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Factors Influencing Mathematics Teachers' Pedagogical Content Knowledge (Pck): A Systematic Review

Darmaraj A/L Sakaria[1*], Siti Mistima Bin Maat[2], Mohd Effendi E. Bin Mohd Matore[3]

[1-3]Universiti Kebangsaan Malaysia, Faculty of Education, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

Abstract

Mathematics teachers play the most pivotal role in reflecting students' abilities and interests, providing a conceptual understanding through high PCK. However, research that comprehensively analyses the available literature relating to factors that could affect mathematics teachers' PCK is still lacking. There is a compelling demand to strengthen our present mathematics teachers in order to close this gap to boost their competence and raise their PCK level. As a result, the purpose of this research is to investigate the aspects that influence the PCK of mathematics teachers, with a focus on primary and secondary mathematics teachers. To perform the systematic review successfully, The Preferred Reporting Items for Systematic Review and Meta-Analyses (guidelines), Web of Science and Scopus (databases) were used to access the evaluated publications in this research from January 2018 to January 2022. The findings revealed that mathematics teachers' PCK is influenced by three types of factors: individual, professional, and organizational. Professional development and teaching experience are the two factors with the highest frequency and dominance. The outcomes of this research may be employed as a maneuverer for researchers in the field of mathematics education who are embarking on PCK studies. This article also makes recommendations for further research on mathematics teachers' PCK.

Keywords: Individual factors, mathematics teacher, organizational factors, pedagogical content knowledge, professional factors.

Introduction

Mathematical knowledge, abilities, and attitudes are essential competencies for efficient mathematics teaching and learning, particularly in the recent era of science and technology (Moh'd et al., 2021, Woldemichael, 2022). These competencies help mathematics teachers effectively design and arrange classes as well as employ suitable teaching tactics (Saad et al., 2015). It also aids teachers in dealing with student issues, misconceptions, and preconceptions (Ma'rufi et al., 2018). In this case, teachers should professionally and skillfully incorporate and change information while providing material in a manner that students may grasp (Ma'rufi et al., 2018). Pedagogical content knowledge is the name given to this type of professional knowledge. Thus, PCK is often said to be the primary knowledge (Sarkim, 2020) in determining unique lesson constructions in classroom practice (Moh'd et al., 2021) since Shulman introduced the model PCK in the early 1980s (Sarkim, 2020).

There is no dispute that PCK is essential in the field of mathematics. Mathematics teachers' education aims to improve the application of mathematics teachers' knowledge via PCK in order to promote mathematics TnL (Jacobson et al., 2017). To put it another way, teaching mathematics necessitates PCK (Alfaro & Joutsenlahti, 2020) to improve effective mathematics TnL practice (Appova & Taylor, 2017). Teachers with good PCK may combine mathematical topic knowledge with other teaching skills to provide holistic learning (Kristanto et al., 2020). According to Moh'd et al. (2021) and Ma'rufi (2019), mathematics teachers may have a sufficient degree of PCK because this affects student learning and, in turn, leads to better performance achievement (Tatto et al., 2020). Teachers having a robust PCK level are highly prone to having pupils who achieve better mathematics grades (Callingham et al., 2016; Cueto, 2017; Kristanto et al., 2020) and mastery of mathematics (Ansah et al., 2020).

Thus, mathematics teachers with strong PCK may successfully convey knowledge and abilities to pupils. This is in accordance with outcomes of research from Hoover et al. (2016), which claimed that high teacher competence in PCK is able to process different learning opportunities through a variety of planned activities as a teacher's PCK is deeply tied to his/ her ability to teach (Hammack & Ivey, 2017). Therefore, the first step in tackling classroom competencies is to recognize the mathematics teachers' PCK level (Moh'd et al., 2021). As a result, the recently revised Secondary School Standard Curriculum (SSSC) and Primary School Standard Curriculum (PSSC) in Malaysia necessitate mathematics teachers to possess the knowledge, skills, and attitudes. This

Corresponding Author: P107710@siswa.ukm.edu.my

https: //orcid.org/0000-0002-5052-2590

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is crucial to develop competencies in mathematics teaching, accomplish an adequate level of PCK and assist students in improving their performance.

