Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/16687
DOI URL: http://dx.doi.org/10.21474/IJAR01/16687

RESEARCH ARTICLE

BIBLIOMETRIC MAPPING OF TPACK RESEARCH FRAMEWORK FROM 2006 TO 2023

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Manuscript Info

Manuscript History
Received: 15 February 2023
Final Accepted: 19 March 2023
Published: April 2023

Key words:-
Bibliometric Analysis, Co-Citation Analysis, Co-Authorship Analysis, Education, Technology Integration

Abstract

This study aimed to provide an overview of the TPACK framework area in terms of bibliometrics by analyzing TPACK-related studies in the Scopus database. The analysis revealed the distribution of studies according to their countries, institutions, authors, and keywords, as well as the trends in the number of studies over time. The results showed that the United States and Australia were the leading countries in TPACK research, and that several universities had established strong collaborations in this field. The study also identified the most cited authors, publications, and keywords in TPACK literature. Moreover, the analysis revealed that current issues, such as pedagogical knowledge, digital competence, and COVID-19, are becoming increasingly important in TPACK research. The study concludes that further investigation is required in this domain to keep up with the digital era in education, and that future studies should use various bibliometric and systematic review methods together and consider high-impact journals. The findings of this study are expected to guide researchers and subject experts in specifying different research subjects in TPACK.

Introduction:-

The TPACK framework, created by Mishra and Koehler in 2006, provides a theoretical framework that helps to understand the complex relationship between technology, pedagogy, and content knowledge in teaching and learning. The framework builds on earlier models of teacher knowledge, including Pedagogical Content Knowledge and the Model of Pedagogical Reasoning and Action. The TPACK framework has gained widespread recognition and is being used in research and teacher education programs to improve education by integrating technology.

TPACK recognizes that technology is not a separate entity but an essential component of the pedagogical process. It also highlights the importance of teachers having the necessary knowledge and skills to integrate technology effectively into their teaching practices. Many professional development programs aimed at enhancing teachers' TPACK have been developed. The framework has also influenced the design and development of educational technologies to align with TPACK principles.

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In recent years, there has been a growing interest in TPACK and its potential to enhance teaching and learning in the digital age. Meta-analyses, systematic reviews, and literature reviews have been conducted to explore the impact of TPACK-based interventions on teachers' technological pedagogical knowledge. These studies have shown that TPACK-based interventions are effective in improving teachers' TPACK. Additionally, studies have identified factors influencing TPACK development, including professional development and technology integration in teacher education programs. Future studies could explore the use of TPACK in online and blended learning environments.

To further explore the impact of the TPACK framework, the current study aims to conduct a bibliometric analysis of research on TPACK. The primary objective of this study is to identify the major trends and patterns in TPACK research, including the most influential publications, authors, and journals. To accomplish this, the study proposes several research questions.

1. What is the distribution of TPACK research publications from 2006-2023 in terms of years, countries, document types, sources, and number of citations?
2. What are the findings of co-author analysis in TPACK research in terms of:
    a. Countries
    b. Institutions
3. What are the results of co-citation analysis in TPACK research in terms of the most frequently cited authors and publications?
4. What are the outcomes of co-word analysis in TPACK research in terms of the most frequent and significant keywords that have been identified?

The objective of this study is to provide a valuable contribution to the development of research on TPACK framework and prevent the repetition of previous studies. To achieve this goal, a bibliometric analysis was conducted on 1,303 TPACK studies published in the Scopus database from 2006 to 2023. The trends and patterns in the field were analyzed to provide new insights into the literature. By doing so, this research aims to offer an innovative perspective to the literature and advance the knowledge in the field of TPACK.

Methodology:-

In this study, the bibliometric analysis method was used to examine studies on TPACK framework. Bibliometrics is a method of analyzing and measuring scientific publications using mathematical and statistical techniques, as defined by Pritchard (1969). Bouyssou and Marchant (2011) describe bibliometric analysis as a method of evaluating the progress of a specific subject, the quality of scientific work, and the influence of sources. The essential information required for bibliometric analysis consists of journal titles, authors, institutions, references, document type, title, terms, keywords, abstracts, subject headings, and acknowledgments, according to Glänzel (2003).

Data Collection

In the current research, the bibliometric data were obtained from the Scopus database. The search engine codes used for scanning the content in Scopus are provided (Article title, abstract, keywords) in the subject TITLE-ABS-KEY ("TPACK" OR “TPCK” OR “TPACK framework” OR “TPCK framework” OR “technological pedagogical content knowledge”) AND PUBYEAR > 2006 AND PUBYEAR < 2023.

