Bibliometric Analysis of Pedagogical Content Knowledge (PCK) Publication Trends in Scopus Database From 2018 to 2022

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Article Info

ABSTRACT

This study aims to determine the research development with Pedagogical Content Knowledge (PCK) in the world from 2018 to 2022. This research is a type of qualitative research with literature studies. Research data was obtained using the Scopus search engine to identify research related to the PCK theme from 2018 to 2022. This study used the VOS viewer to map and analyze data. The findings in this study are that the highest year in research publications is 2020. The United States is the country that contributes the most research publications. Furthermore, topics regarding content knowledge, students, and teaching, which have great opportunities for further research, are related to the theme of PCK. Content knowledge (students or teachers) is the most important topic in scientific research publications with the theme of PCK from 2018 to 2022 indexed by Scopus.

INTRODUCTION

Pedagogical Content Knowledge is a blend of understanding of teaching material (Content Knowledge) and how to educate (Pedagogical Knowledge) which blends into a teacher's needs. Park et al (2020) formulated that Pedagogical Content Knowledge is an understanding of what learning methods are effective for explaining particular material and what makes specific material easy or challenging to learn about Pedagogical Content Knowledge (PCK). Two significant parts comprise Pedagogical Content Knowledge (PCK): content and pedagogical knowledge. According to (KUL et al., 2019) content knowledge includes knowledge of concepts, theories, ideas, frameworks, methods of proof, and evidence. Meanwhile, pedagogical knowledge relates to teaching methods and processes, including class management, assignments, planning, and student learning. Measuring the ability of PCK needs to be based on several aspects. Aspects of PCK have been described by several experts such as (Busch et al., 2022; Krepf et al., 2018; Magnusson et al., 2021; Rodríguez-Becerra et al., 2020; Shinana et al., 2021; Ling et al., 2020; Weitzel & Blank, 2020) study focuses on 3 aspects, namely 1) Knowledge of Material Mastery, 2) Knowledge of Pedagogy, and 3) Knowledge of Learners.

Sintema & Marbán, (2020) suggests that PCK is the knowledge that a teacher must understand because a teacher must be familiar with alternative concepts and difficulties that students will face with diverse backgrounds and be able to organize, compile, run, and assess subject matter, all of which that is summarized in PCK. (Evens et al., 2015) argues that PCK is a thinking concept that gives the understanding that to teach is not enough to understand the content of the material (knowing) but also how to teach (how to teach). Teachers must learn students, curriculum, instructional strategies, and assessments to transform knowledge effectively. (Sintema & Marbán, 2020) argues that in PCK, content is the knowledge that teachers,
including facts, concepts, principles, laws, and theories, should master. Meanwhile, pedagogy means ways that can be done to help students learn and solve problems. Cooper et al., (2022); Nurul Sari et al., (2020); Sæleset & Friedrichsen, (2021); Shinana et al., (2021); Ling et al., (2020); Poitras et al., (2019) argues that one of the possible factors for increasing teacher effectiveness is enriching their PCK by combining content knowledge and pedagogical knowledge built over time and experience so that, in the end, it can produce professional teachers. In a constructivist view, teaching is not merely an activity of transferring knowledge but an activity that allows students to construct their understanding. On this basis, a teacher must have content and pedagogical knowledge (Pedagogic Content Knowledge).

Several studies related to PCK have been carried out. KUL et al., (2019) examined the relationship between knowledge of mathematics and knowledge of teaching mathematics (PCK). Her research shows that while a deep understanding of mathematical knowledge is necessary, more than knowledge is needed to teach mathematics. The study shows a relationship between knowledge of mathematics and knowledge of teaching mathematics (PCK). Primary mathematics teacher candidates should be educated both from the knowledge of mathematics and the PCK aspects. In addition, there is also research conducted by (Koehler, 2006) regarding the difficulties that are often experienced by prospective teachers, one of which is integrating pedagogical knowledge with content knowledge. A teacher must not only master the material or content knowledge but must know how to integrate content knowledge with knowledge about curriculum, learning, and student characteristics. PCK is crucial for an educator to create meaningful student learning. Research on PCK has been conducted by (Akçay & Yager, 2010; Blau et al., 2016; Cetin-Dindar et al., 2018; Chai et al., 2019; Chai & Koh, 2017; Evens et al., 2015; Jimoyiannis, 2010; Kleickmann et al., 2013; Koehler, 2006; KUL et al., 2019; Lee, 2010; Lin & Jou, 2012; Rodríguez-Becerra et al., 2020; Sintema & Marbán, 2020; Tomczyk, 2020; Valtonen et al., 2017) outline the results of their research showing that PCK is essential knowledge for the development of the professional skills of educators and prospective educators.