However, literature underlines that many primary and secondary school mathematics teachers, on the other hand, have been proven to be lacking in PCK-related factors around the globe. This includes Malaysia (Ishak et al., 2019; Rahman et al., 2018), South Africa (Ansah et al., 2020), Indonesia (Hidayat & Satyawan, 2020; Saputra et al., 2019), Africa (Moh'd et al. 2021) and Turkey (Aksu & Kul 2019; Kurt-Birel et al. 2020; Yilmaz & Demir 2021). Although numerous studies have been conducted into the factors causing this issue, there are still significant issues exist with prior research and a dearth of studies, especially with systematic literature reviews/ meta-analysis study/ meta-synthesis studies (Depaepe et al., 2013; Rahman et al., 2018; Şimşek & Boz, 2016; William & Maat, 2020). These findings exhibited that the relationship between the PCK of primary and secondary school mathematics teachers with other factors in the mathematics education context is relatively scarce. Moreover, researchers underscored that there are some issues with the methodology part as these studies were more focused on identifying the scop, dominant trends, patterns, and the research gaps in the field, despite discussing the exact variables that influence mathematics teachers' PCK comprehensively. Additionally, an earlier systematic review suggested an urgency and necessity to concentrate on elements that affect mathematics teachers' PCK in the conclusion part of the study (William & Maat, 2020).

We assert that although there are several variables influencing the success of PCK among mathematics teachers, such as work experience (Ma'rufi et al., 2018), commognitive factors (Zayyadi et al., 2019), socioeconomics (Cueto et al., 2017) and technology integration (Bahador et al., 2017), a more monitoring and review pattern has to be established so that varied cultural capital may be among the criteria utilized to map the PCK profile of a mathematics teacher (Saputra et al., 2019). Thus, as a novelty of this study, there is a need for studies with more in-depth systematic literature findings to understand the relationship and impact of additional factors on PCK in order to fill the paucity gap of pertinent systematic review in mathematics education. Therefore, the study aims to explore the factors that influence mathematics teachers' PCK and identify the research trends in PCK, such as publication year, study design and country.

Methodology

Based on a global viewpoint, this part covers the strategy utilized to extract articles relevant to factors influencing PCK among mathematics teachers. The PRISMA approach incorporates the systematic review's resources from WoS and Scopus, as well as eligibility, exclusion criteria, and review process phases (identification, screening, eligibility and included). As per Higgins et al. (2019), systematic reviews are motivating, worthwhile, and necessary for recognizing the precedence of prospective research and the human knowledge scope in order to make a suitable authoritative judgement. This is in line with Mariano et al. (2017), who states that an SLR is a technique for identifying, evaluating and summarizing state-of-the-art data in a particular field.

It limits data collection from databases, enabling a better objective examination than typical reviews. Using extensive searching tools, predefined search strings and established inclusion and exclusion criteria ('garbage-in' and 'garbage-out'), SLR encourages researchers to hunt for studies outside their subject areas and networks (Robinson & Lowe, 2015). As a result, the number of articles to be included in SLRs is never more than 50 and frequently fewer than 10 (Robinson & Lowe, 2015). Furthermore, because it uses highly systematic procedures, this strategy may reduce bias in literature reviews (Shaffril et al., 2019). However, this type of review places a premium on transparency. For example, all terminologies in inclusion criteria have to be defined and justified. Likewise, article exclusion has to be justified (Greyson et al., 2019) despite acting as a replicable methodology for finding, evaluating, and synthesizing information with high objectivity (Kraus et al., 2020).

The review protocol – PRISMA

PRISMA is a peer-reviewed standard methodology that employs a guideline checklist to help ensure the quality and consistency of the revision process (Abelha et al., 2020). PRISMA offers three main benefits, as per Sierra-Correa and Kintz (2015): creating specific research questions that enable systematic study, setting exclusion and inclusion criteria, and aiming to investigate a huge database of scientific literature in a specified duration.

Resources

Scopus and WoS are bibliographic databases as the primary and leading journal databases to determine empirical research (Joshi, 2016; Pranckute, 2021) and are widely recognized as the most comprehensive data sources for a variety of applications and bibliometric analyses (Singh et al., 2021). WoS was the first international bibliographic database with a broad scope. As a result, it became the most important bibliographic data source utilized for journal selection, research appraisal, bibliometric analysis and other tasks throughout time (Li et al., 2018). WoS is currently maintained by Clarivate Analytics (Birkle et al., 2020; Singh et al., 2021). Pursuant to the latest statistics from 2020, the WoS Core Collection has over 74.8 million academic data and datasets, 1.5 billion cited references (dating back to 1900), and 254 subject disciplines (Singh et al., 2021).

However, Scopus has earned its place as a comprehensive bibliographic data source over time, demonstrating that it is dependable and, in some ways, even superior to WoS (Harzing & Alakangas, 2016). Scopus is Elsevier's peer-reviewed literature abstract and citation database (Rahman et al., 2021). In addition, Scopus has just revised its content coverage guide, which now includes roughly 120 000 conferences, 23 452 active journal titles, as well as 206 000 books from over 5 000 international publishers (Singh et al., 2021). Scopus and WoS, on the other hand, complement each other via journal coverage in terms of impact, prestige and influence (Joshi, 2016).

