

ORIGINAL ARTICLE

**TEACHER DIGITAL PROFESSIONAL DEVELOPMENT: A BIBLIOMETRIC ANALYSIS USING SCOPUS DATABASE FROM 2001-2023****MJSSH**
Muallim Journal of
Social Science and Humanities**Goh Kok Ming¹, Mahaliza Mansor^{*2}, Dayang Rafidah Syariff M. Fuad³**

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Abstract

The integration of digital technologies into education has become essential in the 21st century, necessitating that teachers worldwide improve their digital competencies. Despite knowing the importance of digital competencies, challenges persist, such as centralized planning and rapid technological advancements. This study aims to provide insights and recommendations for understanding Teacher Digital Professional Development (TDPD). This study adopted a bibliometric analysis based on the data obtained from the Scopus online database as of December 2024. Based on the 'keywords' search results, the study finalized 445 valid documents for further analysis. Then, the author employed a VOS viewer for data visualization purposes. As the results revealed, there has been an increased growth rate of digital professional development literature since 2001. The increasing number of works on digital professional development indicates a growing awareness of its importance and specific requirements. The component elements within the Teacher Digital Professional Development model according to this study are situative learning experiences, congruence with teacher beliefs, online environment, TPACK Development, enabling institutional policies, interactive and collaborative activities, and taking consideration of teacher characteristics. In conclusion, this study describes the Teacher Digital Professional Development in detail and future research on this proposed Teacher Digital Professional Development model should be conducted to enable a broader understanding in this field.

Keywords: Bibliometric analysis, teacher digital professional development, digital competencies

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Introduction

In the 21st century, the integration of digital technologies into education has become imperative, necessitating that teachers worldwide enhance their digital competencies. Teacher Digital Professional Development (TDPD) focuses on equipping educators with the necessary skills to effectively incorporate technology into their teaching practices. Globally, various initiatives have been implemented to support this transition. For example, the Organization for Economic Cooperation and Development (OECD) highlights the potential of digital technologies to transform teacher learning and the delivery of professional development activities throughout teachers' careers (Minea-Pic, 2020). In Malaysia, the Ministry of Education has recognized the importance of TDPD and has undertaken several initiatives to enhance teachers' digital competencies. Teacher training programs such as the Smart Teacher Training Course and collaborations with strategic partners like Microsoft, Apple, Google, and UNESCO aim to develop teachers' capacity to integrate ICT into their teaching practices. Despite these efforts, challenges persist in the effective implementation of TDPD in Malaysia. Issues such as centralized planning of professional development programs, which may not address the specific needs of teachers, and the rapid pace of technological advancements necessitate continuous evaluation and improvement of TDPD strategies (Khan et al., 2021). This study can provide valuable insights into the current state of TDPD in Malaysia and offer recommendations for enhancing the effectiveness of professional development training for teachers in the future. This, in turn, can lead to improved teaching practices, better student outcomes, and a more robust education system capable of meeting the demands of the digital age.

Objectives

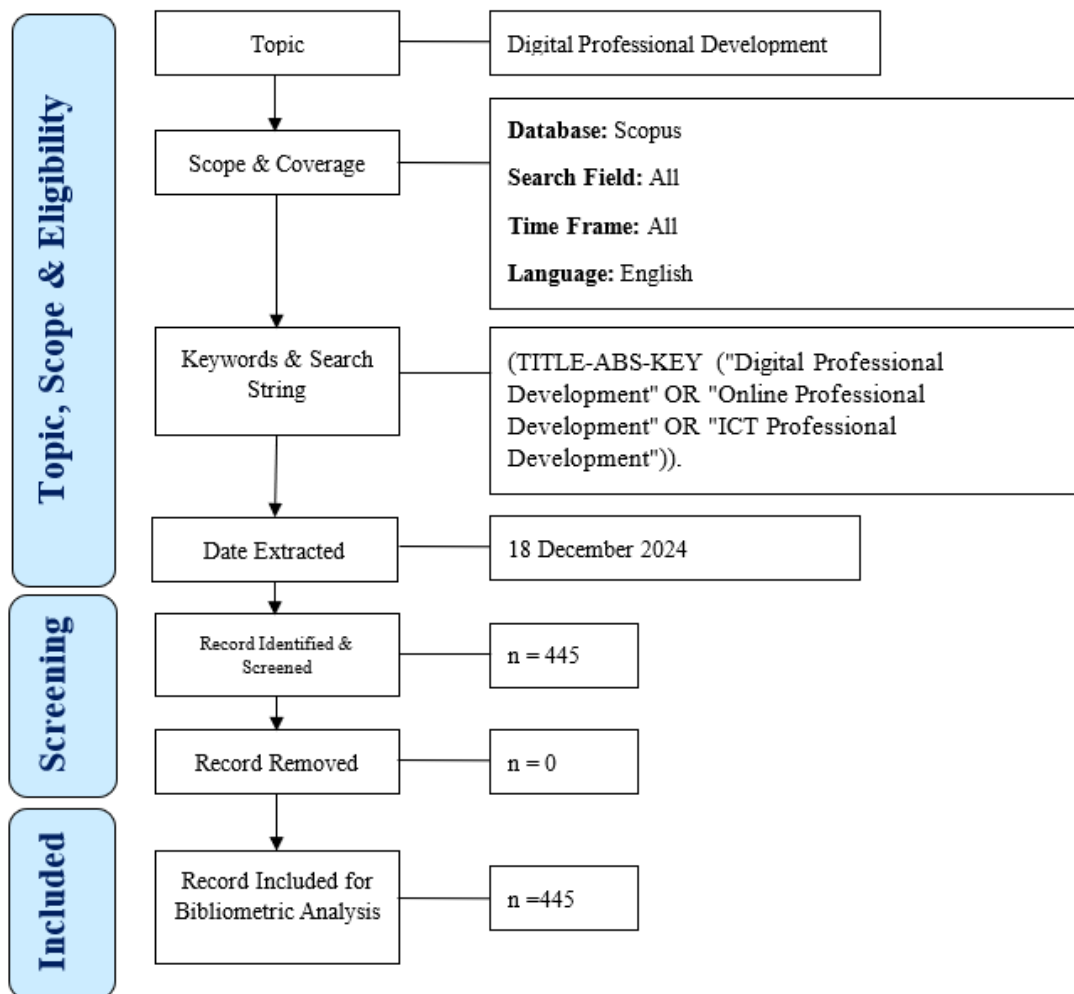
This study conducted a bibliographic analysis of all types of publications connected to "digital professional development" as published in the Scopus online database as of December 2024 in response to the limitation of works analyzing the trend of digital professional development studies. To address the dearth of works analyzing the trend of digital professional development research, this study undertook a bibliographic analysis of all sorts of publications related to "digital professional development" as published in the Scopus online database as of December 2024. Regarding the document type, source of publishing, year of publication, language utilized, subject area, geographical profile, authorship, and citation analysis, this study gives an analysis of all publications under consideration. The pattern of earlier papers on this research issue is helpfully elucidated in this article. This research provides an analysis of all publications considered in terms of the document type, publishing source, year of publication, language used, subject area, geographical profile, authorship, and citation analysis. In this publication, the pattern of previous works on this research subject is clarified. Through bibliometric analysis, this study will attempt to address four research questions as follows:

1. What are the current states and trends of publications about digital professional development literature?
2. What are the recent important keywords for digital professional development?
3. What are the highly cited documents in digital professional development research?
4. What are the insights of publications in the field of digital professional development?

Materials and Methods

Since Scopus is the largest database of scholarly publications (larger than PubMed or Web of Science), the study used this database as a starting point to extract earlier research on digital professional development. Scopus was utilized as a starting point for the study since it has the most prior research on digital professional development and is the largest database of scholarly papers (greater than PubMed or Web of Science). The database offers publication-specific information, such as access type, year, author name, topic matter, document type, source title, keyword, affiliation, nation, source type, and language. In this study, we limited the search of digital professional development studies based on the title to further narrow down the pertinent scholarly publications on the research domain evaluated. The following search term has been added as a result: (TITLE-ABS-KEY ("Digital Professional Development" OR "Online Professional Development" OR "ICT Professional Development")). To further analyze, this query produced a total of 445 documents. On December 18, 2024, the information was obtained. This search returned a total of 445 documents for further analysis. The data was acquired on December 18, 2024.

Figure 1
Flow diagram of the search strategy.



Note. Zakaria et al. (2020), Moher et al. (2009)

Results

The analysis of the extracted scholarly works considers authorship, citation, the language of the document, topic area, language of the source, annual growth, and national productivity in this study. In this study, the analysis of the retrieved academic works takes into consideration authorship, citation, the document's language, the source's language, the topic area, yearly growth, and national productivity. Most conclusions are given as frequency and percentage. In the meanwhile, this study provides annual growth data as the number of documents retrieved annually, together with their frequency, percentage, and cumulative percentage up until December 2024. Most conclusions are expressed as frequency and percentage. Meanwhile, this study gives yearly growth statistics as the number of documents retrieved annually, as well as their frequency, percentage, and cumulative percentage up to December 2024. Furthermore, we presented citation analysis as citation metrics and listed the top 20 publications in digital professional development by the number of citations.

Document and Source Type

In this study, the data is initially examined according to the source and document types. The data in this study is first reviewed based on the source and document types. The “Source Type” is the kind of source document, which might be a journal, conference proceedings, book series, book, or trade publication. Meanwhile, the “Document Type” refers to a type of document based on the originality of the document, such as a conference paper, article, or book chapter. The conference paper shown under the “Document Type” might not be the same as the one listed under the “Source Type” (Sweileh et al., 2017). For example, a paper presented at a conference will be classified as a conference paper under document type. However, the same paper may be classified as a full journal article, conference proceeding, or book chapter under source type depending on its publication status.

As summarized in Table 1, the documents published on digital professional development spread into seven document types. According to further evidence, articles account for more than half of the total publications (69.89%), with conference papers coming in second (13.48%) and book chapters coming in third (12.36%). Less than 5% of the entire publication was made up of other types of documents.