For this research, the search outcomes were refined to encompass the period between 2006 and 2023. This study assessed studies on TPACK that were scanned by Scopus from 2006 onwards, as Mishra and Koehler's (2006) study on TPACK, which was published in 2006, was considered a pioneering publication that contributed to the development of discussions in this field. The selection of publications was made through various screening processes. Initially, a keyword search yielded 2,777 results, which was reduced to 2,023 by selecting the Social Sciences subject area only. Further screening left only 1,397 publications, and finally, English language-only publications were chosen, leaving a total of 1,303 studies. The final screening was conducted in March 2023. The research collected bibliographic data from the publications including details like publication years, types of publication, languages used, titles of the publication, author names, countries of origin of the authors, citation numbers, abstracts, keywords used, and bibliography information.

Data Analysis

The research utilized both bibliometric and descriptive content analyses to analyze the data. The Scopus database was used to perform the content analysis, while VOSviewer (Version 1.6.19, Centre for Science and Technology

Studies of Leiden University) was employed as the mapping and visualization software tool for bibliometric analyses. VOSviewer is an effective tool in bibliometric analysis that enables the identification of patterns, trends, and relationships within complex bibliometric data (van Eck and Waltman, 2010). The study examined the distribution of studies by years, publication types, and languages, and analyzed the sources where the studies were indexed and the number of citations received. The bibliometric analysis included co-author (countries, institutions), co-citation (authors), and co-word analyses to further explore the subject.

Results And Discussion:-

The research aimed to uncover specific findings related to its purpose, and these findings are presented in tables and figures below for easier understanding and visualization.

Descriptive Findings

Distribution of Publications by Years

Firstly, the study analyzed the distribution of TPACK studies published in the Scopus database over time (2006-2023), with the resulting findings presented in Figure 1.

Figure 1 below reveals that the earliest study on TPACK was conducted in 2006, which served as the starting point for the bibliometric analysis. Despite a general increase in the number of TPACK studies over time, there were several years in which the number of studies decreased. For example, the number of studies dropped from 90 in 2013 to 26.76% in the following year, 2014. Likewise, there was a 3.07% decrease in studies from 2015 to its succeeding year, as well as a 3.03% decrease in 2017. The year with the highest number of TPACK studies was 2015, with a total of 205 published studies.

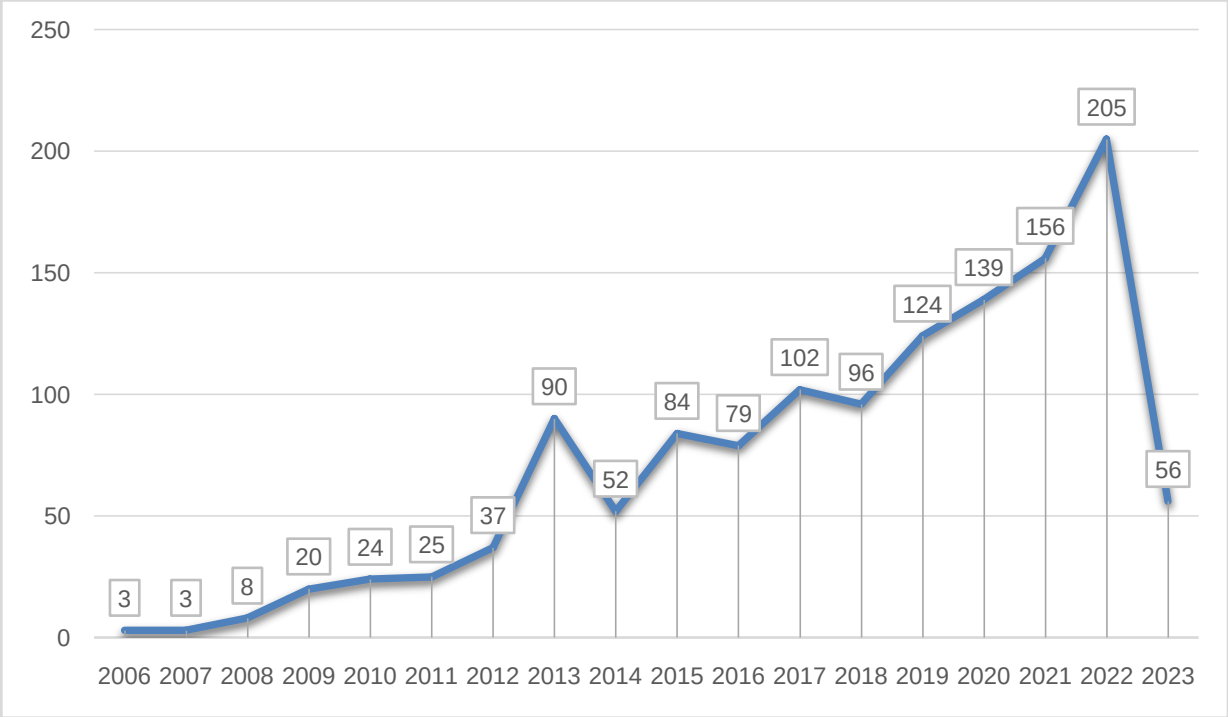

Figure 1:- Distribution of Publication by Years.