Systematic review process

This SLR follows the PRISMA guidelines by Page et al. (2021) and includes the following phases: identification review, screening, eligibility and inclusion (Page et al., 2021). These four steps are employed to discover relevant papers. Using these strategies, the authors were able to fully discover and synthesize the research, resulting in a well-organized and transparent SLR.

Identification

The identification procedure is covered in the first phase of the systematic review. The review procedure was executed in January 2022. Keywords that were utilized in SLR were identified in the first phase. To eliminate bias, the search results were discussed with co-authors as peer-reviewed papers. For a more rigorous outcome, Delgado-Rodrgueza and Sillero-Arenas (2018) advised using article searches and query strings undertaken by the researcher. We widened our search phrases and strategies after verifying that the chosen keywords were correct in revealing as many related publications as possible. Utilizing the Thesaurus electronic dictionary and Oxford Lexico with informatics phrase searching, wild card, truncation, and combining Boolean operators, we modified the search terms for Scopus as indicated in Table 1. By employing the TS (title search) command, the identical search phrase was inserted into the WoS database. A total of 225 potential articles were found from the specified databases (Scopus, n=160 & Wos, n=65) (Table 1).

Screening

The reviewers used a variety of inclusion and exclusion criteria during the screening process, as shown in Table 2. First, journal articles with empirical data were chosen as the literature category, with systematic review articles, conference proceedings, book chapters, books, and book series eliminated. Secondly, by focusing on English journal papers, the possibility of ambiguous or difficult translations was minimized. Thirdly, the reviewers looked at works that had been published during the last five years (between 2018 and 2022). The quantity of published research was sufficient to conduct a representative review; thus, this timeline was chosen.

Hence, no particular regions or countries were excluded. Moreover, the reviewers focused on publications dealing with the mathematics discipline in the final stage of the exclusion and inclusion process. Furthermore, the final inclusion was based on a review of prospective full-text relevant studies, which was amended in collaboration with co-authors. As illustrated in Figure 1, the eligibility process resulted in all the articles. One hundred fifty-four journal articles were excluded from the study since they did not fit the criteria and were irrelevant to the topic discussed. In addition, journal articles that did not address mathematics literacy were also excluded. Therefore, 71 articles were deemed appropriate for additional screening, while 13 duplicate articles were eliminated following the screening. At the end of the review process, 58 articles were found, as indicated in Figure 1.

Table 1: *The search string used for the systematic review process*

Databases	*Keywords used*
Scopus	TITLE-ABS-KEY((“factor*” OR “influence*” OR “element*” OR “effect*” OR “affect” OR “contribution*”) AND (“pedagogy* content knowledge” OR “pedagogy* knowledge” OR “pedagogy* strategy*” OR “content* knowledge” OR “subject* knowledge”) AND (“elementary” OR “primary” OR “middle” OR “secondary” OR “high” OR “school”) AND (“mathematics* teacher”))

Table 2: The inclusion and exclusion criteria

Criterion	*Eligibility*	*Exclusion*
Literature type	Journal (Research articles)	Journals (systematic review), book series, book, chapters in book and conference proceeding
Language	English	Non-English
Timeline	Between 2018 and 2022	Before 2018

Eligibility

The author manually reviewed the recovered articles to ensure that all remaining articles complied with the measures. This was performed by reading the publications' titles, abstracts and full texts. This stage of the procedure excluded 27 articles since they did not emphasize the aspect impacting PCK of the mathematics teachers and education and were published as a book's chapter. Ultimately, 31 robustly connected articles were considered for inclusion in an SLR.

Included

As for the included phase, the first author read and coded all 31 linked articles with other second co-authors. A consensus agreement among authors based on the coding process was reached by asking for a second opinion from the first co-author. Next, themes and sub-themes were determined by reviewing the abstracts of the publications and then reading the entire articles (in-depth). The articles in this systematic

review focused on factors influencing mathematics teachers' PCK. The studies included are shown in Table 3.

Results

Background of the selected studies

The results in this section were discovered using the above-mentioned systematic revision process and are organized by the number of articles by year, research method and factors that influence mathematics teachers' PCK based on countries, as shown in Table 3.

Factors influencing mathematics teachers' PCK by year

The years of publication are shown in Table 4. Overall, according to the reviewers, 2, 8, 5, 11, and 5 studies were published in 2022, 2021, 2020, 2019 and 2018, respectively. Generally, the year 2019 was the most often published in terms of the publishing year. This finding is similar to the previous SLR, which found that 2019 was the most highly published year on PCK studies (William & Maat, 2020) (Table 4).

