The Influence of Professional Learning Community (PLC) on TPACK at Higher Learning Institutions HLI: A Bibliometric Analysis

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Article Information	Abstract
Keywords Professional Learning Community PLC, Technological Pedagogical Content Knowledge TPACK, Higher Education, Technology Integration, Professional Development.	The current study is bibliometric analysis on the influence of Professional Learning Community PLC on Technological Pedagogical Content Knowledge TPACK at higher education. The purpose of this study is to orient the researchers on the current status of research on the influence of PLC on TPACK. The existing bibliometric studies on the domain of PLC and TPACK do not clearly and sufficiently analyse the bibliometric de-tails of the available research on this topic. Therefore, the current study uses bibliometric details of the publications and deploys thematic analysis. This study obtained a sample of 1201 empirical research publications available from 2012 – 2022 in the Scopus database under the subject area of social sciences. The findings provide a substantial reference on the trend of publications over the time period, core authors, cite score on publications and, the key themes that emerge from the keywords analysis as well.

INTRODUCTION

In recent years research and publication on learning communities have increased dramatically. In this respect, Professional Learning Community PLC has become a widespread model that focuses on improving professional development among educators and practitioners. The initial roots of PLC can be traced to Senge's learning organisation theory (Blankenship & Ruona, 2007). Reasonable research has appeared on this domain since Hord coined this concept as PLC in 1997. PLC can be referred to a community of learners who share a common purpose and values towards professional development (Hord, 1997). Hord's PLC concept (1997) has remained as one of the most cited frameworks under the umbrella of professional development. Thus, PLC is an edition of community built on the notion of learning communities focusing on professional development. PLC model by Hord, (1997) is based on five key dimensions including i) shared and supportive leadership, ii) collective learning and its application, iii) sharing personal practice, iv) shared beliefs, values and visions, and v) supportive conditions. The dimensions of PLC are illustrated in Figure 1 below.

PLC framework by Hord (1997) has received worldwide acceptance among educators from different disciplines and different levels (DuFour, 2004, 2007; Hord, 1998, 2008). Following the footsteps of Hord (1997), a number of researchers have continued and elaborated research on this model. During this journey, the technological advancements over the years, have paved the way towards even new forms of PLC such as online learning communities (Battersby, 2019; Xing & Gao, 2018). As such, during the last two decades, research linked to PLC

has significantly increased across the subject areas, nations, and contexts. As a result, it has now become more difficult for researchers to keep up with recent trends, developments, and the current status of research on PLC. In fact, studies serving this purpose are rare. One possible solution to this problem is to examine the bibliometric details of the publications under this topic. They can provide a better picture of the overall trends and summaries of the scientific research available (Broadus, 1987).
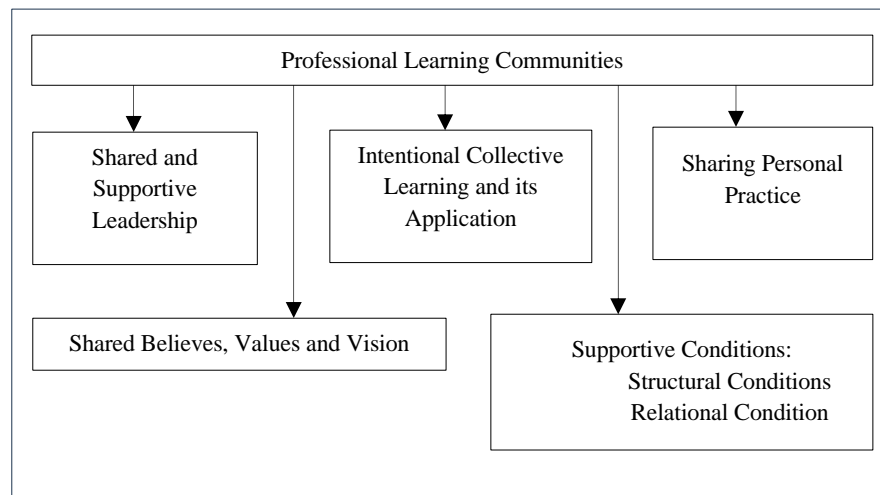

Fig. 1.
Model of PLC. Adopted from (Hord et al., 2009).

As aforementioned, the current bibliometric analysis intends to provide an overview of bibliometric details of the existing publications that focused on the influence of PLC on Technological Pedagogical Content Knowledge TPACK. TPACK has been reported as one of the earliest frameworks guiding educators towards technology integration (Maor, 2017; Mishra & Koehler, 2006). This model represents not only the key domains of knowledge but also the interplay between these knowledge dimensions essential for technology integration. The origin of the TPACK model is linked to the works of Shulman, 1986 who coined the concept as Pedagogical Content Knowledge PCK. Later Mishra and Koehler (2006) proposed and embedded technological knowledge TK as a significant dimension of knowledge, thus forming the TPACK framework that we use today.
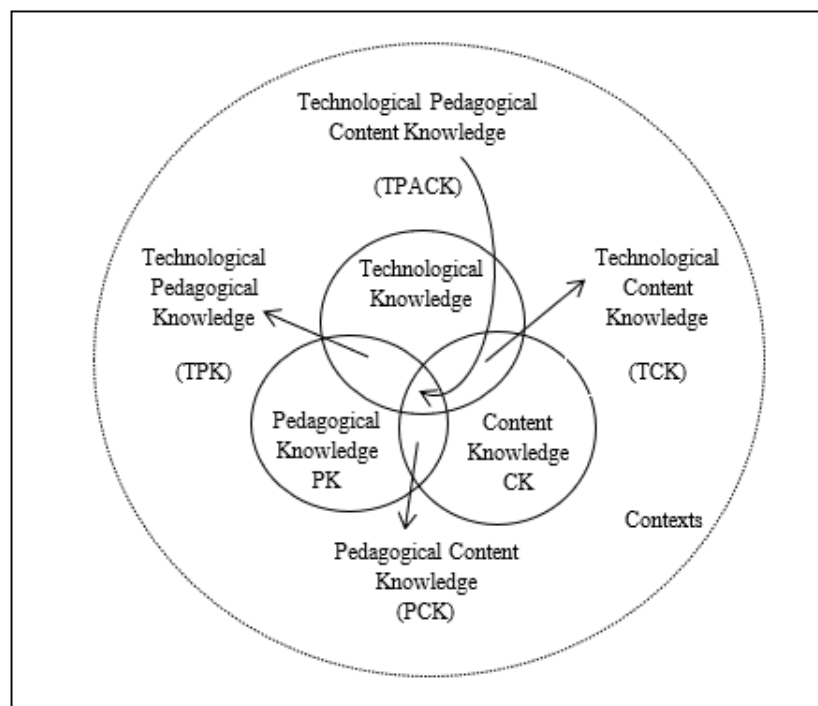

Fig. 2.
Model of TPACK. Adopted from Mishra & Koehler (2006).