Distribution of Publications by Countries

The distribution of 1,303 studies published on the subject by countries are shown in Figure 2.

According to Figure 2, the United States (f=322; 24.71%) has the most TPACK publications, followed by Turkey (f=154; 11.82%) and Australia (f=102; 7.83%). In Asia, Turkey is the leading country in TPACK publications, while South Africa is the leading country in Africa.

TPACK has had a significant impact on education in the US, as evidenced by the development of teacher training programs and educational technologies that align with TPACK principles (Schmidt et al, 2009). In Turkey, TPACK has gained attention in the field of teacher education, and there is a need to integrate it more effectively into teacher education programs (Seferoglu et al, 2018).

In South Africa, technology is playing an increasingly important role in education, and TPACK offers a framework for educators to effectively integrate technology into their teaching practices (Chigona et al, 2015). TPACK can help educators to understand the complex interplay between technology, pedagogy, and content knowledge in the context of teaching and learning, making it relevant and useful in the South African educational setting.

In summary, this bibliometric analysis of TPACK publications has provided insights into the development and impact of TPACK in various countries over the years. The analysis has shown that the United States, Turkey, and Australia are among the leading countries in TPACK research and publication, with other countries also contributing to the body of literature on the subject.

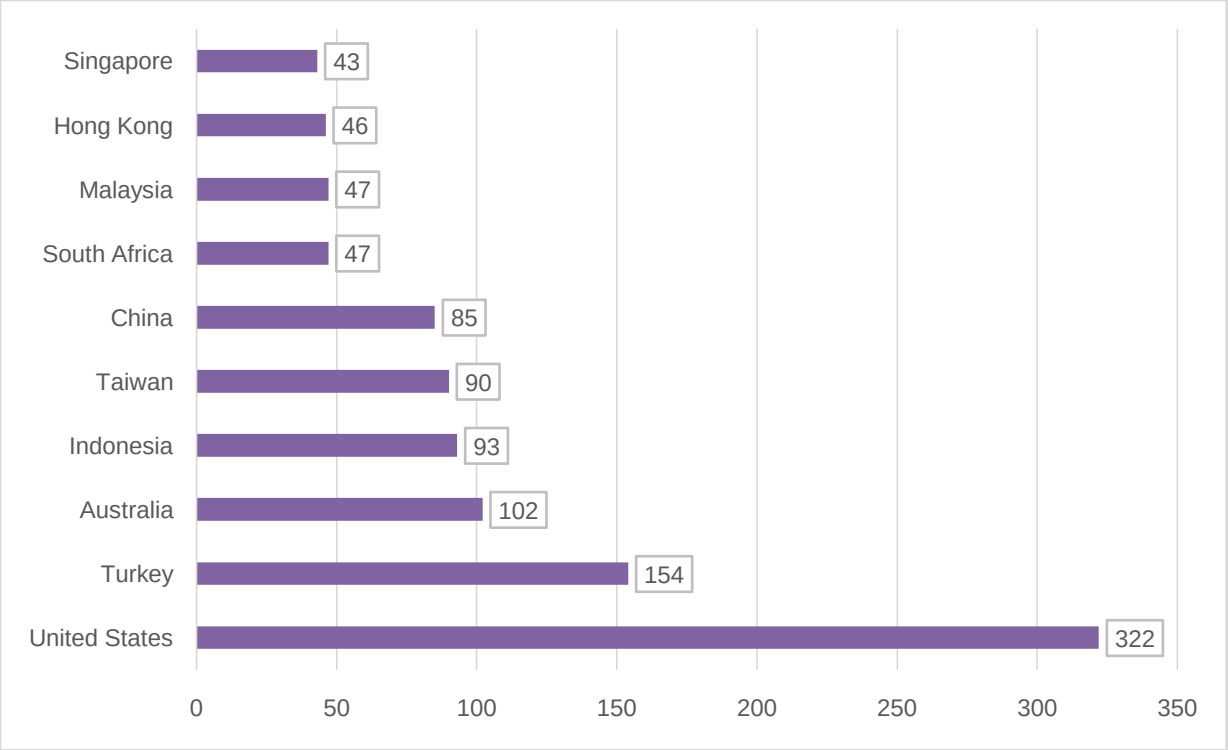

Figure 2:- The Top 10 Countries that have published on TPACK.

Distribution of the Publications by Types

The distribution of 1,303 studies published on the subject by publication types are shown in Table 1.

Table 1:- Distribution of the Publications by Types.