Factors influencing mathematics teachers' PCK by research method

Researchers attempted to give the necessary understanding of their issue utilizing all of the methods listed above. The PCK of mathematics teachers has been studied utilizing a variety of methods by various researchers. In evaluating the PCK of mathematics teachers, several researchers employed qualitative approaches (16 studies). Others, on the other hand, employed quantitative methods (6 studies). Finally, several re-

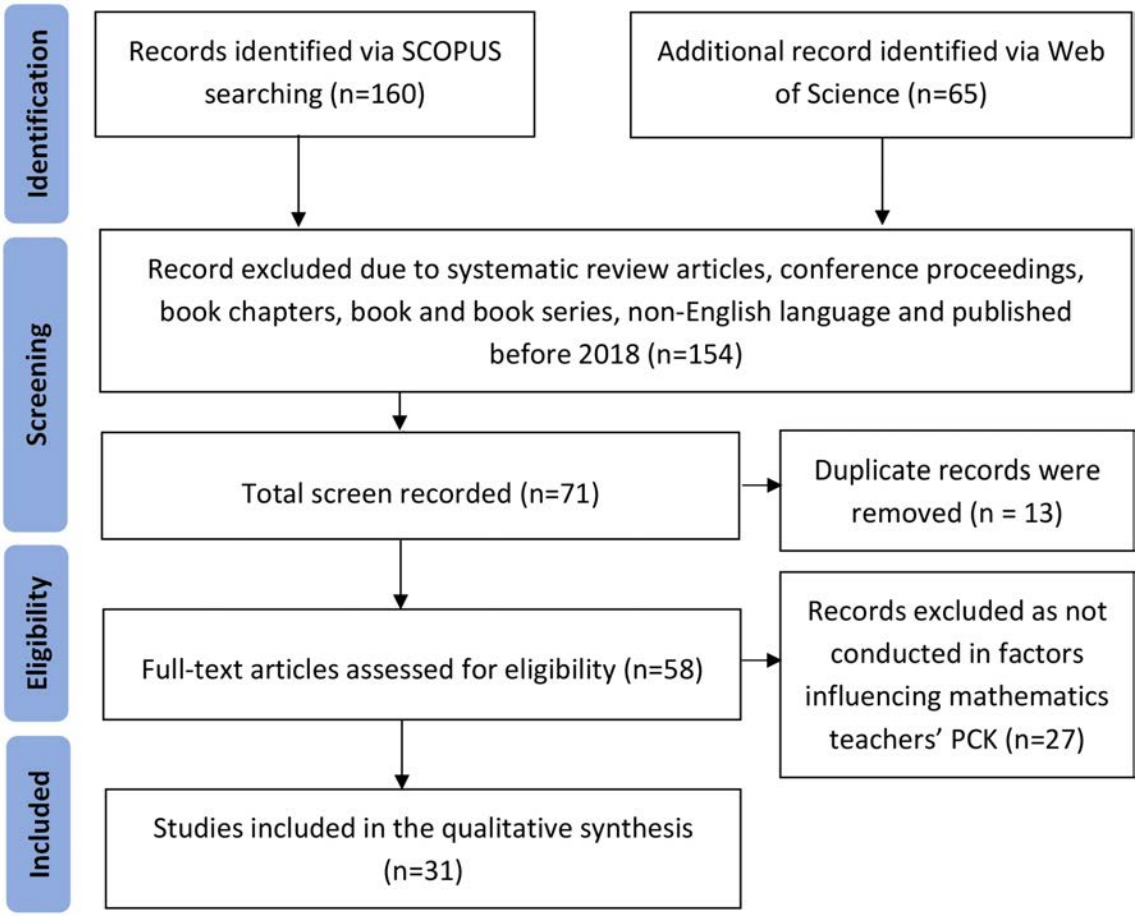

Fig. 1: Study flow diagram (adapted from Page et al. 2021)

QN – Quantitative; QL - Qualitative; MM - Mixed-method

Individual factors	*Professional factors*	*Organizational factor*
TE – Teaching experience ED – Educational level SE – Self-efficacy MV – Motivation	BL – Belief PD – Professional development	SM – School management

Table 3: The number of articles by year, research method and factors influencing mathematics teachers' PCK based on country