The results of previous studies show that the level of educators' PCK still needs to be higher. This research includes research by (Sintema & Marbán, 2020) titled "Pre-service Secondary Teachers' Mathematical PCK Self-concept related to their Content Knowledge of Functions and Students." The results of this study indicate that educators' content knowledge still needs to be improved, and educators have some difficulties in learning in class. In addition, the inability of educators to design instructional activities and appropriate assessments is also a matter of great concern: another research from (Margiyono & Mampouw, 2011). The results of their study show that from a pedagogical content standpoint, educators still need help planning and implementing their learning. Meanwhile, regarding content knowledge, the teacher's mastery of the material differs from the student's learning outcomes.

PCK is vital for educators to have because this PCK will affect the performance of educators in teaching. In addition, PCK can create valuable learning for students. According to (Akçay & Avci, 2022; Busch et al., 2022; Correia & Baptista, 2022; Mumcu et al., 2022), PCK is the knowledge that is important for developing the professional skills of educators and prospective educators. The research findings show that in terms of pedagogical content, educators master the curriculum and realize that this material is complex for students to accept. However, they still need help planning and implementing their learning. Pedagogic competencies that still need improvement are mastery of teaching and understanding students' needs. Educators still need to start using learning methods that can further motivate students to learn rational numbers, and students' mastery of weak prerequisite material has not become a concern of educators. Previous research on PCK has not examined the impact of contextual knowledge on PCK; however, these studies provide important clues about this impact (Lertdechapat & Faikhampa, 2021; Milewski, 2022; Thohir et al., 2022). For example, previous research has shown that pre-service teachers' preparation time for teaching and their concerns about classroom management (Sintema & Marbán, 2020), teacher characteristics, and background (Lee, 2010) influence their instructional strategies.
According to research conducted by (Lee, 2010) teacher candidates prefer multiple instructional strategies in their lessons because prospective teachers learn science better through these strategies when they are undergraduate students. Likewise, teacher characteristics influence the teacher's selection of instructional strategies. For example, teacher candidates who consider themselves unready report that they do not prefer presentation and discussion methods in their teaching. Similarly, research by (Sintema & Marbán, 2020) shows that fun science experiments attended by pre-service teachers, field trips that increase the curiosity of pre-service teachers, and teaching experiences positively influence pre-service teachers' orientation towards science. Previous research conducted with in-service teachers also showed that experienced teachers and teachers who received feedback from last teaching had richer PCK compared to their peers; teaching experience and methods courses taken at the undergraduate level influence the choice of instructional strategies (Archambault et al., 2022; Scharfenberg & Bogner, 2021) conferences that teachers attend and have family members working in science-related jobs positively influence teacher knowledge (Evens et al., 2015) and teachers' reactions to student questions affect teachers' pedagogical context knowledge (Baker & Chick, 2006). PCK research has been carried out by several Indonesian and foreign researchers such as (Ambusaidi et al., 2021; Aydin-Gunbatar et al., 2020; Berisha & Vula, 2021; Fikriyah et al., 2021; Krepf et al., 2018; Ma'Rufi et al., 2018; Muhtarom et al., 2019; Pondee & Srisawasdi, 2021; Schiering et al., 2023) in general, the results of his research show that PCK is essential knowledge for the development of the professional skills of educators and prospective educators.