Types	**Frequency**	**Percentage**
Journal	1,295	99.38
Book series	5	0.38
Conference proceeding	2	0.15
Book	1	0.08
TOTAL	1,303	100.0

Upon examining Table 1, it became apparent that studies on TPACK published in the Scopus database were distributed across various types of publications. Specifically, when analyzing the publication type of studies between 2006 and 2023, it was found that the vast majority (99.38%) of studies were published in academic journals.

Distribution of Publication by Sources
The table below presents the sources where the studies on TPACK are indexed in the Scopus database.

Table 2:- The Top 10 Productive Sources on TPACK framework.

Rank	Source	f	Cite Score 2021	Scopus coverage	Publisher
1	Education and Information Technologies	60	6.6	1996-2002; 2005-present	Springer Nature
2	Computers and Education	53	19.8	1976-present	Elsevier Ltd.
3	Journal of Digital Learning in Teacher Education	41	3.5	2010-present	Taylor & Francis
4	Australasian Journal of Educational Technology	41	5.9	2008-2022	Australasian Society for Computers in Learning in Tertiary Education (ASCILITE)
5	Journal of Research on Technology in Education	38	4.6	2001-present	Taylor & Francis
6	Technology, Pedagogy and Education	30	5.2	2003-present	Taylor & Francis
6	Journal of Educational Computing Research	30	7.2	1990; 1996-present	SAGE
8	British Journal of Educational Technology	23	9.6	1970-present	Wiley-Blackwell
9	TechTrends	22	3.3	1982; 1985-1996; 2000; 2004; 2006-present	Springer Nature
10	Educational Technology Research and Development	19	5.4	1957; 1989-present	Springer Nature

Upon examination of the TPACK framework studies, it can be observed that Education and Information Technologies (f=60; Cite Score of 6.6) is among the sources with the highest publication rate. On the other hand, Computers and Education has the highest Cite Score of 19.8, with a total of 53 TPACK-related studies published.

Distribution of the Publications by Affiliation
Below is a table showing the affiliations where the studies on TPACK were conducted.

The universities with the highest number of TPACK studies published are Nanyang Technological University and National Institute of Education, both located in Singapore, followed by Chinese University of Hongkong and National Taiwan Normal University. The reasons behind this trend could be varied. One possible explanation is that these universities may have established research centers or departments that are focused on educational technology, which can attract researchers interested in TPACK. It is also possible that these universities have strong partnerships orcollaborations with other institutions or organizations involved in educational technology and TPACK research. Another factor could be the availability of resources such as funding and equipment, as well as the academic expertise and experience of the researchers and faculty members in these universities. These claims are supported by a study by Lee et al. (2013).

Table 3:- The Top 11 Affiliations on TPACK framework.

Rank	Affiliations	Country	f	%
1	Nanyang Technological University	Singapore	40	3.07
2	National Institute of Education	Singapore	29	2.23
3	Chinese University of Hong Kong	Hong Kong	23	1.77
3	National Taiwan Normal University	Taiwan	23	1.77

continued…

5	National Taiwan University of Science and Technology	Taiwan	22	1.69
6	The Education University of Hong Kong	Hong Kong	17	1.30
7	Arizona State University	USA	16	1.23
7	Middle East Technical University	Turkey	16	1.23
7	Beijing Normal University	China	16	1.23
7	Universitas Negeri Yogyakarta	Indonesia	16	1.23
7	Necmettin Erbakan Üniversitesi	Turkey	16	1.23

Distribution of the Publications According to the Number of Citations

Bibliometric studies often use citation analysis to provide researchers with valuable data. The distribution of the examined studies based on the number of citations they received is shown in Table 4.

Table 4:- Distribution of the Publications According to the Number of Citations.

Number of Citations	f	%
0	209	16.04
1-10	573	43.98
11-24	276	21.18
25-49	126	9.67
50-99	75	5.76
100-250	32	2.46
250-779	12	0.92
TOTAL	**1,303**	**100**

Out of the 1,303 studies examined, 1,094 of them received citations from other publications. However, 209 studies or 16.04% of them did not receive any citations. Furthermore, the research includes data on the most cited publications on the subject, which can be found in Table 5.

Table 5:- The Top 10 Most Cited Publications on TPACK Framework.