As such, TPACK framework consists of Technological Knowledge TK, Pedagogical Knowledge PK and Content Knowledge CK. Furthermore, the integration of these primary dimensions produces Technological Pedagogical Knowledge TPK, Pedagogical Content Knowledge PCK and Technological Content Knowledge TCK. Thus, the ultimate combination of these secondary dimensions results in Technological Pedagogical Content Knowledge (TPACK) (Glowatz & O'Brien, 2017; Malik et al., 2019; Mishra & Koehler, 2006; Yurdakul, 2018). Figure 2 above illustrates TPACK Model (Mishra & Koehler, 2006).

Problem Statement
A number of bibliometric analyses have been published in the domain of PLC providing what has been researched up to date. For instance, Ling and Amzah (2022) provided the current trend of research on teachers' PLC based on the studies published from 2012 – 2022. A similar study has been conducted by WeiYou and Xiang (2020) as an analysis of current research status of teacher PLC based on the research published for the past 10 years. At the same time, Hernández et al. (2017) offered a bibliometric analysis to examine the research trends in the study of ICT based learning communities. Although the existing bibliometric analysis has sufficiently focused PLC towards professional development in various angles, studies providing the current status of research on the influence of PLC on TPACK on the basis of bibliometric data are rare.

The closest bibliometric analysis found with a similar focus to the current is a one authored by Hernández et al. (2017) which provides the state of research on learning communities based on ICT. However, Hernández et al. (2017) did not explore how learning communities can influence technology-based teaching and learning, rather it provides in-sights into research on learning communities that are based on ICT. As such, a clear gap exists in the domain of bibliometric analysis that considers the current status of research on the influence of PLC on TPACK. Therefore, the current study examines the influence of PLC on TPACK.

Research Objectives
The current bibliometric analysis intends to examine the current state of research on the influence of PLC on TPACK. The purpose is to orient researchers about the most significant journals, authors, and articles to consider in their efforts to further study this phenomenon. Furthermore, the focus of the current study includes analysing the empirical studies for the timeframe 2012 and 2022 on the topic to determine the key themes that emerge from the keywords. Particularly is has focused on three types of documents including journal articles, conference papers and reviews available under the area of social sciences. The broad objective on the study includes:

1) Identifying the journals that have the most intense coverage of publications on the topic.
2) Be informed about the core authors on the topic.
3) Examine the most cited articles and authors on the topic.
4) Examine the overall trend of publications for past 10 years, and
5) Develop and discuss the major themes that emerge from analysis.

Besides the huge volume of research available for the past 10 years on the models focused on professional development including PLC and TPACK, studies examining the relationship between these key variables via bibliometric analysis are rare. A number of studies have highlighted the significance of the role of PLC in professional development and this recognised the significance of this study. PLC can be a substantial and effective vehicle to facilitate PD in particular helping educators to transfer knowledge into practice (Battersby, 2019; Bedford & Rossow, 2017; Cherrington et al., 2018; Du Plessis & Muzaffar, 2010; Hudson et al., 2013; Stewart, 2014). At the same time, TPACK has been recognised as an established model focused on mediating teaching and learning towards technology integration (Garrett, 2014; Goradia, 2018; Kihoza et al., 2016; Maor, 2017; Tondeur et al., 2017). Its significance to academia can also be recognised considering the growing rate of research on this variable. Therefore, the importance of research, especially a bibliometric analysis out of the huge volume of research concerning these two variables are utmost importance.

METHODS
The contemporary methods deployed in conducting bibliometric analysis are observable across literature. Bibliometric analysis has received considerable attention in the research community across various fields of research (Donthu et al., 2021). The idea of bibliometric analysis has been discussed and practiced among researchers since 1950 (Wallin, 2005). As such, Donthu et al. (2021) argue that bibliometric analysis is more appropriate where the scope of the review is not only broad but more strain to review manually. It is a helpful approach to determine the existing trends in a specific research filed and help generate summaries of the existing research (Bjork et al., 2014; Kreps & Neuhauser, 2013; Rey-Martí et al., 2016). It is a well-known process in making meaning and developing trends from a large volume of data on specific field of research (Donthu et al., 2021; Rey-Martí et al., 2016). In every field, bibliometric analysis has been growing at remarkable rate in recent

years (Donthu et al., 2021). Other similar methods of analysis such as systematic literature review and meta-analysis have been used by researchers considering the goal of the review, scope, and nature of the literature.

Literature indicates that, in developing bibliometric analysis, a number of focuses have been used by the researchers. Mainly it includes the number of publications and number of citations of an author. At the same time, an open discussion is seen in considering the most significant factors to be taken into consideration. For instance, Podsakoff et al. (2008) argue that number of citations override the significance of number of publications as the former portrays the influence of the researcher. The number of publications illustrate the output of the researcher while the number of citations indicate the influence of the researcher in the specific discipline Bonilla et al. (2015).

With insignificant modification and variations, a common process is evident in the bibliometric publications across the disciplines. The current study deploys a similar process followed in few of the previous studies including (Bonilla et al., 2015; Donthu et al., 2021; Rey-Martí et al., 2016). The process used for the current study is adopted from some of the previous bibliometric analysis including Donthu et al. 2021 and Rasidi et al. (2020). For this study the process can be divided into 5 major steps and their sequence has been illustrated in the following figure (Figure 3). In brief it includes defining the aims, purpose, and objectives of the study. This is followed by getting a suitable technique for conducting the analysis. The technique should certainly facilitate achieving the aims and objectives of the study. Next is the data collection stage where the researcher must thoroughly follow the parameters of the search process. At the same time, effective inclusion and exclusion criteria are necessary to keep the collection of publications more suitable and useful. Finally, the analysis can be run, and findings can be reported accordingly.