PCK is knowledge about material and how to teach it or a mixture of content and pedagogy that forms an understanding of how a topic, problem, or issue is organized and represented according to learning abilities (Fore et al., 2015; Gökçe & Güner, 2021). According to (Koehler, 2006; Ma’rufi et al., 2017; Muhtarom et al., 2019) PCK is pedagogic knowledge that applies to teaching specific content. PCK includes what approaches are appropriate to the content, or it can also be how content elements can be arranged for better learning. Another definition of PCK was also put forward by (Lee, 2010), who stated that PCK is the knowledge of an educator in providing teaching situations to assist students in understanding the content of scientific facts. Zhang et al., (2019) defines PCK as knowledge about pedagogy, learning practices, and learning planning, as well as appropriate methods for teaching material. Krepf et al., (2018) states that PCK includes ways to represent or formulate material so that other people understand. In this case, they know why a particular topic learning material is difficult or easy (level of material difficulty), the knowledge that students of various ages and backgrounds are brought to them to be taught specific learning topics (KUL et al., 2019). So, in this case, PCK is the ability of educators to transfer knowledge to students. PCK of a teacher can influence the success of a chemistry lesson, such as the research results (Evens et al., 2015; Kleickmann et al., 2013; Ma’Rufi et al., 2017) which states that the teacher's pedagogical competence affects student learning difficulties and learning outcomes (Muhtarom et al., 2019).

**RESEARCH METHOD**

This research is a type of qualitative research with an iterative study. Qualitative research methods using literature study techniques are data collection techniques based on finding written data such as notes, books, articles or articles, journals, etc. In a bibliometric study, data can be obtained from primary, secondary, or tertiary journals covering a period and analyzed from various angles to determine whether the data displayed are articles by affiliation, articles by country or region, articles by type, articles by subject area, articles by source, and articles by year. This study uses the Scopus search engine to identify research related to PCK that will be conducted from 2018 to 2022. There are 368 research publications related to PCK worldwide from 2018 to 2022. The Scopus database has become a significant study resource for evaluating scientific research. As one of the largest data centres in the world, Scopus can index scientific literature to provide accurate information about the metadata of each scientific article, including
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https://doi.org/10.46627/silet.v4i2.222

publication date, abstracts, references, etc. (Valderrama-Zurián et al., 2015). Figure 1 shows the stages in data collection and analysis of data processing obtained in the Scopus database.

**Figure 1.** Shows the trend of research publications with the theme PCK from 2018 to 2022

This study also uses VOSviewer to map scientific research publications on PCK in the World. This study uses VOSviewer for publication visualization analysis in co-occurrence analysis. VOSviewer pays special attention to the graphical representation of bibliometric maps. VOSviewer is a software tool for building and visualizing bibliometric networks (van Eck & Waltman, 2010). The VOSviewer functionality is useful for displaying large bibliometric maps in an easy-to-interpret way (van Eck & Waltman, 2010). Therefore, this research will answer how the development of research with the theme of PCK in the world from 2018 to 2022.

**RESULTS AND DISCUSSION**

**Results**

a. Global publication analysis

The analysis of 368 scientific publications from the Scopus database produces various data. Scientific publications related to PCK in the world from 2018 to 2022 have multiple points of view. This study analyzes and classifies data starting from the year of the document. This country significantly contributes to scientific publications, journal sources, authors, institutional outputs, and document affiliations.

**Figure 2.** Number of articles published each year

Figure 2 shows research publications with PCK from 2018 to 2022. In 2018 there were 55 published articles indexed by Scopus, then in 2019 and 2020, there was a very significant increase, namely 81 and 92 articles. Then the following year, namely 2021, there will be a decrease from 92 to 85 articles. Then in 2022. Then in 2022, there will be a reduction to 55 articles.

b. State contribution

Twenty countries contributed to publishing global scientific research with PCK from 2018 to 2022. Figure 2 shows countries contributing to research publications around the world.
Table 1. Articles by country

<table>
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<th>No</th>
<th>Country</th>
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<td>19</td>
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<tr>
<td>20</td>
<td>Spain</td>
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</table>

Table 1 shows that the United States is the country that contributes the most to Scopus-indexed scientific research publications with the theme PCK from 2018 to 2022 with 208 articles—followed by the United Kingdom, which has 73 articles. Germany also has a high contribution by contributing 50 articles. Canada also has 43 articles, followed by Italy, with 32 articles. In addition, the Netherlands contributed 28 articles, Australia 25 articles, France 23 articles, China and Russia 18 articles, Switzerland 17 articles, India 13 articles, and Belgium, Israel, Japan, and South Korea every 12 articles. Meanwhile, Austria, Brazil, Finland, and Spain contributed scientific publications with the theme PCK 2018 to 2022 with 9 articles.