Rank	Article	Authors	Year	Source	Cited by
1	Technological pedagogical content knowledge (Track): The development and validation of an assessment instrument for preservice teachers	Schmidt D.A.; Baran E.; Thompson A.D.; Mishra P.; Koehler M.J.; Shin T.S.	2009	Journal of Research on Technology in Education	779
2	Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK)	Angeli C.; Valanides N.	2009	Computers and Education	650
3	Digital storytelling: A powerful technology tool for the 21st century classroom	Robin B.R.	2008	Theory into Practice	567
4	Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration refrained	Harris J.; Mishra P.; Koehler M.	2009	Journal of Research on Technology in Education	483
5	Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology	Koehler M.J.; Mishra P.; Yahya K.	2007	Computers and Education	464

continued…

6	Technological pedagogical content knowledge - A review of the literature	Voogt J.; Fisser P.; Pareja Roblin N.; Tondeur J.; van Braak J.	2013	Journal of Computer Assisted Learning	402
7	Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World wide Web	Lee M.-H.; Tsai C.-C.	2010	Instructional Science	326
8	Theoretical considerations for understanding technological pedagogical content knowledge (TPACK)	Graham C.R.	2011	Computers and Education	325
9	Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK)	Chai C.S.; Koh J.H.L.; Tsai C.-C.	2010	Educational Technology and Society	304
10	Revisiting technological pedagogical content knowledge: Exploring the TPACK framework	Archambault L.M.; Barnett J.H.	2010	Computers and Education	295

Table 5 provides details on the authors and the number of citations for the most cited publications in the Scopus database. Among these, the most cited study is by Schmidt et al. (2009), with 779 citations, followed by Angeli&Valanides (2009) and Robin (2008). Notably, four of these publications are published in Computers & Education, which aligns with the fact that this journal has the highest Cite Score of 19.8 (as per Table 2).

Bibliometric Findings

Co-author analysis (Countries)

Figure 3 below displays the network structure between the countries of the authors of the publications in the research. It indicates that countries that are closer have stronger and wider connections.

Based on the results obtained, it was found that the United States collaborated with 27 different countries. Australia had the second highest number of collaborations with 18 links, followed by the United Kingdom with 17 links, China with 16 links, and Finland with 12 links, among others.

Collaborations among researchers and institutions on TPACK-related studies were facilitated by co-authorship and citation networks. Researchers from various countries worked together on TPACK-related studies, and their works were cited by other researchers worldwide. These networks created a web of connections among researchers and institutions, allowing collaboration and knowledge exchange.

In a study by Deveci and Turel (2017), the co-authorship network of TPACK-related studies was analyzed, revealing that the United States had the most extensive collaborations with other countries. The study also identified Australia, Canada, and Turkey as other countries with significant collaborations with the United States.

Furthermore, Liu et al., (2020) analyzed the citation network of TPACK-related studies and found that the United States was the most influential country in the network. The study also identified China, Australia, and Taiwan as other countries with significant contributions to the TPACK literature.