Table 1
Document Type

Document Type	Frequency	% (N=445)
Article	311	69.89%
Conference Paper	60	13.48%
Book Chapter	55	12.36%
Review	13	2.92%
Conference Review	3	0.67%
Book	2	0.45%
Note	1	0.22%
Total	445	100.00%

Meanwhile, as shown in Table 2, the papers may be classified into four distinct source categories, with journals being the most common source type with 327 documents (73.48%) and conference proceedings coming in second with 58 documents (13.03%). At 12.36% (55 documents), book series make up a sizable portion of the overall number of publications. However, the book series represents the least source type with 5 documents (1.12%). Book series account for a considerable fraction of the total number of publications, accounting for 12.36% (55 items). However, with 5 papers (1.12%), the book series is the least common source type.

Table 2
Source Type

Source Type	Frequency	% (N=445)
Journal	327	73.48%
Conference Proceeding	58	13.03%
Book	55	12.36%
Book Series	5	1.12%
Total	445	100.00%

Publication by Year and Annual Growth

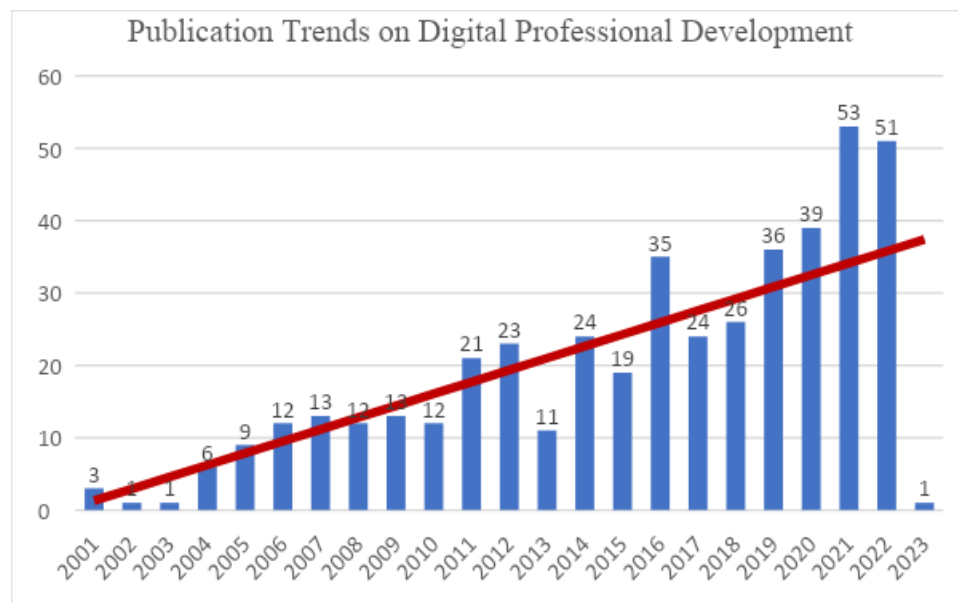
Table 3 and Figure 2 show detailed information on digital professional development papers from 2001 to 2023. According to Scopus archives, MacKenzie and Staleyfirst were the first to research online professional development in 2001. The connected publication's growth was a little modest in the following years, but it picked up in 2018 and has averaged 41 publications each year since then. With a total of 53 articles (11.91%), 2021 saw the most publications overall. According to Scopus archives, the first study on online professional development was done in 2001 by MacKenzie and Staleyfirst. The related publication grew slowly during the next several years, but it started to gain momentum in 2018 and has averaged 41 publications per year since then. The year with the most publications overall was 2021, with a total of 53 articles (11.91%).

Table 3
Publication Year and Annual Growth

Year	Frequency	% (N=445)	Cumulative Percent
2001	3	0.67	0.67
2002	1	0.22	0.90
2003	1	0.22	1.12
2004	6	1.35	2.47
2005	9	2.02	4.49
2006	12	2.70	7.19
2007	13	2.92	10.11
2008	12	2.70	12.81
2009	13	2.92	15.73
2010	12	2.70	18.43
2011	21	4.72	23.15
2012	23	5.17	28.31
2013	11	2.47	30.79

2014	24	5.39	36.18
2015	19	4.27	40.45
2016	35	7.87	48.31
2017	24	5.39	53.71
2018	26	5.84	59.55
2019	36	8.09	67.64
2020	39	8.76	76.40
2021	53	11.91	88.31
2022	51	11.46	99.78
2023	1	0.22	100.00
Total	445	100.00	100.00

Figure 2
Publication Trends on Digital Professional Development



Languages of Documents

According to Table 4, most publications in this field of study (444; 99.11%) are written in English. Spanish (2, 0.45%), Chinese, and French (1, 0.22 %) are other regularly used languages. Three documents have been released in both English and Spanish, and the remaining document is published in Chinese. Table 4 shows that 444 (44.11%) of the papers in this field of study are authored in English. Other frequently used languages are Chinese (1, 0.22%), French (1, 0.45%), and Spanish (2, 0.45%). The remaining document is published in Chinese, and three documents have been made available in both English and Spanish.