Step 1: Define the Aim, Purpose, and Scope of Bibliometric Analysis.

↓

Step 2: Choosing a Technique

↓

Step 3: Data Collection

↓

Step 4: Run the Bibliometric Analysis
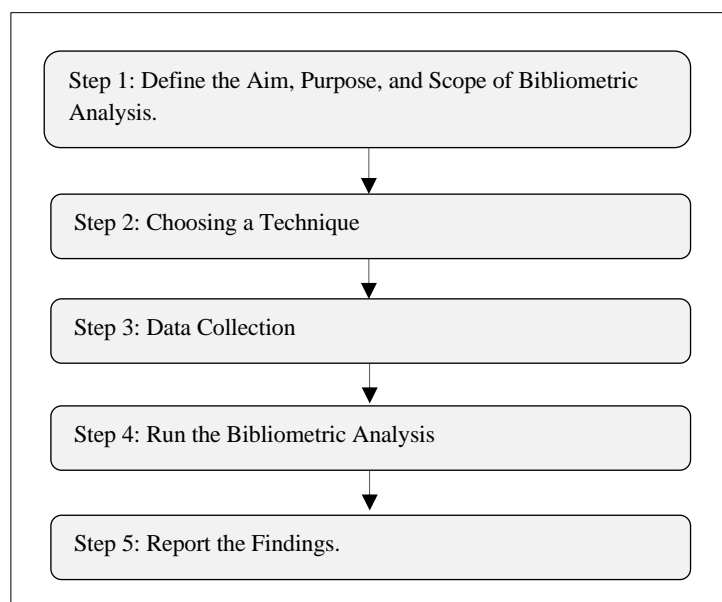
↓

Step 5: Report the Findings.

Fig. 3.
Bibliometric Approach as Adapted from (Donthu et al., 2021; Rasidi et al., 2020)

The purpose of this study is to orient the researchers on the bibliometric details of available publications concerning the influence of PLC on TPACK. As such, the current study intended to answer the following research questions.

1) RQ1: Which journals have the most intense coverage of publications on the influence of PLC on TPACK?
2) RQ2: What are the most common authors on the topic?
3) RQ3: Which articles have been cited most?
4) RQ4: What are the most influential authors on the topic?
5) RQ5: What is the overall trend of publications for the past 10 years?
6) RQ6: What are the major themes that emerge from the keywords?

Generally, bibliometric analysis has been conducted with different techniques and these techniques can be broadly grouped into two main categories including i) performance analysis and science mapping (Donthu et al.,

2021). The difference is, while performance analysis takes into account the contributions of research constituents, and science mapping considers the relationship between research constituents (Donthu et al., 2021). The current study deploys performance analysis. As a descriptive analysis in nature, it focuses on characteristics such as authors, number of publications, institutions, citations, countries, and keywords. Other considerations of this approach may include considering the number of sole-authored publications, number of co- authored, number of contributing authors, total citations, average citations, and citations per publications (Donthu et al., 2021).

Data collection in bibliometric analysis is guided by the parameters and inclusion and exclusion criteria set for the study. These parameters guide the researcher towards a suitable data collection path out of the enormous volume of publications. In fact, a vast sum of documents has been published on this topic and it is one reason for opting for a bibliometric analysis for the current study. According to Donthu et al. (2021) bibliometric analysis is more suitable when the data set is too large for a manual review or analysis. Therefore, in the current study, the search has been narrowed down to the most important parameters including timeframe, context, keywords, language, document type, subject area, and database. These are some of the common indicators used by researchers including (Rasidi et al., 2020; Rey-Martí et al., 2016). According to Bonilla et al. (2015) a fundamental step in developing bibliometric analysis is determining the core parameters to guide the search towards the purpose of the study. As such, a clear focus on key words that binds PLC, TPACK and higher education has been held constant throughout the search.

The search process has been designed and administered during August 2023. The search has been enclosed for documents published in the Scopus database only. Scopus is considered one of the top-rated databases in recent years which consists of a enormous volume of scientific multidisciplinary materials. The recent statistics show its size as over 90 million records and 17 million researcher profiles as well. Other similar databases may include Web of Science WoS, Google Scholar, Science Direct, PubMed, ERIC, JSTOR and EBSCO host. As a timeframe, documents published in a period of 10 years (between 2012 to 2022) have only been taken into consideration. Next it has only focused on the documents that focus on higher learning institutions including colleges and universities only. Finally, a couple of key words including "professional learning community", "learning community" "professional learning", "professional development", "higher education", "technological knowledge", pedagogical knowledge", and content knowledge" has been accepted. In short, the following list of requirements is strictly included in the inclusion criteria.

1) Timeframe:
2) Language:
3) Context:
4) Documentation type:
5) Subject area:
6) Key words:

As such, the following search query is used during the search within the Scopus database. ("Professional Learning Community" OR "learning community" OR "professional learning" OR "professional development" OR "higher education") AND ("technological knowledge" OR "pedagogical knowledge" OR "content knowledge"). Notable changes in the search results have been observed during the search process with the application of various filters in accordance with the search filters. The results of the search will be detailed in the findings section below. The results have been analysed by using Scopus database, VOSviewer 1.6.19. and Microsoft Excel. As such, the Coma Separated Values CSV file of the search results is downloaded and imported to the VOSviewer for the analysis to proceed.