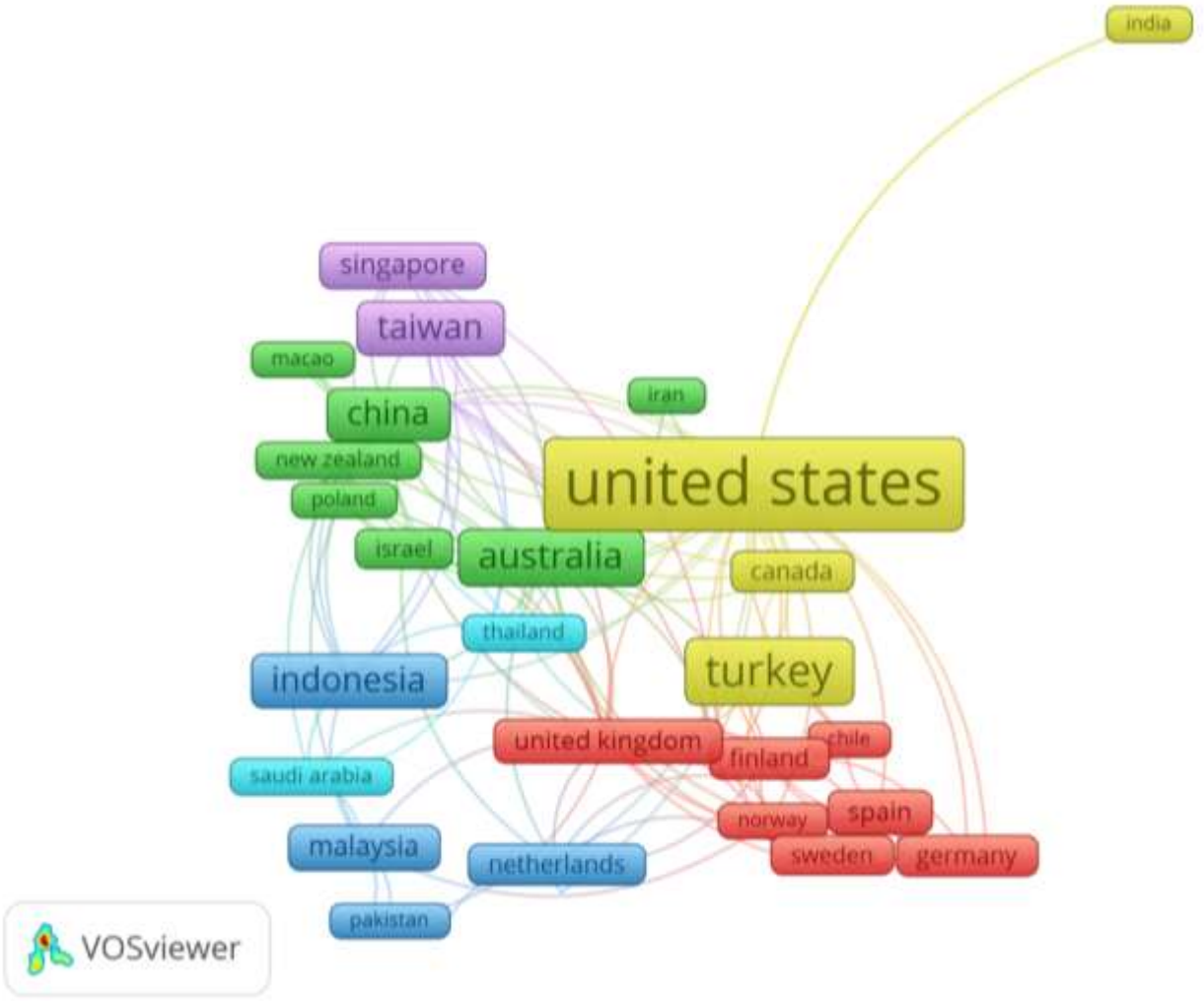

Figure 3:- Cooperation network between the countries.

Co-author analysis (Institution)
Co-author analysis for inter-institutional cooperation is presented in Figure 4.

As can be seen in Figure 4, it is seen that Queensland University of Technology, Curtin University, Griffith University, University of Tasmania and George Mason University are dominant on the map.

The institutional cooperation network among Queensland University of Technology, Curtin University, Griffith University, University of Tasmania, and George Mason University in TPACK implies that these institutions haveestablished a collaborative relationship with each other in the field of educational technology and TPACK research. This network suggests that they share a common interest in TPACK research and may have worked together on joint research projects or collaborated on publications. Moreover, the network suggests that these institutions may have similar research priorities and areas of expertise. The network serves as a platform for these institutions to exchange ideas and knowledge, share resources, and further their research in the field of TPACK.

Co-citation Analysis (Author)
Figure 5 presents the network structure of the co-citation analysis for the authors of the publications related to the subject.

Figure 5 illustrates the co-citation network of authors on the subject, where each round figure represents an author. The size of each figure represents the frequency of the author's name mentioned in publications from 2006 to 2023.

If there is a line between two authors, it indicates that they have worked together, with the thickness of the line reflecting the extent of their collaboration. The network structure has multiple clusters, with authors who receive many citations together forming the same cluster. Among these clusters, the red, green, and blue clusters are larger and more prominent than others. Upon examining the entire Figure 5, it becomes evident that Mishra P. and Koehler M.J are relatively central and associated with many different clusters. The most frequently cited authors in various fields are Mishra P. (3,268 citations), Koehler M.J. (2,517 citations), Chai C.S (1,446 citations), Tondeur J. (810 citations), and Tsai (784 citations).

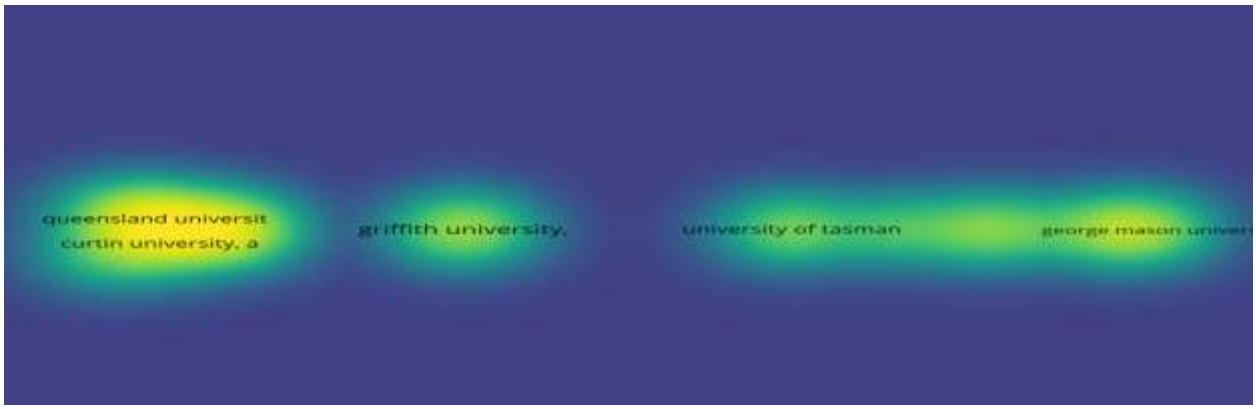

Figure 4:- Institutional Cooperation Network.