Study code	*Authors*	*Research method*	*Countries*	*Target/ level*	*Individual factors*				*Professional factors*		*Organizational factor*
					TE	ED	SE	MV	BL	PD	SM
1	Maboya et al. (2022)	QL	South Africa	Primary school						/	
2	Taylan et al. (2022)	QL	Turkey	University	/			/		/	
3	Helmbold et al. (2021)	MM	South Africa	Primary school				/		/	/
4	Masri et al. (2021)	QN	Malaysia	Primary school			/				
5	Yilmaz & Demir (2021)	QL	Turkey	Secondary school & University	/					/	
6	Fischman & Riggs (2021)	QL	USA	Preschool & Primary school						/	
7	Richter et al. (2021)	MM	Germany	Secondary school						/	
8	Jeschke et al. (2021)	MM	Germany	Secondary school						/	
9	Gambini & Lenart (2021)	QL	Italy and Hungary	Primary & Secondary school	/					/	
10	Moh'd et al. (2021)	MM	East Africa	Secondary school	/	/				/	
11	Hidayat & Setyawan (2020)	QL	Indonesia	Secondary school	/	/				/	
12	Chang et al. (2020)	QN	USA	Elementary school						/	
13	Sarkim (2020)	MM	Indonesia	Junior High School						/	
14	Kurt-Birel et al. (2020)	QL	Turkey	Primary school						/	
15	Ansah et al. (2020)	QN	West Africa	High school	/					/	
16	Saputra et al. (2019)	QN	Indonesia	High School	/					/	
17	Aksu (2019)	QL	Turkey	University	/	/					
18	Schoen et al. (2019)	QN	USA	Secondary school & University	/	/				/	
19	Lau (2019)	MM	China	University						/	
20	Aksu & Kul (2019)	QN	Turkey	Middle school			/				
21	Ekmekci et al. (2019)	MM	USA	Elementary and middle school	/	/	/		/	/	/
22	Yildiz & Akyuz (2019)	QL	Turkey	Middle school						/	
23	Doğan & Kılıç (2019)	QL	Turkey	University & Middle school						/	
24	Manderfeld & Siller (2019)	MM	Germany	University					/	/	
25	Sunzuma & Maharaj (2019)	MM	South Africa	Secondary school						/	
26	Mhakure (2019)	QL	South Africa	Primary & Secondary school						/	/
27	Hilton & Hilton (2018)	QL	Australia	Primary school				/		/	/
28	Ma'rufi et al. (2018)	QL	Indonesia	High School	/						
29	Setyaningrum et al. (2018)	QL	Indonesia	University	/					/	
30	Tang (2018)	QL	Malaysia	High school	/	/				/	/
31	Lee et al. (2018)	QL	USA	Middle/ high school						/	
Frequency of total studies (f)					13	6	3	3	2	27	5
Frequency of total studies (f)					25				29		5

searchers employed mixed-method to measure the PCK of mathematics teachers (9 studies). It is noted that qualitative research design was mostly carried out by researchers, as indicated in Table 5. This is in line with the finding of SLR (William & Maat, 2020), the meta-analysis study (Rahman et al., 2018) and the meta-synthesis study (Şimşek & Boz, 2016). Here, a majority of previous studies about PCK among mathematics teachers have conducted a qualitative approach, especially those using a case study design (Table 5).

Factors influencing mathematics teachers' PCK based on countries

The studies on mathematics teachers' PCK were conducted in a variety of nations around the world, as shown in Table 6. From 31 articles, a total of 7 studies focused on Turkey. Furthermore, 6 studies that were conducted on Africa focused on the South (4 studies), East (1 study) and West (1 study). Next, 5 studies focused on USA and Indonesia, respectively. Besides this, 3 studies were conducted in Germany, and 2 studies were carried out in Malaysia. Finally, the remaining research studies focused on Australia, Italy, Hungary, and China. In short, Turkey was the highest rate country that contributes to the PCK field according to the data obtained (Table 6).

The developed theme

The thematic analysis consisted of an examination of 31 articles divided into 3 categories. The review's conclusions are grouped into sections based on common characteristics and similarities across components. The categories proposed by Na'imah et al. (2020) and Yildirim (2014) were used because they align better with the teacher's professional knowledge and education. The synthesis of the study results shows that mathematics teachers' PCK is determined by individual, professional and organizational factors. Individual factors have been the most often researched factors, accounting for four altogether, preceded by professional factors, accounting for two. The organizational factor, which only utilized one factor, is the smallest. Additionally, each factor was derived from the other sources of articles as a strong suggestion to contribute to mathematics teachers' PCK, as shown in Figure 2.

Table 4: Previous research of mathematics teachers' PCK by year

Year of publication	*f*	*Study code*
2022	2	1, 2
2021	8	3, 4, 5, 6, 7, 8, 9, 10
2020	5	11, 12, 13, 14, 15
2019	11	16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
2018	5	27, 28, 29, 30, 31

Table 5: Previous research of mathematics teachers' PCK by research method

Research method	*f*	*Study code*
Qualitative	16	1, 2, 5, 6, 9, 11, 14, 17, 22, 23, 26, 27, 28, 29, 30, 31
Quantitative	6	4, 12, 15, 16, 18, 20
Mixed-method	9	3, 7, 8, 10, 13, 19, 21, 24, 25

Individual factors

The factors covered in the individual category are listed in Table 7. According to the findings, individual factors impacted mathematics teachers' PCK in as many as 25 researches. Overall, from 25 researches, 4 factors were identified, which include teaching experience (13 studies), educational level (6 studies), self-efficacy (3 studies), and motivation (3 studies). It was noted that teaching experience was perhaps the most frequent factor in the study. Furthermore, educational level was the second highest factor contributing to mathematics teachers' PCK. Following this, self-efficacy and motivation were the factors that impacted mathematics teachers' PCK levels the least, with 3 studies, respectively (Table 7).