Figure 3. Network mapping of 368 articles by country
c. Analysis of publication sources

Several publication sources publish scientific research related to PCK. Figure 3 shows the top twenty sources that published this research.

1. Publisher

<table>
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<th>Publisher</th>
<th>Records</th>
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<tr>
<td>1</td>
<td>Philosophical Studies</td>
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<tr>
<td>2</td>
<td>AIP Conference Proceedings</td>
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<tr>
<td>3</td>
<td>Science and Education</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>American Journal of Physics</td>
<td>11</td>
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<tr>
<td>5</td>
<td>Studies in History and Philosophy of Science Part A</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>Foundations of Science</td>
<td>9</td>
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<tr>
<td>7</td>
<td>Physics Teacher</td>
<td>9</td>
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<tr>
<td>8</td>
<td>Journal for General Philosophy of Science</td>
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<tr>
<td>9</td>
<td>Philosophy of Science</td>
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<tr>
<td>10</td>
<td>Synthesis</td>
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<td>12</td>
<td>Erkenntnis</td>
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<tr>
<td>13</td>
<td>European Journal of Physics</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>Minds and Machines</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>Physics Essays</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>Religions</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>Acta Analytica</td>
<td>5</td>
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<tr>
<td>18</td>
<td>Boston Studies in the Philosophy and History of Science</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>European Journal for Philosophy of Science</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>Foundations of Physics</td>
<td>4</td>
</tr>
</tbody>
</table>

2. Authors

This section will discuss aspects of the author's character, country of origin, and author's institution. As shown in Table 3, researchers from America are the most involved in PCK research, the country contributing the most Scopus-indexed scientific research publications with the theme PCK from 2018 to 2022, with 208 articles. Followed by the United Kingdom, which has 73 articles. Germany also has a high contribution by contributing 50 articles. Canada also has 43 articles, followed by Italy, with 32 articles. In addition, the Netherlands contributed 28 articles, Australia 25 articles, France 23 articles, China and Russia 18 articles, Switzerland 17 articles, India 13 articles, and Belgium, Israel, Japan, and South Korea every 12 articles. Meanwhile, Austria, Brazil, Finland, and Spain contributed scientific publications with the theme PCK 2018 to 2022, namely 9 articles (Figure 4)

Figure 4. Pedagogical content knowledge publication authors map
3. Keywords

This study uses a minimum number of occurrences of keywords five times in all research publications analyzed using VOSviewer. Figure 5 shows the 40 identified keywords classified into seven clusters.

**Figure 5.** Network visualization keywords

Colours indicate groups, while image labels indicate keywords or terms that appear frequently. Clustering is used to gain insight or an overview of bibliometric groupings, while image mapping is used to get an overall picture of a bibliometric network. Figure 5 shows some clusters matched with various colours. Cluster 1 is red, cluster 2 is green, cluster 3 is blue, and cluster 4 is yellow. Furthermore, cluster 5 is purple, cluster 6 is light blue, and cluster 7 is orange.


**Figure 6.** Density of visualization keywords
Discussion

This study discusses publications related to PCK in Education from the database dimension and analyzed and visualized through descriptive and evaluative bibliometric analysis methods, such as country bibliography pair, Institution bibliography pair, journal bibliography pair, publication bibliography pair, author bibliography pair, and Author co-occurrence keywords. In the bibliographic pairs of countries, the United States ranks first in terms of the total power of links. Then, in second place is occupied by the country. Although it is in second place in total link strength, the United States ranks first regarding the number of citations. Other influential countries in this field are Mexico, Malaysia, India, Germany, China, Taiwan, Spain, Cyprus, Australia, Netherlands, Italy, England, Peru, Ecuador, and New Zealand. The first cluster of the largest in terms of the intensity of links with one another is Indonesia, China, Germany, India, Malaysia, the Netherlands, and New Zealand. The second cluster is Ecuador, Italy, Mexico, Peru, and Spain. Australia, Cyprus, and Taiwan are in the third cluster, and the United Kingdom and the United States are in the fourth cluster. In the bibliographical pair of Institutions, Beijing Normal University (China) ranks first with influence in this field.