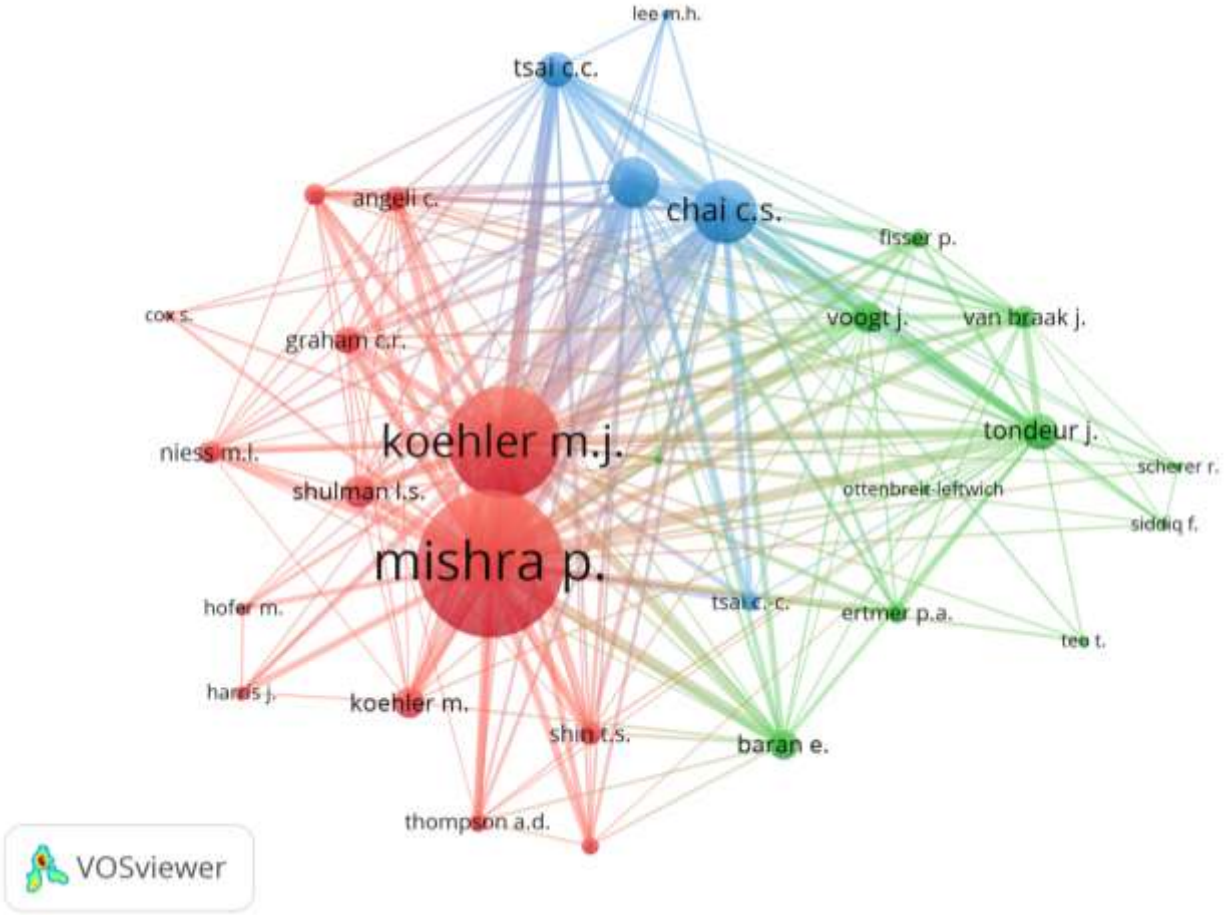

Figure 5:- Co-citation (author) Network.

Co-word Analysis

A network analysis was conducted to explore the relationships between keywords used in the publications on TPACK. The results of this analysis are presented in Figure 6, where the size of the circles represents the frequency of the respective keyword being mentioned in the publications. Additionally, the yellow areas in the network indicate the most current and popular topics in TPACK research.

Figure 6 shows that the central concepts in the network are "TPACK" and "technological pedagogical content knowledge," which are related to other clusters. The current issues that stand out in the network are "pedagogical knowledge," "digital competence," "teacher educators," "ICT integration," and "COVID-19," which are represented by the yellow areas in the figure.