FINDINGS AND DISCUSSIONS

Initially, the above-mentioned search query is run leaving all other parameters flexible. As such, the initial search results count up to 2442 publications. In the second step, the time frame of publications is filtered to the duration 2012-2022. This dramatically reduced the number of articles from 2442 to 1586 (nearly 65%). Thirdly, the document type is limited to three types including articles, conference papers and reviews. In the next step, English language is selected as a filter but, it did not make much difference in the results. During the fifth stage, suitable subject areas are identified. Here the publications on social sciences were only made applicable. Finally, some of the keywords that do not confirm the scope and context of this study are excluded. With all the above mandatory criteria being made effective, the results declined from 2442 to 1201. The summary of the search process is given in Figure 4 below.
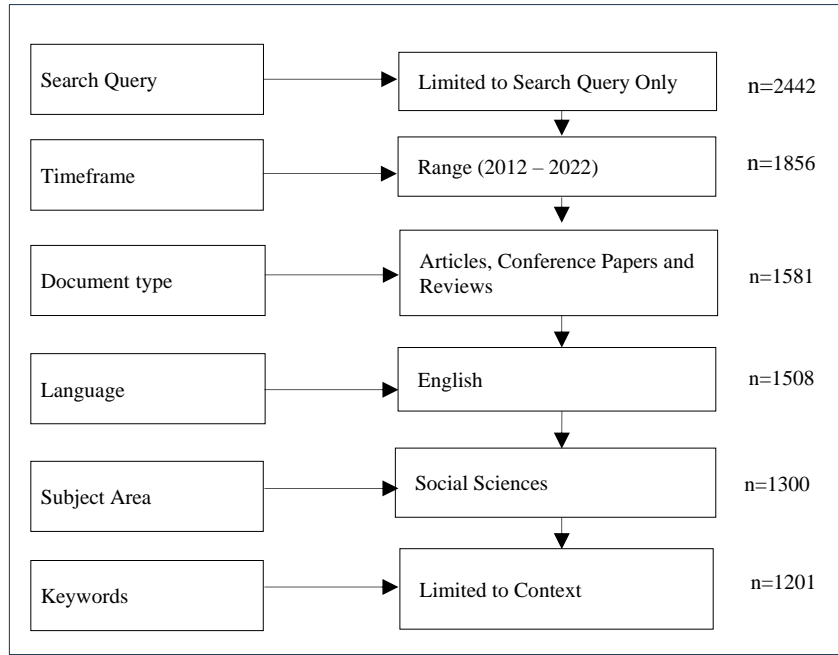
Fig. 4.
Summary of the Search Process

TABLE I
DETAILS OF THE INCLUSION AND EXCLUSION CRITERIA AT VARIOUS STAGES

Stage	Criteria	Details
1	The initial search	Search query only
2	Timeframe	Limited to 2012-2022
3	Document types	Limited to:
		Articles
		Conference papers
		Reviews
4	Language	Limited to English
5	Subject area	Limited to Social Sciences Only
6	Key Words	Exclusions:
		Stem Education
		Secondary Education
		Middle School
		Early Childhood
		High School Teachers
		EFL Teachers
		Secondary Schools
		STEM (science, Technology, Engineering and Mathematics).

The results of the analysis have been presented under the units of analysis including i) year of publication, ii) journals, iii) authors iv) number of citations for articles, iv) number of citations for authors and v) thematic analysis. The following segment provides the details of the findings under each category separately.

1) Volume and Trend of Publications during 2012 - 2022
2) Journals
3) Authors and Number of Publications
4) Number of citations for publications and authors
5) Thematic analysis (Keywords)

Volume and trend of Publications during 2012 - 2022

The results of the search in Scopus for the broad topic TPACK and PLC indicated that articles are available from the early 1990s but until 2010 in a very small number has been identified. The documents in Scopus have boosted to three folds approximately from 2012 on-wards. It is found that the number of documents has dramatically decreased from 2013 to 2014. However, starting from 2014 the volume of publications is in a drastic increasing trend up to 2023. In particular, a notable sharp increase has been found from 2015 to 2016 and from 2021 to 2022. Comparing these two periods, the number of publications is higher in number from 2021 – 2022 which an increase of about 90%.

TABLE 2
TOTAL NUMBER OF PUBLICATIONS FROM 2012 – 2022

#	Year	Number of Publication
1	2022	189
2	2021	151
3	2020	130
4	2019	123
5	2018	112
6	2017	101
7	2016	97
8	2015	77
9	2014	63
10	2013	98
11	2012	59
	Total	1201

The table above provides a detailed overview of the total number of publications over a period of 10 years. A total of 1201 documents have been identified with the search confirming the inclusion criteria for a period of 10 years. On average, the number of documents published counts up to 109 publications per year. The table helps in understanding the evolution of publications for the period. As detailed in the table 2 the number of publications on the topic has increased as the initial number of publications were recorded 59 while this number has increased up to three folds in 2022. Notably the highest number of publications has been recorded in 2022 as 189. One notable sharp increase in total number of publications is observed from 2020 to 2022. Overall, a noticeable uptick trend of research output on the topic has been confirmed from the overall data. The line graph below (Figure 5) illustrates the overview more clearly.
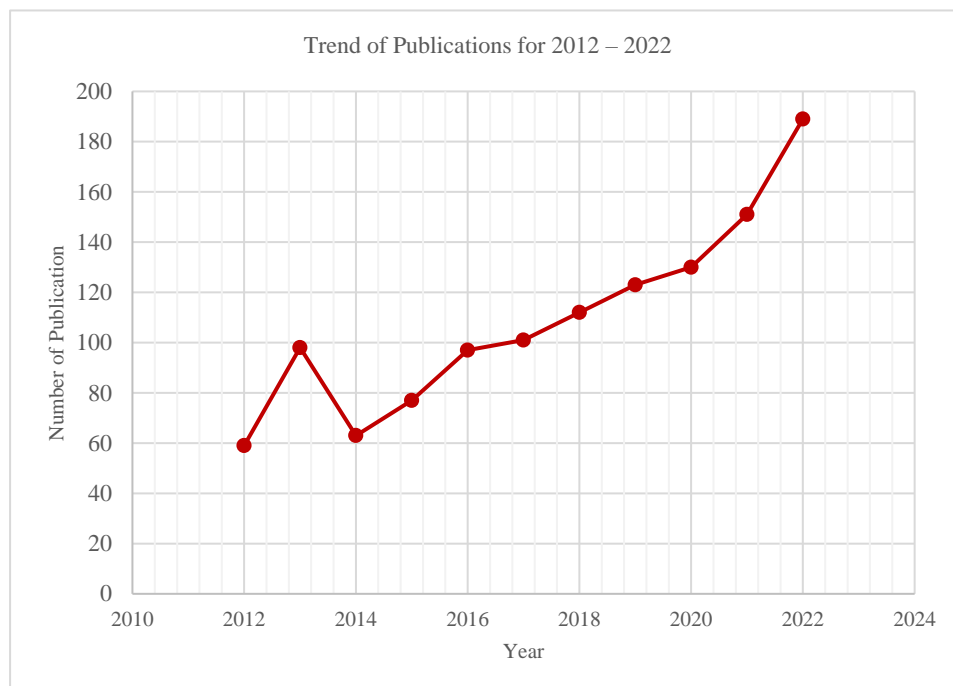