Table 4
Languages Used for Publications

Language	Frequency	% (N=445)
English	444	99.11%
Spanish	2	0.45%
Chinese	1	0.22%
French	1	0.22%
Total	448	100.00%

Note. two documents published in dual languages: one document in Chinese

Subject Area

The published documents in this study are then categorized depending on their subject area, as shown in Table 5. Overall, the distribution shows that studies on digital professional development are being conducted in a variety of fields, including social science, business/management, engineering, healthcare, and environmental sciences. According to reports, social science (85.84%) and computer science (28.76%) make up most of the documents analyzed. Table 5 shows how the published materials in this study are classified based on their subject matter. Overall, the distribution indicates that digital professional development research is being conducted in a wide range of fields including social science, business/management, engineering, healthcare, and environmental sciences. According to reports, most of the materials examined are from social science (85.84%) and computer science (28.76%). Psychology (9.66%), Arts and Humanities (7.64%), Medicine (6.07%), Engineering (5.62%), Mathematics (3.15%), Business, Management, and Accounting (2.92%), Economics, Econometrics, and Finance (1.8%), Health Professions (1.8%), and Nursing (1.12%) were the next most popular majors. Other fields, such as Agricultural and Biological Sciences, Chemistry, Environmental Science, and Material Science, had only one publication, with a frequency of less than 1%.

Table 5
Subject Area for Publications

Subject Area	Frequency	% (N=707)
Social Sciences	382	85.84%
Computer Science	128	28.76%
Psychology	43	9.66%
Arts and Humanities	34	7.64%
Medicine	27	6.07%
Engineering	25	5.62%
Mathematics	14	3.15%
Business, Management and Accounting	13	2.92%
Economics, Econometrics and Finance	8	1.80%
Health Professions	8	1.80%
Nursing	5	1.12%
Decision Sciences	4	0.90%
Physics and Astronomy	4	0.90%
Earth and Planetary Sciences	2	0.45%

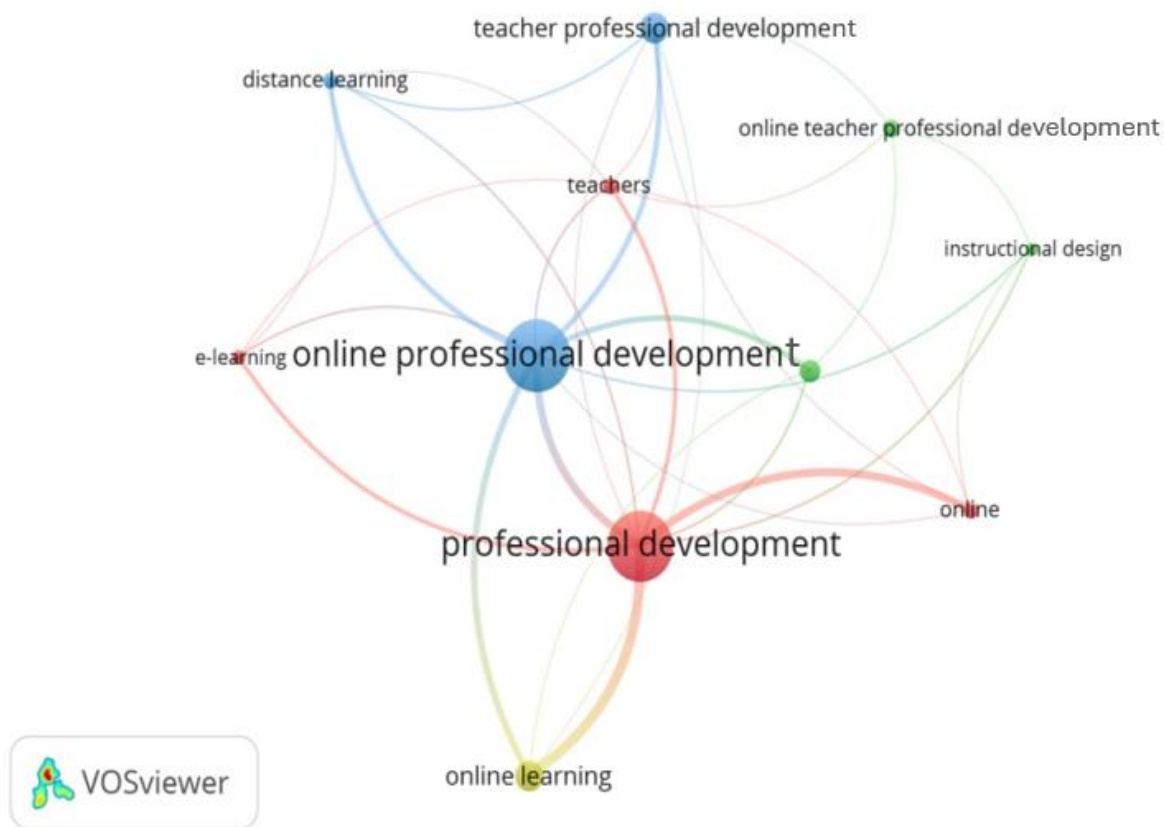
Neuroscience	2	0.45%
Agricultural and Biological Sciences	1	0.22%
Biochemistry, Genetics and Molecular Biology	1	0.22%
Chemistry	1	0.22%
Environmental Science	1	0.22%
Materials Science	1	0.22%
Multidisciplinary	1	0.22%
Pharmacology, Toxicology and Pharmaceutics	1	0.22%
Veterinary	1	0.22%
Total	707	100.00%

Note. Some documents are classified in more than one subject area.