The current issues in education such as pedagogical knowledge, digital competence, teacher educators, ICT integration, and COVID-19 have gained more prominence in the TPACK literature due to their relevance to the current situation and developments in the field of education. The fast-paced progress of technology and the shift towards digital learning have made it increasingly necessary for educators to address these issues in their teaching practices. Moreover, the COVID-19 pandemic has highlighted the significance of technology in education and has accelerated the need for educators to enhance their digital competence and integrate ICT in their teaching. Therefore, these current issues have gained more attention and are now more prominent in the TPACK literature.

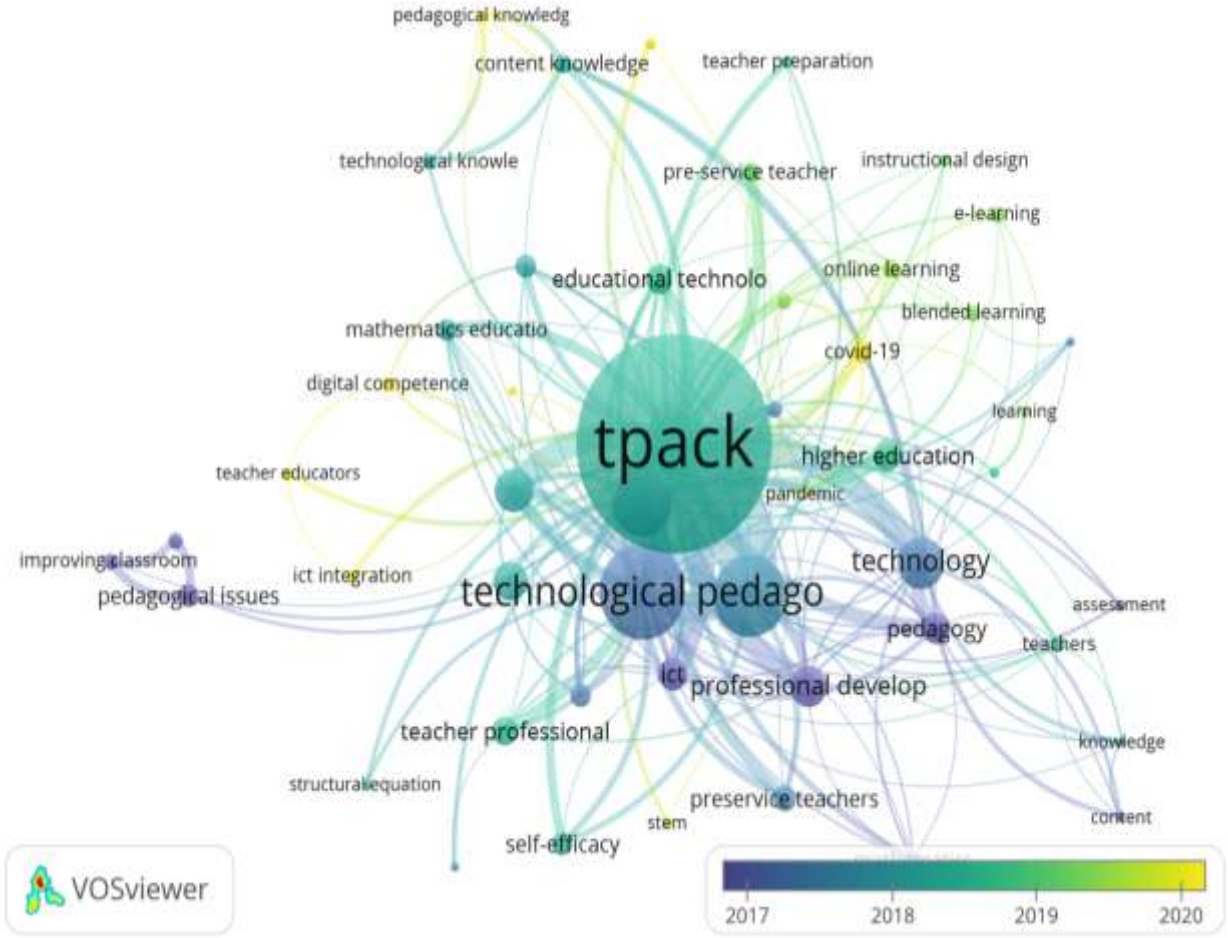

Figure 6:- Network Analysis of the Keywords.

Recommendations:-

This study provides an overview of the developments in the research on TPACK framework and serves as a valuable resource for researchers interested in conducting new studies in this field. To further advance research in the area of educational technology and TPACK, future studies can explore various bibliometric and systematic review methods

and consider including studies from the Web of Science. Researchers can contribute to this field by conducting studies on relevant topics and publishing their findings in high-impact journals. As the digital era in education continues to evolve, more research is needed to guide educational institutions in taking concrete steps to implement technology in teaching and learning. Overall, this study can help guide subject experts in identifying different research subjects related to TPACK framework.

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