Professional factors

Professional factors had an impact on mathematics teachers' PCK in as many as 29 researches (Table 8). Based on the analysis, the belief was the least common factor and was only present in 2 out of 29 studies. However, the professional development factor was found to be a common factor in every study. It shows that professional development factors have a high impact on the PCK of mathematics teachers (Table 8).

Table 6: Previous research of mathematics teachers' PCK by countries

Countries	*f*	*Study code*
Turkey	7	2, 5, 14, 17, 20, 22, 23
Africa	6	1, 3, 10, 15, 25, 26
USA	5	6, 12, 21, 31, 18
Indonesia	5	11, 13, 16, 28, 29
Germany	3	7, 8, 24,
Malaysia	2	4, 30
Australia	1	27
Italy & Hungary	1	9
China	1	19

Table 7: Previous research of mathematics teachers' PCK related to individual factors

Individual factors	*f*	*Study code*
Teaching experience	13	2, 5, 9, 10, 11, 15, 16, 17, 18, 21, 28, 29, 30
Educational level	6	10,11, 17, 18, 21, 30
Self-efficacy	3	4, 20, 21
Motivation	3	2, 3, 27

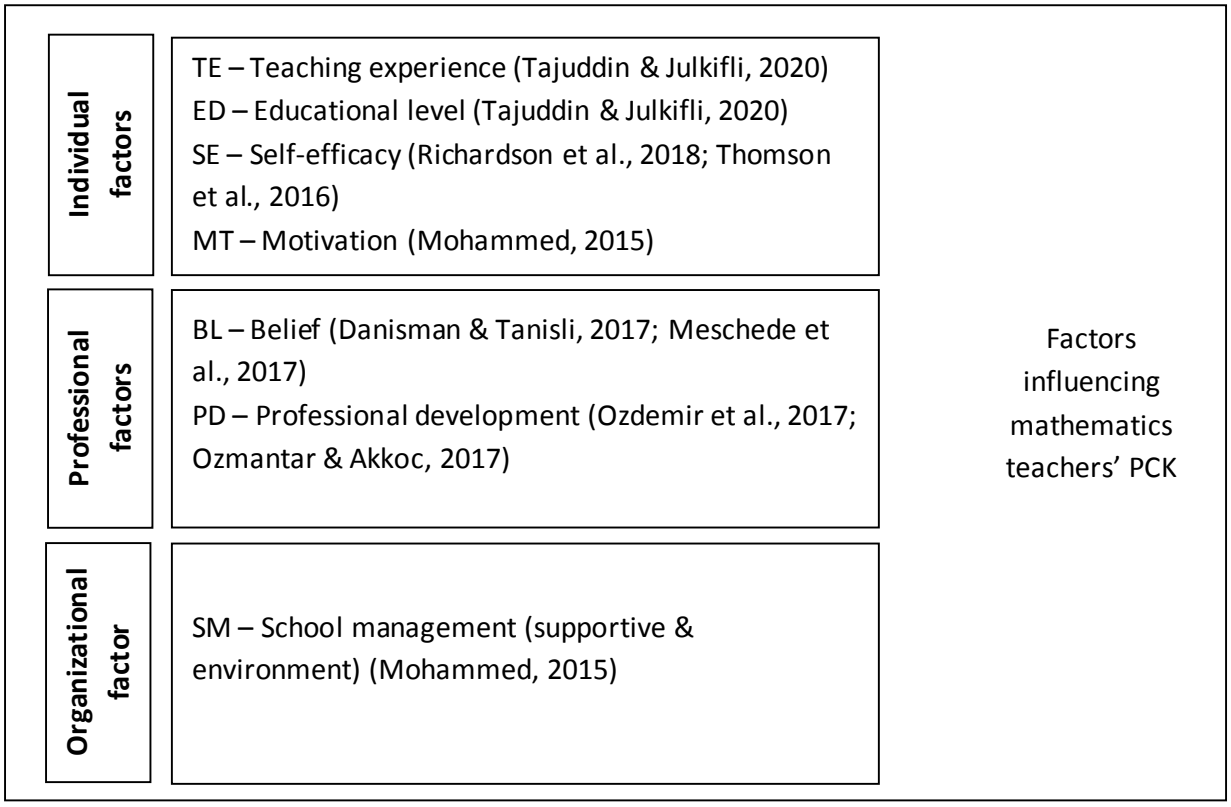

Fig. 2: Categories of factors influencing mathematics teachers' PCK (adapted from Na'imah et al., 2020; Yildirim, 2014)

Organizational factor

The analysis revealed that 5 studies possess organizational factor on the PCK of mathematics teachers (Table 9). The only theme, school management with a supportive and environmental factor, was in 5 studies as a contributor to PCK among mathematics school teachers (Table 9).