Keyword Analysis

To conduct a keyword analysis, the authors used the VOS viewer, a program for creating and displaying bibliometric networks, to map the keywords provided for each article (Figure 3). The authors utilized the VOS viewer, a tool for constructing and presenting bibliometric networks, to map the keywords provided for each article to conduct a keyword analysis (Figure 3). Color, circle size, text size, and the thickness of connecting lines in Figure 3's network representation of the authors' keywords created by the VOS viewer indicate how strongly the keywords are related to one another. The color, circle size, text size, and thickness of connecting lines in Figure 3's network representation of the authors' keywords generated by the VOS viewer indicate how closely connected the keywords are to one another. Commonly included together are keywords that are related as indicated by the same color. Based on the graphics shown, for instance, professional development, online professional development, teacher professional development, distance learning, online learning, e-learning, and instructional design are all tightly related and frequently co-occur. Similar keywords, as shown by the same color, are frequently included together. Professional development, online professional development, teacher professional development, distant learning, online learning, e-learning, and instructional design, for example, are all strongly connected and regularly co-occur, according to the picture.

Figure 3
 Network visualization map of the author keywords



Meanwhile, professional aspects, e-learning, teaching, education, human, online learning, teacher professional development, and curricula are among the keywords with the highest occurrences after removing core keywords specified in the search query, for example namely professional development and online professional development (see Table 6).

Table 6
 Author Keywords

Author Keywords	Frequency	Percent
Professional Aspects	52	11.69%
E-learning	50	11.24%
Teaching	49	11.01%
Education	34	7.64%
Human	31	6.97%
Online Learning	29	6.52%
Teacher Professional Development	28	6.29%
Curricula	27	6.07%

Top 20 Most-Cited Articles

The analysis shows that 5,057 citations were registered in 21 years (2001 - 2023) for 445 retrieved publications, with an average of 240.81 citations/year. Meanwhile, Table 7 discloses the 20 most cited articles (based on the number of times cited). The document entitled “Contemporary approaches to teacher professional development” by Borko et al. (2010) has so far received the highest number of citations (242 citations or an average of 20.17 citations per year). Meanwhile, Table 10 shows the top 20 most-cited papers (based on the number of times cited). Borko, Jacobs, and Koellner's work "*Contemporary methods to teacher professional development*," released in 2010, has gotten the most citations thus far (242 citations or an average of 20.17 citations per year). "*The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology*" by Rienties et al. (2013) came in second (177 citations, an average of 19.67 citations per year), followed by "*The beliefs that influence teachers' ICT practices*" by S. Prestridge (2012) with 166 citations (16.2 average citations per year).

Table 7
Top 20 Most Cited Articles

No.	Author(s) Year	& Title	Total Citations	Citations/ Year
1	Borko et al. (2010)	Contemporary approaches to teacher professional development	242	20.17
2	Rienties et al. (2013)	The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology	177	19.67
3	Prestridge (2012)	The beliefs behind the teacher that influences their ICT practices	162	16.2
4	Carpenter & Krutka (2015)	Engagement through microblogging: educator professional development via Twitter	137	19.57
5	Wise et al. (2004)	The effects of teacher social presence on student satisfaction, engagement, and learning	115	6.39
6	Kelly & Antonio (2016)	Teacher peer support in social network sites	100	16.67
7	Koh et al. (2017)	Teacher Professional Development for TPACK-21CL: Effects on Teacher ICT Integration and Student Outcomes	89	17.8
8	Barab et al. (2004)	Designing system dualities: Characterizing an online professional development community	80	4.44

9	Zhang et al. (2017)	Interactive networks and social knowledge construction behavioral patterns in primary school teachers' online collaborative learning activities	70	14
10	Vanderlinde et al. (2014)	Institutionalized ICT use in primary education: A multilevel analysis	64	8
11	Downer et al. (2009)	Teacher characteristics associated with responsiveness and exposure to consultation and online professional development resources	63	4.85
12	Alt (2018)	Science teachers' conceptions of teaching and learning, ICT efficacy, ICT professional development and ICT practices enacted in their classrooms	62	15.5
13	Smith & Sivo (2012)	Predicting continued use of online teacher professional development and the influence of social presence and sociability	61	6.1
14	Koh & Chai (2016)	Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK)	58	9.67
15	Mackey & Evans (2011)	Interconnecting networks of practice for professional learning	56	5.09
16	Parsons et al. (2019)	U.S. teachers' perceptions of online professional development	55	18.33
17	Vrasidas & Zembylas (2004)	Online professional development: Lessons from the field	55	3.06
18	Niess et al. (2010)	Knowledge Growth in Teaching Mathematics/Science with Spreadsheets: Moving PCK to TPACK through Online Professional Development	54	4.5
19	Powell & Bodur (2019)	Teachers' perceptions of an online professional development experience: Implications for a design and implementation framework	53	17.67
20	Kerckaert et al. (2015)	The role of ICT in early childhood education: Scale development and research on ICT use and influencing factors	49	7

Based on Table 7, the top 20 most-cited articles in teacher digital professional development (TDPD) offer valuable insights into effective strategies, essential components, and emerging

constructs. Borko et al. (2010) emphasized the importance of situated perspectives in professional development, advocating for learning experiences situated in authentic teaching contexts. They highlighted the collaborative learning among teachers and the integration of content knowledge with pedagogical skills. This approach acknowledges the complexities of classroom dynamics and the necessity for professional development to be adaptable to individual teacher needs and local contexts. Prestridge (2012) explored the underlying beliefs that shape teachers' use of Information and Communication Technology (ICT) in classrooms. The study highlights the need for professional development programs to address teachers' beliefs to effectively change ICT practices. However, they note that factors such as disciplinary differences, institutional cultures, and time investment play crucial roles in training retention and effectiveness.