Fig. 5.
Overall Trend of Publications

Journals

The purpose of the study includes orienting the researchers on the most substantial aca-demic journals to consult in the interest of conducting research on this topic. The search in the Scopus database is run in accordance with this criterion and the search was not limited to any specific journals. Therefore, any journal comprising publications meeting the inclu-sion criteria has been taken into consideration with the final list of publications. The results reported 150 journals with various accepted forms of publications on the topic. The least amount of publication on a journal is recorded as 2 and highest is 29. To provide an over-view of the significant contributions by the journals, the top 10 journals with the highest publications are detailed in Table 3 and Figure 6 below.

TABLE 3
PUBLICATIONS BY THE JOURNALS FOR THE TOP 10 JOURNALS

#	Journal	Number of Publications
1	Journal Of Science Teacher Education	29
2	International Journal of Science Education	28
3	Professional Development in Education	26
4	Education Sciences	18
5	Teaching And Teacher Education	18
6	Journal Of Research in Science Teaching	17
7	International Journal of Science and Mathematics Education	15
8	Australasian Journal of Educational Technology	14
9	Eurasia Journal of Mathematics Science and Technology Education	14
10	Journal Of Mathematics Teacher Education	14
	Total for top 10 Journal	193
	Remaining 140 Journal	603
	Total	796

The search results on this domain indicate the distribution of the publication on the topic across various journals providing academic and scientific information. As it is recorded, Journal of Science Teacher Education JOSTE has attributed with the highest number of documents making it the most significant contributor for the research on the topic. It is recorded 29 publications on this topic over a period of 10 years. At the same time, the International Journal of Science Education IJSOE and the Professional Development in Education PDIE do have publications at similar and equivalent levels. These three journals have a record number of publications compared to the rest of all journals. Another interesting observation is that publications appeared on the topic belong to the journals of a diverse focus. Some examples of such journals include Journal of Science Teacher Education, Eurasia Journal of Mathematics Science and Technology Education and Journal of Mathematics Teacher Education. To provide a better picture, this information is visualised across the time frame and illustrated in the form of line-graph below in Figure 6. To summarise the information the top 5 journals with the highest publication are only considered for the figure. As such, most substantial publications records are notable for researchers and academics with interest on this topic.
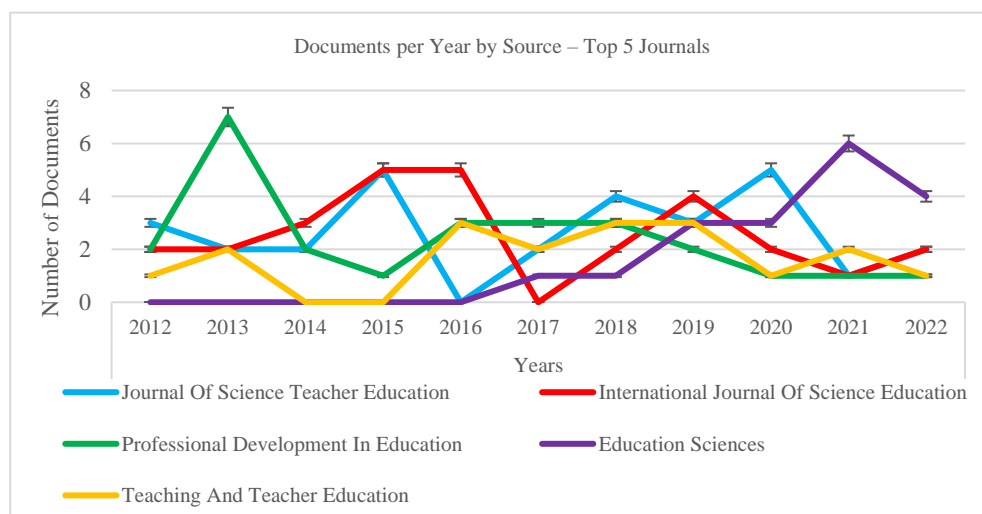

Fig. 6.
Trend of Publications by top 5 Journals

Number of Publications

Another important research question that this study intends to answer is the most common authors on the topic. As mentioned earlier, the total number of publications represents the productivity and contribution of a researcher on the specific domain of research (Bonilla et al., 2015). A number of substantial authors have been identified with search in the Scopus database. One intention here is to inform the researchers about the authors with the highest range of publications. In this quest, more than 150 authors have been identified from a basis of 1201 publications. The number of publications ranged from 2 to 26 for the pool of authors, however, the selected authors' have a minimum number of 4 publications. Some researchers accept 3 or more publication for a period of 10 years in considering core authors in bibliometric analysis (WeiYou & Xiang, 2020). To inform the researchers about the most significant or productive authors in terms of research output, the authors were ranked based on the total number of publications for the time period. On this criterion, 10 authors with the highest number of publications are taken into consideration. This accounts for 6% of the authors compared to the 150 authors appeared on the final search results.