Table 8: *Previous research of mathematics teachers' PCK related to professional factors*

Professional factors	*f*	*Study code*
Belief	2	21, 24
Professional development	27	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31

Table 9: Previous research of mathematics teachers' PCK related to an organizational factor

Organizational factor	*f*	*Study code*
School management	5	3, 21, 26, 27, 30

Discussion

Individual factors

Teaching experience

There are 13 studies out of 31 papers that analyze the impact of teaching experience on PCK among mathematic teachers (Table 7). The results of the studies on teaching experience showed that it had a positive impact on PCK. For example, studies imply that teachers with more than ten years of experience gained more knowledge than their less-experienced peers (Schoen et al., 2019). Aside from the new teachers, the results demonstrated that the majority of mathematics teachers had excellent PCK (Tang, 2018). This study shows that most senior and experienced mathematics teachers may exchange their experiences, increasing their PCK level. When compared to novice teachers, experienced teachers are more likely to use more instructional approaches in response to student performance cues (Ekmekci et al., 2019). Furthermore, according to the findings, prospective teachers have fewer PCK than in-service teachers (Yilmaz & Demir, 2021). It has been believed that the lack of prospective teachers' experiences or subject matter knowledge leads to this phenomenon.

Thus, prospective teachers, even pre-service teachers undergoing educational programs at university, should be given opportunities to work with students in order to increase their teaching experiences. This agrees with the past research conducted by Setyaningrum et al. (2018), which says that pre-service teachers should be provided opportunities to engage with students in order to obtain experience in how to help students understand mathematics, and recognize, correct student errors, and misconceptions in order to

improve their pedagogical knowledge. Moreover, teaching experience had an impact on a greater PCK level for certain secondary school mathematics teachers, according to Moh'd et al. (2021). This finding shows that teaching experience had a moderate effect. Even though teaching experience is a supporting factor for the development of mathematics teachers' PCK (Saputra et al., 2019), a study from Kurt-Birel et al. (2020) found that despite a significant amount of teaching experience, an improvement in PCK also depends on having a well-established understanding of the concept of a subject and the relationships between them.

In conclusion, teaching experience impacts PCK among mathematic teachers. In other words, PCK construction was likely improved by teaching experience (Ping et al., 2018). Teachers having multiple experience years in the classroom produced strong subject matter knowledge (Anney & Bulayi, 2020; Ewetan & Ewetan, 2015) and pedagogical knowledge. This is because teaching experience may be divided into two categories: expert (teachers with a minimum of 10 years of classroom management experience who have been recognized by peers and/or school officials) and novice (teachers with fewer than 10 years of classroom teaching experience). When it comes to anticipating classroom management events, experienced teachers have been demonstrated to be far more successful than inexperienced teachers (Wolff et al., 2014). This demonstrates that when teachers get more experience, they acquire a better understanding of classroom management, enabling them to anticipate difficulties and alter their classroom management tactics accordingly. To conclude, teaching experience proves to be an important factor to examine, as it is connected to teaching practises, self-efficacy, and overall TnL paradigms (Berger et al., 2018).

Educational level

12 studies out of 31 publications were examined for the effects of the educational levels among mathematic teachers on PCK level (Table 7). According to the findings of the study on educational levels, a favorable impact was found on PCK. Consider the following scenario: Aksu's (2019) findings discussed that pre-service mathematics teachers' PCK is projected to be higher when completing nearly all of their undergraduate courses and teaching practices compared to those who didn't complete any courses. Additional research indicated that the biggest variances in content knowledge and PCK were detected between the beginning and the completion of initial teacher education (Tang, 2018). In mathematics teachers' content knowledge and PCK, differences in the organization of teacher education were effectively recreated. As per Moh'd et al. (2021), there was a considerable variation in the degree of education of mathematic teachers in Tanzania. In practise, there was considerable variation in the PCK level for teachers depending on their educational background, which influenced the PCK level. Possessing a bachelor's degree in mathematics was one of the teacher-level characteristics that had a significant and direct influence on students' mathematics success (Ekmekci et al., 2019). This discovery is even more noteworthy considering that only a small percentage of the teachers had a mathematics degree.