Rienties et al. (2013) examined how online professional development influences higher education teachers' beliefs about teaching and their intentions to integrate technology. They suggested that well-designed online professional development can positively affect teachers' pedagogical beliefs and technology adoption. The study suggested that aligning professional development with teachers' existing beliefs and providing evidence of ICT's effectiveness in enhancing student learning can facilitate more meaningful integration of technology in teaching practices. Carpenter and Krutka (2015) investigated how educators use Twitter for professional development. They found that microblogging platforms can facilitate meaningful professional learning communities, offering opportunities for resource sharing and reflective practice. Their findings suggest that the informal, accessible, and collaborative nature of social media allows for the development of personalized learning networks, fostering a culture of continuous improvement and peer support among educators.

Wise et al. (2004) examined the role of teacher social presence in online learning environments. Findings indicated that a strong teacher presence can enhance student satisfaction, engagement, and learning outcomes, underscoring the need for professional development in building online teaching competencies. Their study highlighted the need for fostering a sense of community and interaction in online professional development programs to enhance engagement and learning outcomes. Creating opportunities for meaningful interaction, collaboration, and feedback in online settings can mitigate feelings of isolation and promote a more engaging and supportive learning experience for teachers. Similarly, Kelly and Antonio (2016) explored how social networking sites serve as platforms for teacher peer support. They suggested that these platforms can be effective for sharing resources and experiences, contributing to professional development. Engaging in online communities allows teachers to access diverse perspectives, receive constructive feedback, and collaboratively solve problems, thereby enhancing their professional practice and resilience.

Koh et al. (2017) discussed professional development aimed at enhancing teachers' Technological Pedagogical Content Knowledge (TPACK) for 21st-century learning. Findings showed that such professional development leads to improved ICT integration and positive student outcomes. Barab et al. (2004) characterized the dynamics of online professional development communities, highlighting the balance between individual and collective learning needs. They provided insights into designing effective online professional development environments. Zhang et al. (2017) analyzed behavioral patterns in online collaborative learning among primary school teachers. They emphasized the importance of interactive networks in facilitating social knowledge construction. The findings suggest that structured online collaborative activities promote the co-

construction of knowledge, critical thinking, and the application of new teaching strategies, thereby enhancing the overall quality of professional development experiences.

Vanderlinde et al. (2014) presented a multilevel analysis of ICT integration in primary education, highlighting factors at the teacher, school, and policy levels that influence effective use. The study highlighted the need for supportive school policies and infrastructure to facilitate effective ICT use by teachers. Institutional commitment, including providing adequate resources, leadership, and a conducive culture, is essential for the successful implementation of ICT initiatives and the sustainability of professional development outcomes. Downer et al. (2009) identified teacher characteristics that predict engagement with online professional development resources, suggesting that certain dispositions may influence professional development participation. Teachers with higher levels of education and more years of experience demonstrated greater engagement with online professional development resources. Teachers may recognize the value of continuous learning and are more inclined to utilize available resources. The study found that teachers who held positive attitudes towards technology and its integration into the classroom were more responsive to online professional development. This highlighted the importance of fostering positive perceptions of technology to enhance professional development engagement. Teachers with higher self-efficacy, or confidence in their teaching abilities, were more likely to engage deeply with professional development resources, indicating that belief in one's capabilities can drive professional growth.

Alt (2018) examined the relationship between science teachers' conceptions of teaching, ICT efficacy, and their ICT practices, highlighting the role of professional development in shaping these factors. Alt (2018) stated that teachers who embraced constructivist approaches to teaching and learning were more likely to integrate ICT into their classrooms effectively. This suggests that pedagogical beliefs influence technology adoption. The study found that participation in ICT-focused professional development was positively correlated with teachers' confidence in using technology (ICT efficacy) and the subsequent implementation of ICT practices in the classroom. This suggests the importance of targeted professional development in building ICT skills and found that ICT efficacy served as a mediator between professional development and classroom practices. Smith and Sivo (2012) explored factors that predict teachers' continued use of online professional development platforms, emphasizing the importance of social presence and sociability in sustaining engagement. The perception of being connected with others in an online environment (social presence) significantly predicted teachers' intentions to continue using online professional development platforms. This suggests that feeling part of a community enhances engagement of teacher digital professional development. Smith and Sivo (2012) stated that the design elements that facilitate social interaction (sociability) within the online platform also play a crucial role in sustained use. Platforms that encouraged interaction among participants fostered a sense of belonging and collaboration. The findings imply that online professional development platforms should incorporate features that enhance social presence and sociability, such as discussion forums, peer feedback mechanisms, and collaborative projects, to promote continued teacher engagement.

