the Americas, Asia, Africa, Australia and Europe. Thus, these publications are spread evenly in various parts of the world. Interestingly, the Indonesian state has a significant impact in this study, in line with the findings by Nasir et al., (2023) which states that Indonesia and the United States are the countries with the most number of published articles in this field.

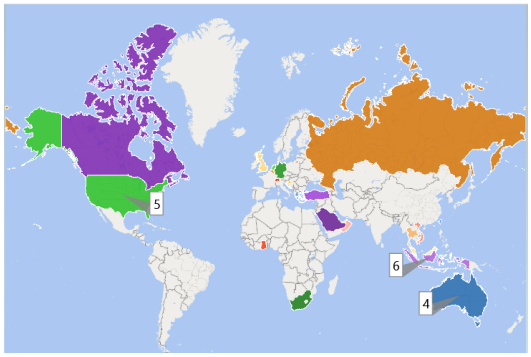

Figure 3. Geographic distribution

Figure 4 provides an overview of the relationship between countries based on the number of links. The United States of America has the highest number of links, namely 16 links. This shows the high level of cooperation between the United States and other countries. Figure 3 also shows the clusters that are distinguished by the color of the circle. The first cluster, which is marked with a red circle, consists of 13 countries that form separate clusters and conduct research collaboratively. Furthermore, the second cluster is marked with a green circle. Overall, it can be concluded that the United States has a significant influence in research related to TPACK on learning outcomes. Even though the

number of publications in the United States is only one difference from Indonesia, the United States has many links with other countries, indicating a high level of collaboration between researchers from the United States and other countries.

Figure 4. Patterns of relations between countries

What is the focus of research and novelty related to TPACK's research on learning outcomes?

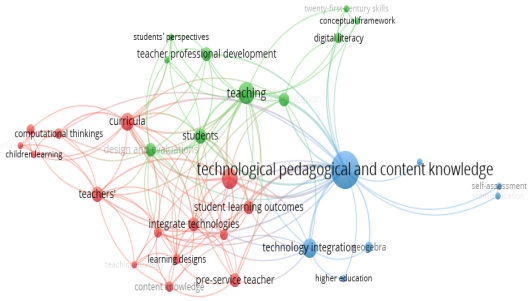

Figure 5. Network visualization

Figure 5 shows the keywords used together by researchers in the TPACK research on learning outcomes from 2009 to 2023. A total of 32 keyword items are displayed. The focus of this research can be divided into three parts which can be seen from the color of the circle in the image. The largest cluster marked in red is the main research focus, followed by green and blue. The size of the circle indicates the degree to which these keywords are used together. The larger the occurrence value, the larger the circle size.

The first research focus, which is marked with a red circle and consists of 15 keyword items, shows the importance of the two main keywords, namely engineering and curriculum, as the main research focus. Research conducted by Rufaida & Nurfadilah, (2021); Tunjera & Chigona, (2020) has further explained these two keywords. Research by Rufaida & Nurfadilah, (2021) proposes a new approach in the development of TPACK-based learning in the field of electronics, using hyper content and QR code modules to increase students' technological literacy. This study also notes that this approach can be a guide for students who wish to apply the same learning model after they graduate. On the other hand, research by Tunjera & Chigona, (2020) observed that most teachers used traditional teacher-centred teaching strategies in their teaching, while only two participants used collaborative and project-based teaching strategies. This finding also shows that teachers have limited technological knowledge in their teaching. Despite being limited in such knowledge, the study participants continued to believe that their technological knowledge would enable them to adequately and constructively prepare teacher candidates for the 21st century teaching and learning environment. This research has limitations, such as the limited number of participants, only eight teachers were interviewed, and it was conducted in one particular educational institution. Therefore, the results of this study may not be universally applicable to the entire teacher population. In addition, this study only uses qualitative methods, so it does not provide a comprehensive picture of the use of technology in teacher teaching.

The second research focus, marked with a green circle and consisting of 10 keyword items, shows the importance of the teaching and student keywords as the main research focus. The third research focus, marked with a blue circle and consisting of 7 keyword items, indicates that the keywords TPACK and technology integration are the focus of the last research. The focus of this research can be used as a reference for future researchers who want to take a theme that is appropriate to this field.

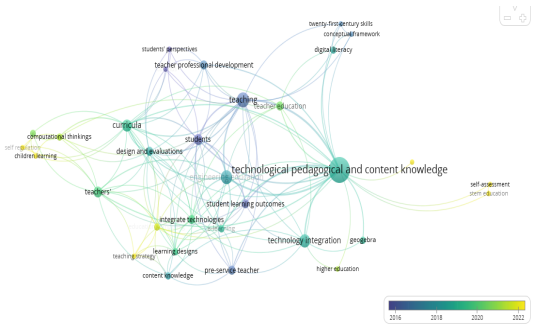

Figure 6. Visualization Overlays

Figure 6 displays an overlay visualization that shows the link between keywords and the color of the keyword circle, to see the level of novelty of research related to TPACK on learning outcomes from 2009 to 2023. Researchers focus on two important categories in the analysis of novelty, namely keywords which became the focus of research and keywords which became the new theme. New themes are marked with yellow circles, such as self-regulation, children learning, self-assessment, teaching strategies, learning activities, and education computing. This indicates that these keywords have only been used together in recent years, indicating a novelty in research related to TPACK and learning outcomes.

The TPACK keyword which has the largest circle in the third research focus is not directly connected with the three new theme keywords, namely self-regulation, children learning, and teaching strategies. However, it is important to note that the relationship between these keywords can be a novelty aspect in research related to TPACK and learning outcomes. The discovery of a link between the TPACK keywords and the new theme keywords can be an interesting research area for future researchers. Thus, future research can further explore the relationship and implications between the TPACK concept and aspects of self-regulation, children learning, and teaching strategies. This will contribute to the development of knowledge and understanding in this field.

IV. CONCLUSION

The highest number of publications related to TPACK and learning outcomes occurred in 2022 with a total of 6 publications. Meanwhile, the highest number of citations occurred in the 2017 publication which was cited 267 times. Research on TPACK and learning outcomes is heavily influenced by researchers from the United States. The focus of research in this field can be divided into three parts, namely engineering and curriculum, teaching and student, and technology integration. There are also new themes emerging in this field, such as self-regulation, children learning, self-assessment, teaching strategies, learning activities and educational computing. However, the TPACK keyword which became the most dominant in the third research focus was not directly connected with the three new theme keywords, namely self-regulation, children learning, and teaching strategies.

The novelty of this research has the potential to become a reference for future researchers who are interested in the same field. The relationship between the keywords described can be an innovative aspect in research related to TPACK and its impact on learning outcomes. In addition, researchers can obtain data from various sources such as the Wos database, Google Scholar, and others. The data used in this study were collected on June 27, 2023. Thus, research results published after that date have not been discussed in this study, so there may be discrepancies with future findings.

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