TABLE 4
PUBLICATIONS BY TOP 10 AUTHORS

#	Author	Number of Publication
1	Chai, C.S.	26
2	Koh, J.H.L.	17
3	Ward, P.	13
4	Tsai, C.C.	7
5	Blonder, R.	5
6	Liang, J.C.	5
7	Voogt, J.	5
8	Chang Rundgren, S.N.	4
9	Ince, M.L.	4
10	Kim, I.	4
	Total for top 10 Authors	90
	Total for rest of 140 authors	361
	Total	451

Considering research results, the table above details the most prominent authors for the period of 10 years. As per the statistics given, Chai, C.S has been recorded as the most prolific author with 26 publications over a period of 10 years. Chai's number of publications are remarkably well above the rest of the authors, thus, regarded as the leading author on this topic. As such, Chai's contribution for research and academia on the topic professional learning and community and TPACK is commendable. Notably, among the rest of the authors, Koh, J.H.L (17 articles) and Ward, P. (13 articles) have contributed to the topic reasonably as detailed in Table 4 and Figure 7 below. These two authors' individual contribution is nearly half of the leading author. Knowing the core authors and their contribution on specific domain with certainly helps researchers and students to align their footsteps towards the most appropriate materials and this can certainly provide some reference for follow-up research (WeiYou & Xiang, 2020).
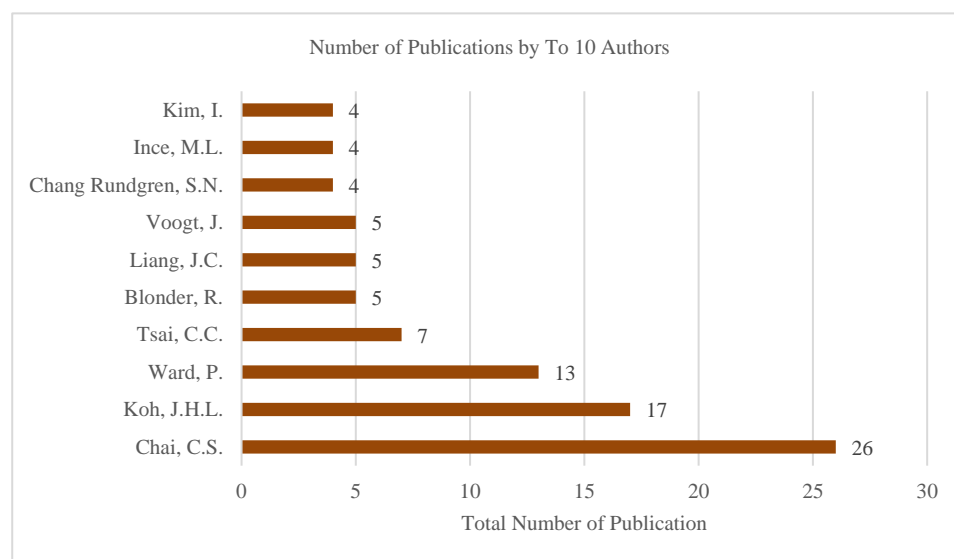

Fig. 7.
Publication Trend by Top 10 Authors

Number of Citations

One important indicator of usefulness and impact of research in academia is the number of citations over time. The number of citations demonstrate the influence of researchers in the academic landscapes (Bonilla et al., 2015). To orient the researchers on this aspect of this research topic, one of the research questions of this study intends to analyse the cite score of the articles and authors resulted from the search. The cite score of the published documents are filtered in terms of highest to lowest score. For the search results including the 1201 documents a total cite score of 16710 has been identified while the average cite score is recorded as 16.05 citations per document. In order to identify the most cited documents, the cite score for the top 15 most cited documents has only been reported in this study. This accounts for 17% of the total publications. As such, considering these 15 documents, the total cite score reaches up to 2880 leaving an average of 192 citations per document. The table below illustrates this information including the cite score for the 15 most cited documents and the authors of these publications as well. Across the articles, the cite score ranges from 93 to 845. The key observations for these statistics are reported in Table 5 considering the name of the document, author, and number of citations.

Initially the article with highest citations is reported is the article titled "Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity" published by Spinger International Publishing in 2020. This article has reached 845 citations until August 2023. The number of citations for this article in other databases are also remarkably high. For example, in Google Scholar the number of citations has reached up to 2100 by August 2023. It has been authored by Rapanta Chrysi, Botturi Luca, Goodyear Peter, Guàrdia Lourdes, and Koole Marguerite. The rest of the articles' citations are relatively low compared to this article. These articles can be grouped in a range from 200 – 300 citations and 100 – 199 citations. As reported in the table below only 2 articles appear in the middle range and 7 articles fall in lowest range. Comparing this in-formation with the number of publications by the authors (Number of publications by Authors – To 10 Authors: given point number 3 above), it shows as a similar picture. The authors with the highest number of publications include Chai, C.S. and Koh, J.H.L who are also included in the top 15 most cited publications' list. These two authors appear in 13th and 14th in the list with more than 100citations. Table 5 below provides the details on articles and the number of citations.

TABLE 5
NUMBER OF CITATIONS FOR TOP 15 ARTICLES

#	Title	Authors	Year	Cited by
1	Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity	Rapanta C.; Botturi L.; Goodyear P.; Guàrdia L.; Koole M.	2020	845
2	Best Practices in Teachers' Professional Development in the United States	Desimone L.M.; Garet M.S.	2015	237
3	Teacher professional development focusing on pedagogical content knowledge	van Driel J.H.; Berry A.	2012	228
4	The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology	Rienties B.; Brouwer N.; Lygo-Baker S.	2013	190
5	Teacher STEM perception and preparation: Inquiry-based stem professional development for elementary teachers	Nadelson L.S.; Callahan J.; Pyke P.; Hay A.; Dance M.; Pfiester J.	2013	186
6	Differential effects of three professional development models on teacher knowledge and student achievement in elementary science	Heller J.I.; Daehler K.R.; Wong N.; Shinohara M.; Miratrix L.W.	2012	157
7	Exploring the Development of Pre-Service Science Elementary Teachers' Pedagogical Content Knowledge	Nilsson P.; Loughran J.	2012	151
8	Teachers' pedagogical content knowledge of scientific argumentation: The impact of professional development on K-12 teachers	McNeill K.L.; Knight A.M.	2013	130
9	Students' patterns of engagement and course performance in a Massive Open Online Course	Phan T.; McNeil S.G.; Robin B.R.	2016	130
10	Factors influencing the functioning of data teams	Schildkamp K.; Poortman C.	2015	114
11	Teacher pedagogical content knowledge, practice, and student achievement	Gess-Newsome J.; Taylor J.A.; Carlson J.; Gardner A.L.; Wilson C.D.;	2019	112

Stuhlsatz M.A.M.