In line with that, Koh et al. (2016) identified seven design frames that teachers employ when integrating technology, providing a framework for professional development programs to enhance TPACK. The seven design frames are: the Content-Driven frame emphasizes enhancing the delivery of specific content through technology. The Pedagogy-Driven frame focuses on how technology can support and improve various teaching methods. The Technology-Driven frame

begins with a technological tool and explores its applications in teaching and content delivery. The Learner-Centered frame prioritizes meeting the diverse needs of learners through technological integration. The Contextual frame considers the specific educational environment and how technology fits within that context. The Activity-Focused frame involves designing learning activities that are enhanced by technological tools. Finally, the Assessment-Oriented frame utilizes technology to effectively assess student learning outcomes. Understanding these frames is crucial for designing professional development programs aimed at enhancing Technological Pedagogical Content Knowledge (TPACK), as they provide a comprehensive approach to addressing the varied ways in which teachers can integrate technology into their instructional practices. Mackey and Evans (2011) discussed the concept of interconnected networks of practice, where teachers engage in multiple communities for professional learning, facilitated by digital technologies. Parsons et al. (2019) studied U.S. teachers' perceptions of online professional development, finding generally positive attitudes but also highlighting challenges such as time constraints and varying quality. Vrasidas and Zembylas (2004) shared lessons learned from implementing online professional development programs, emphasizing the need for careful design and consideration of contextual factors.

Niess et al. (2010) examined how in-service K–8 teachers develop their Technological Pedagogical Content Knowledge (TPACK) through an online graduate course focused on integrating dynamic spreadsheets into mathematics and science teaching. The study highlighted the progression from Pedagogical Content Knowledge (PCK) to TPACK. Powell and Bodur (2019) explored teachers' perceptions of an online professional development (OPD) experience, focusing on its design and implementation. They suggested that well-designed online professional development programs should incorporate interactive and practical elements to enhance teacher engagement and learning outcomes. Teachers appreciated the convenience of accessing professional development materials online, allowing them to engage at their own pace. The study highlighted the importance of interactive components, such as discussion forums and peer feedback, and was highlighted as essential for effective learning. Teachers valued content that was directly applicable to their classroom practices, emphasizing the need for practical strategies in online professional development programs. Kerckaert et al. (2015) investigated the use of Information and Communication Technology (ICT) in early childhood education. They identified two primary types—ICT supporting basic skills and attitudes, and ICT supporting content and individual learning needs. They examined factors that affect ICT integration, such as teacher attitudes, access to resources, and institutional support, and developed a reliable scale to measure ICT use in early childhood education settings.

Discussions

Bibliometric analysis serves as a pivotal tool in evaluating the landscape of teacher digital professional development (TDPD). By systematically analyzing academic publications, this paper offers insights into publication trends, influential research, and emerging themes within the teacher's digital professional development. The literature on teacher digital professional development has experienced significant growth over the past decade. Studies indicate a continuous increase in publications from 2013 to 2020, with a notable surge post-2018. This uptick reflects the escalating integration of digital competencies in educational settings and the heightened emphasis on equipping teachers with necessary digital skills. Spain and Germany have emerged as leading contributors, underscoring their commitment to advancing digital

competencies in education (Senita Butar Butar et al., 2024). In Malaysia, the government's commitment to enhancing digital competencies is evident through various policies and educational reforms. For example, the Malaysia Education Blueprint 2013–2025 underscores the necessity for educators to adapt to digital advancements, aiming to produce a digitally competent teaching workforce. Furthermore, the ICT Transformation Plan 2019–2023 was launched to support the digital education agenda, encouraging principals and teachers to master digital technology skills. Malaysia's commitment to integrating digital technology into its education system is exemplified by the launch of the Digital Education Policy (DEP) on November 28, 2023, to set a clear framework for digital education. These examples manifest Malaysia's contributions in this field are emerging. However, there is a need for increased academic focus on teacher digital professional development to ensure the effective integration of digital competencies in educational settings.

Despite visualizing bibliometric analysis can be complex, it can be facilitated through the VOS viewer to understand the relational patterns among variables and research trends in teacher digital professional development. It helps in planning research strategies by identifying collaboration opportunities and underexplored research areas (Boran et al., 2024). Keyword analysis within bibliometric studies reveals prevalent themes such as "digital competence," "ICT," "educational technology," "digital literacy," and "teacher training." These terms highlight the central focus on enhancing teachers' abilities to effectively integrate digital tools into their pedagogy. Emerging keywords like "digital teaching competence," "improvement," and "digital tools" suggest a shift towards refining specific digital skills and the practical application of digital resources in teaching environments. These emerging keywords remind us that while the focus on digital competence and tools is growing, challenges such as insufficient training, lack of technical support, and low motivation among teachers persist (Diachuk, 2024). Addressing these issues requires comprehensive strategies, including the development of national standards and policies on digital literacy, to ensure equitable access and effective use of digital resources in education. In line with that, Zhankushkov et al. (2024) emphasize the formation of digital competence among future primary school teachers through the effective use of electronic resources like SCRUM boards, Quizlet, and Google Forms.