Then followed by Chitkara University (India) in second place, Indian Institute of Technology Bombay (India) in third place, National Taiwan Normal University (Taiwan) in fourth place, Indonesia University of Education (Indonesia) in fifth place, there is European University Cyprus (Cyrus ), Monterrey Institute of Technology and Higher Education (Mexico), Eindhoven University of Technology (Netherlands), University of Auckland (New Zealand), Brigham Young University (United States), National University of Malaysia (Malaysia), Yogyakarta State University (Indonesia), the University of Technology Malaysia (Malaysia), State University of Semarang (Indonesia), State University of Padang (Indonesia), Ruhr University Bochum (Germany). The Journal of Physics Conference Series occupies the top rank influencing PCK, then in succession, namely, Interactive Learning Environments, Education Sciences, Education and Information Technologies, Lecture Notes in Computer Science, Procedia Computer Science, and Communications in Computer and Information Science. López-Vargas et al., (2017) ranks first with the most influential publications in the publication bibliography pair in this field. In second place is (Weitze& Blank, 2020) and followed by (Cooper et al., 2022), (Lin et al., 2013), (Karim et al., 2018), (Rodríguez-Becerra et al., 2020), (Zhang et al., 2019), and (Hsu, 2016). Salinas et al., (2013) ranks first in influencing this field. Second in line is Chai et al., (2019), Ling et al., (2020), then in succession, namely, González-mendivil, Eduardo, Mantri, Archana, and Quintero (Salinas et al., 2013). Mantri Archana has published several articles around 2020 (Gargrish et al., 2020). Meanwhile, articles published for a long time in this field were written by Salinas Patricia. On co-occurrence of author keywords.

Cetin-Dindar et al. (2018), with the title Development of pre-service chemistry teachers' technological PCK, concluded that in planning lessons, science teachers use lesson plans prepared from the MGMP and adjusted again to the time of each school. The teacher has developed his creativity in the learning process. Aspects of creativity that arise include visualization and relating. Learning activities are scientific and have led students to discover, but the problem identification stage has yet to emerge. The integration of science has been raised but is still constrained by the factor of mastery of knowledge by the teacher's scientific background. Margiyono and Mampouw (2011)'s research, with the title Description of PCK Teachers on the Discussion of Rational Numbers, concluded that the uniqueness of rational number material is a challenge for teachers, and teachers are required to have pedagogical and professional competencies to present learning that can achieve the expected goals. The results showed that in terms of pedagogical content, the teacher mastered the curriculum and realized that this material was difficult for students to accept. However, they still had difficulty planning and implementing their learning. Teacher content knowledge is not differentiated based on academic qualifications, but the teacher's mastery of rational numbers does not align with student learning outcomes. The pedagogical competencies that still need to be improved are mastery of teaching and understanding students' needs. Teachers still need to use learning methods that can further
motivate students to learn rational numbers, and students' weak mastery of prerequisite material has not caught teachers' attention. The results of this study can help math teachers evaluate learning as part of an effort to improve student achievement.

**CONCLUSION**

This study concludes that the trend of global publication of the PCK model has increased from 2018 to 2020 but has decreased from 2020 to 2022 due to a decrease in the number of researchers related to PCK. 2020 was the year with the highest number of Scopus-indexed PCK model publications from 2018 to 2022 regarding the country that contributed the most, namely the United States. Then in terms of the publisher, Philosophical Studies has the highest records.

In addition, visualization results using VOSViewer reveal that 40 cluster keywords have a keyword-based network, with PCK and pedagogical content, as well as teaching appearing the most frequently. In addition, there are significant opportunities for further research on issues related to PCK. Based on the results of this study, the researcher claims that the bibliometric analysis of PCK published in Scopus-indexed journals in the period 2018-2022 (4 years) can be used as a reference for PCK in the future. However, the researcher realizes that this research is still very limited, so the researcher recommends two things. First, this research is not only limited to Scopus-indexed journals. Second, more in-depth analysis is needed on PCK in learning.

**ACKNOWLEDGEMENTS**

We would like to thank the supervisor who assisted in this research and Ernawati, who reviewed the manuscript in English.

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