12	Mentoring as professional development: 'growth for both' mentor and mentee	Hudson P.	2013	105
13	Teacher Professional Development for TPACK-21CL: Effects on Teacher ICT Integration and Student Outcomes	Koh J.H.L.; Chai C.S.; Lim W.Y.	2017	102
14	Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modeling approach	Koh J.H.L.; Chai C.S.; Tsai C.-C.	2013	100
15	Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens	Brinkley-Etzkorn K.E.	2018	93

Thematic Analysis (Keywords)

Analysing the keywords or keywords mapping on a research topic can help determine the overall trends of research over the period of time. According to WeiYou and Xiang (2020) analysing the trend of keywords on a research topic can provide reasonable reference for the follow-up research. In other words, the landscape of scientific research on specific re-search area can be obtained via bibliometric keywords mapping. This analysis often portrays the frequency of keywords and connections among themselves. According to Donthu et al. (2021) keywords can help researchers in bibliometrics to uncover the emerging themes and networks. Keyword analysis in bibliometrics informs the researchers about the evolving interest of the authors over time as well. More importantly, around the vast volume of literature, the broader themes emerge can be visualised by deploying keywords mapping approach.

Aa a part of this study, it intends to determine the overall trend of research on the topic on the basis of the keywords. For this purpose, data that resulted from the search has been exported as a CSV file. The analysis is performed by using VOSviewer 1.6.19 desktop application. In order understand the co-occurrence rate of keywords, their connections and more importantly to get the overall trend, different maps based on bibliographic data are developed. As a result, the results are presented as maps illustrating the cooccurrence of keywords (author keywords and index keywords). Three forms of maps have been generated including network visualisation, overlay visualisation and density visualization as given in Appendix 1. The minimum number of cooccurrence of a key is set to 5 as a basic parameter for the keywords mapping. The total number of keyword count reached 3374 and out of these 176 keywords are confirmed to this inclusion criteria. This represents 5% of the total keywords identified. The results are presented in terms of the frequency of the keywords and the interplay among the terms.

In keywords mapping, VOSviewer determines the clusters based on keywords considering the number of co-occurrences, total links, and link strength as well. A total of 8 clusters are identified by the keywords alnalysis performed by VOSviewer, however, the most prominent 5 clusters of keywords or themes that emerge from the analysis will be discussed here. It included professional development (red), teaching (green), content knowledge (dark blue), technology integration (yellow), TPACK (purple), higher education (light blue), science teachers (orange) and inquiry (brown) as colored in Figure 8. The keyword representing each cluster is assigned based on its density. The details of the clusters are provided in Table 6 below. Among these clusters of keywords, professional development is the most significant theme in terms of density, overlay and network as illustrated in Figure 8 below. Professional development has been ranked as the most prominent cluster with the highest co-occurrence rate (297 co-occurrence score, 160 links to other keywords and a score of 930 as a link strength).

One reason is having PLC as one of the core variables of this study, and it is in fact a commonly accepted model focused on professional development across the globe. PLC is a widely accepted vehicle for and is shown as effective framework for professional development (Battersby, 2019; Bedford & Rossow, 2017; Cherrington et al., 2018; Du Plessis & Muzaffar, 2010). This component is linked to most of the key variables resulted from the study. For instance, it has found strong connections to variables including teaching, TPACK and technology integration as well. Considering the available literature, PLC has been found as a variable that can effect TPACK and technology integration as well (Adulyasas, 2018; Gillow-Wiles, 2011; Paulus et al., 2020). Some of the researchers including Gillow-Wiles (2011) noted that PLC is not only linked to TPACK but also a predictor of TPACK. Table 6 below shows major clusters and their details.

TABLE 6
MAIN CLUSTERS AND CO-OCCURRENCE RATE

#	Keywords	Clusters	Occurrences	Links	Link Strength
1	Professional Development	1	297	160	930
2	Teaching	2	114	139	762
3	Content Knowledge	3	91	112	383
4	Technology Integration	4	42	50	132

5	TPACK	5	98	82	324
6	Higher Education	6	98	82	226
7	Science Teachers	7	15	37	69
8	Inquiry	8	9	16	27

The second theme emerged from keywords mapping is "teaching" and it is observed that this concept has clear connections to most of the key terms aforementioned. It has co-occurrence counts up to 114, nearly 140 connections to other keywords and a score of 762 for link strength. Some of the most obvious ends of its network are linked to teacher professional development, education, educational technology and to the primary dimension of TPACK as visualized in Figure 8. These relationships can be explained based on some of the recent literature. For example, Cope and Ward (2002) argue that promoting and integrating technology in education in recent years have been supported by many countries across the globe. Teacher professional development is one of the keywords that appeared with this level of significance.

The third most significant cluster obtained from the analysis is the "content knowledge". Besides pedagogical content knowledge PCK is more clearly visible than CK, PCK has not been considered as separate clusters as it is counted in cluster 1 (professional development). CK is attributed to 91 co-occurrences, 112 links and a total score of 383 as a link strength. As visible from the analysis it has its connection to other clusters including TPACK, teaching higher education, and technology integration as well. As quoted in the literature, CK is one of the primary dimensions of TPACK (Mishra & Koehler, 2006). In fact, CK as a dimension of TPACK has been included in the search query. Literature on TPACK indicates a strong bond between TPACK and technology integration. Some researchers on this line including Glowatz and O'Brien (2017) considers TPACK as a yardstick to examine technology enabled learning. The overall trend and the major themes that emerge from the keywords are illustrated in Figure 8 below.
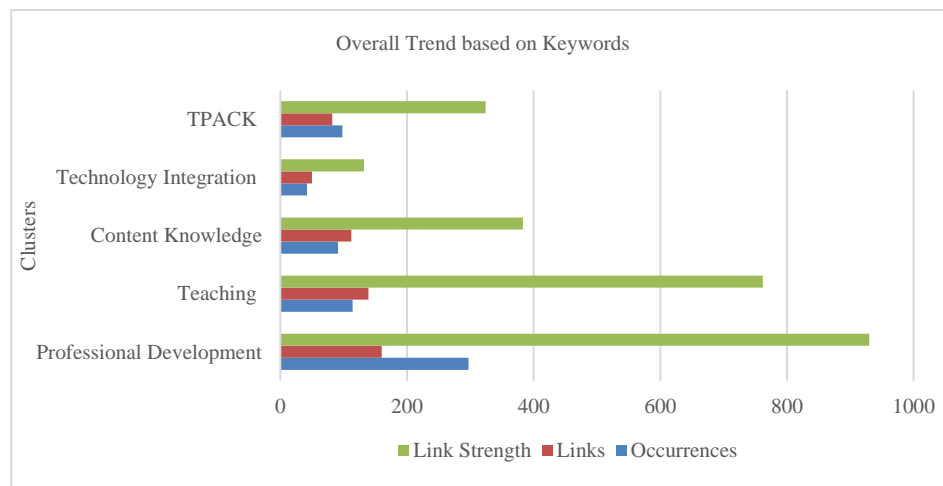