Furthermore, identifying highly cited documents is essential for highlighting several key implications, and emerging themes, and suggesting effective models for enhancing teachers' digital professional development. For the aspect of key implications, future professional development should be situated within authentic teaching environments, promoting collaborative learning among teachers and integrating content knowledge with pedagogical skills (Borko et al., 2010). This approach acknowledges classroom complexities and the need for adaptable professional development tailored to individual teacher needs and local contexts. This study also highlights the importance of aligning professional development programs with teachers' existing beliefs to effectively change digital practices (Prestridge, 2012). Factors such as disciplinary differences, institutional cultures, and time investment are crucial for training retention and effectiveness. Furthermore, this study suggests that well-designed online professional developments can positively influence higher education teachers' pedagogical beliefs and technology adoption, facilitating meaningful integration of technology in teaching practices (Rienties et al., 2013; Koh et al., 2016). Interestingly, this study notifies that social media platforms can be utilized to be professional development platforms. These platforms facilitate the acquisition of professional competencies and personal qualities necessary for adapting to the modern economy and social environment due to their informal, accessible, and collaborative nature (Wilson, 2024; Mackey & Evans, 2011; Carpenter & Krutka, 2015; Kelly & Antonio, 2016). Hota (2024) supports

social media platforms like YouTube, WhatsApp, X (previously Twitter), and Facebook, providing a vast repository of educational content and helping in skill development and knowledge acquisition to enhance teachers' digital professional development.

This study highlights that teachers' social presence in online professional development is crucial for fostering engagement, connection, and community among teachers. The transition to online learning, especially during the COVID-19 pandemic, highlighted the importance of social presence in maintaining effective communication and interaction in virtual environments (Smith & Sivo, 2012). Wise et al. (2004) highlight that a strong teacher presence in online environments enhances student satisfaction, engagement, and learning outcomes, underscoring the need for professional development in building online teaching competencies. In line with that, Rodhiyya and Bhakti (2024) developed the Job-Embedded Professional Development (JEPD) model to offer a structured approach to improving teachers' social presence skills through online learning. Kourkouli (2024) stated that teachers' social presence in online learning can be achieved through direct instruction and active participation in online forums. Therefore, teachers' digital professional development training should consider the importance of teachers' social presence in online learning.

In addition, this study constructs and proposes an effective Teacher Digital Professional Development (TDPD) model based on the findings of the top 20 most cited articles. This TDPD model should encompass the following components: (i) situative learning experiences where professional development programs should be designed and situated in authentic teaching contexts, promoting collaborative learning among teachers and integrating content knowledge with pedagogical skills; (ii) alignment with teacher beliefs where professional development programs should be developed by considering and aligning with teachers' existing beliefs, addressing factors such as disciplinary differences and institutional cultures to enhance training retention and effectiveness; (iii) utilization of online platforms where well-designed online professional development platforms should be incorporated to facilitate meaningful professional learning communities, offering opportunities for resource sharing, reflective practice, and personalized learning networks; (iv) emphasis on TPACK Development where the focus on enhancing teachers' Technological Pedagogical Content Knowledge should be prioritized to improve teachers' ICT integration and achieve positive student outcomes; (v) supportive institutional policies where supportive school policies and infrastructure are in place to facilitate effective ICT use, providing adequate resources, leadership, and a conducive culture for successful implementation of ICT initiatives; (vi) interactive and collaborative activities where structured online collaborative activities should be designed to promote the co-construction of knowledge, critical thinking, and the application of new teaching strategies; and, (vii) consideration of teacher characteristics, where professional development programs should consider teacher characteristics such as education level, experience, attitudes towards technology, and self-efficacy to enhance engagement and effectiveness. In summary, implementing a TDPD model that integrates these components can lead to more effective professional development experiences, fostering continuous improvement and resilience among educators in the digital age.

Conclusion

Greater concern over digital professional development issues comes hand in hand with the growing Internet reliance by today's digital technology advancement. This has attracted considerable

attention from scholars worldwide to examine and recommend possible solutions to deal with issues regarding digital professional development. In response, this study has initiated a review of all kinds of scholarly works published to date on this topic. The study reports the trend of earlier studies using selected bibliometric indicators as obtained from the Scopus database. The bibliometric details of 445 documents were extracted from the Scopus database. The results indicate that English becomes a primary language in the majority (99.11%) of the retrieved documents. While about 24.64% of documents are single-authored, close to 80% of the documents have either two or three authors. The data also shows an increasing trend in the number of authorships per document over time. As for the contributing authors, the USA reported the highest number of contributing authors, followed by Spain and the UK. However, there are sizable contributions of scholarly works on this research domain from other European and Asian countries. Diverse academic disciplines, including computer science, social sciences, mathematics, and engineering, are paying attention to issues related to digital professional development. Nevertheless, computer science is the category in which roughly half of the documents under examination fall. In another regard, since 2018, there have been more publications on digital professional development. This analysis shows that the average number of authors per document has increased over time, along with the frequency of publications per year. In some ways, this pattern suggests increased author collaboration in this field.

There are a few limitations that should be aware of. despite the article's insightful findings. To discover the first list of scholarly works published and indexed by Scopus, this study used searches and keywords. However, this method has been employed frequently for prior bibliometrics-related studies. Scopus is one of the biggest online databases that indexes all scholarly papers, however, it is not comprehensive in its coverage of all sources. Therefore, some exclusions from this study are to be expected. Additionally, no search term is 100% accurate in capturing all the academic articles in this field. As a result, inaccurate results—both positive and negative—are always expected. To rank the authors and institutions included in this study, the authors used Scopus' definition. Additionally, some institutions or authors might use alternative spellings or register different names in Scopus. The accuracy of their authorship and affiliation information, as a result, was produced. Despite these drawbacks, this study was one of the first to examine bibliometric indicators of digital professional development literature.

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