Fig. 8.
Overall Trend and Major Themes

Next, as a forth cluster "technology integration" has been identified in the findings. The analysis reveals its co-occurrence rate over 40, 50 connections to other keywords and 132 as a link strength score. Moreover, this concept has been significantly networked to professional development and to the sub-dimensions of TPACK. Literature concerned with technology integration is aligned with this association. TPACK has been regarded as one of most widely accepted frameworks for technology integration and professional development towards assistive technology (Glowatz & O'Brien, 2017; Malik et al., 2019; Mishra & Koehler, 2006; Tondeur et al., 2017). In addition to this, technology integration has been reported with a clear relationship with keywords such as online learning, e-learning, blended learning and learning community as well.

Finally, TPACK is considered as the fifth cluster based on the analysis. TPACK model includes the keywords such as content knowledge CK, pedagogical content knowledge PCK, technological pedagogical content TCK as well. TPACK is one of the prime keywords of the search query developed for this study. The search query included other keywords related to TPACK including i) technological knowledge ii) pedagogical knowledge and iii) content knowledge. In fact, these are the are primary dimensions of TPACK framework (Mishra & Koehler, 2006). TPACK itself and several terms associated with TPACK appeared among the most co-occurring keywords.

Considering TPACK alone it has hit more than 90 co-occurrence counts, more than 80 links to other variables and a score of 324 for signal strength as well. It is not surprising that this variable's link strength is higher than the fourth cluster "Technology Integration" (132). One may observe from the findings that this terminology has been connected not only to its sub-dimensions, but also to the keywords such as professional development and teacher education as well. TPACK and its sub-dimensions are associated with the most obvious key concepts of the study including professional development, teacher professional

development, and higher education. At the same time, these connections are linked to most of the keywords in general, while all of these key words are connected to each other.
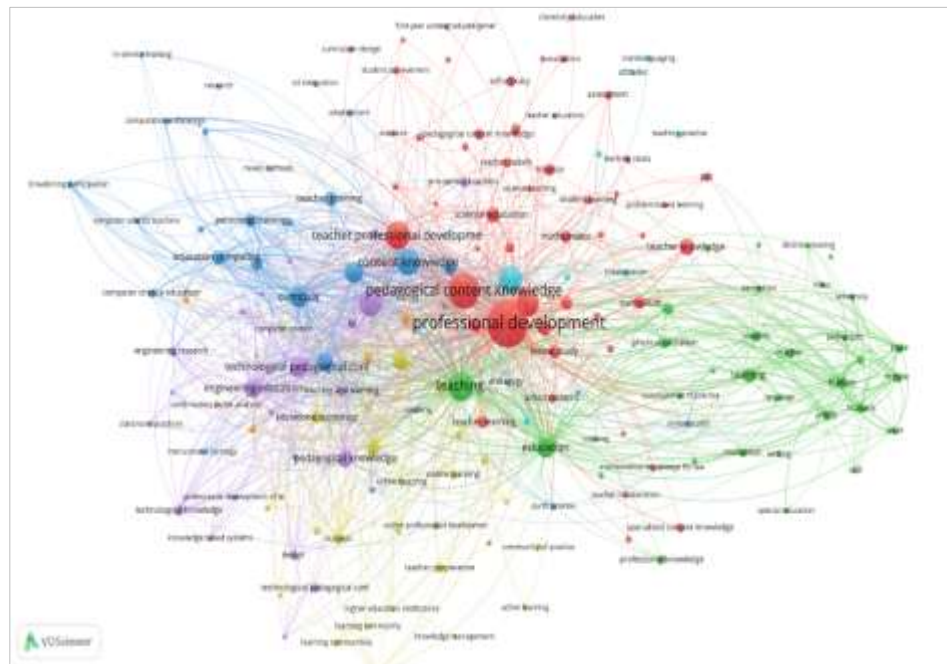

Fig. 9.
Main Themes and Their Network

It is worth noting that, besides "learning community" and "professional learning community" have been included in the search query, this variable did not emerge as a key theme. In the analysis a few keywords related to professional learning community have appeared but under other major themes of clusters including cluster 4 and 1 (technology integration and professional development) with less than 10 co-occurrences only. Figure 9 above illustrates the major themes and their networks for all keywords.

SUMMARY

Based on their bibliometric information, this study has attempted to determine the overall trend and the key themes that emerge from the research on PLC and its influence on TPACK. For this purpose, it has anlysed more than 1200 documents obtained from the Scopus database. These documents include journal articles, conference papers and reviews only. It concentrated on the subject area of social sciences and documents published between 2012 – 2022 only. One observation is that the volume of research on the topic over the past 10 years has increased with an upward trend in general. At the same time, considering the journals with scientific publications on this topic, JOSTE has been recorded as the most substantial journal to opt in the interest to study the topic further.

Considering the authors' contribution on the topic, Chai, C.S. and Koh, J.H.L. have been identified as the core authors of this topic. Next, considering the available documents "Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity" has been recorded as the most cited article across the timeframe. Finally, based on keywords mapping, a handful of themes that emerge from the clusters of keywords have been identified. It included i) professional development, ii) Teaching, iii) content knowledge iv) technology integration and finally v) TPACK. In a nutshell, these terms have been used multiple times as keywords and they have a clear relationship to one another considering publications for the past 10 years.

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