In short, educational level highly influences mathematic teachers' PCK. Basically, education level refers to the teacher's educational background or academic qualification, for instance, whether a teacher has a PMR/SPM, STPM, diploma, degree, master's degree or PhD in education. It is also referred to as a teacher's highest level of formal education completed (Fishbein et at., 2021). This educational level determined the level of PCK of an individual mathematics teacher. A teacher with a high level of education, such as a doctorate, possesses a high degree of PCK in TnL compared to a teacher with a diploma or STPM certificate. Thus, mathematics teachers with a high PCK level are those who have a high-level educational background.

Self-efficacy

Only a few studies (3 out of 31 research publications) evaluate the effects of self-efficacy on PCK among mathematics teachers (Table 7). However, according to the evidence, self-efficacy has a positive impact on PCK. For example, Aksu and Kul (2019) claimed a strong correlation between PCK and mathematics self-efficacy. According to the research, this might be related to higher PCK among pre-service teachers. Furthermore, teachers with strong PCK experience lower teaching anxiety and higher self-efficacy. In addition, as per the results of a study conducted among mathematics teachers in the LMS district, mathematics teachers' grasp of PCK, as well as their effectiveness, are extraordinarily excellent (Masri et al., 2021). From this, they tend to accept new ideas, believe in students' freedom to go to higher levels and pay more attention to TnL practices.

Briefly, there is a significant positive relationship between PCK and self-efficacy. In other words, self-efficacy correlates with PCK, as shown in previous studies (Ambotong & Andin, 2020; Ghazali, 2017; Yun & Ah, 2015). PCK and self-efficacy are important factors in the effectiveness of the learning process (Suharta & Parwati, 2020). Studies have found that the role of PCK, content knowledge, self-efficacy, skills, and attitudes are able to influence a teacher's behavior (Avsec & Jagiello-Kowalczyk, 2018). Therefore, PCK factors with other psychological elements such as professional competence need to be developed through teacher self-efficacy to improve student achievement progress (Bonne & Johnston, 2016) and mathematics teachers' PCK levels. The level of self-efficacy of a mathematics teacher should be in a consistent state to ensure student achievement in the subject of mathematics (Ayllon et al., 2019).

Motivation

Only 3 research papers (out of 31 in total) examine the impact of motivation on PCK among mathematics teachers (Table 7). However, it is found that the findings of previous studies underline that there is a significant positive relationship between PCK with motivation. The findings of the study reported that teacher educators were motivated to observe and assess student knowledge as a result of adopting various instructional strategies and materials (Helmbold et al., 2021). Moreover, teachers were motivated to increase their contribution more and attempt to incorporate new learning into classroom practices in their own classroom settings. In the study by Hilton and Hilton (2018), teachers were motivated to participate in more interventions to improve their own PCK (MKT).

In summary, the findings of prior studies show that motivation and PCK have a substantial positive association. Teacher motivation is divided into two, namely intrinsic and extrinsic motivation. Both kinds of motivations boost the desire to learn among students (Johnson, 2017) and mathematics teachers. Mathematics teachers with high levels of motivation are more likely to perform tasks efficiently. In order to overcome patterns for efficient educational practice, competent or better teachers have to travel a path that results in a greater awareness of teaching (Santos et al., 2016) via high motivation in mathematics TnL.

Professional factors

Belief

Only 2 out of the 31 research publications focus on the impact of belief on PCK among mathematics teachers (Table 8). The findings of the studies show that there is a considerable positive link between belief and PCK. Beliefs have been shown to influence learning processes, making them relevant in the preparation of pre-service mathematics instructors in terms of the PCK provided in university-level mathematics didactics courses (Manderfeld & Siller, 2019). Another study stated that teachers' content knowledge and beliefs about TnL are important elements in effective teaching and, as a result, in student achievement (Ekmekci et al., 2019).

In conclusion, based on the findings of the above studies, beliefs greatly influence mathematic teachers' PCK. In other words, beliefs correlate with PCK and teaching practices as a system (Muhtarom et al., 2019). Therefore, teachers' mathematical beliefs have to be correct in providing an excellent teaching process (Adnan & Zakaria, 2019). This is a key component of knowing how teachers affect their work and is critical to understanding their teaching techniques and classroom decisions (Gilakjani & Sabouri, 2017).

Professional development

According to the data, 28 out of 31 research papers discuss the impact of professional development on PCK among mathematics teachers (Table 8). The results of the study detailing professional development showed a good effect on PCK. For instance, professional development programs (Ekmekci et al., 2019; Hidayat & Setyawan, 2020; Maboya et al., 2022; Sarkim, 2020), content-focused professional development (Richter et al., 2021), model/ professional training/ teacher training/ collaboration programs (Gambini & Lenart, 2021; Jeschke et al., 2021; Kurt-Birel et al., 2020; Manderfeld & Siller, 2019; Saputra et al., 2019; Sunzuma & Maharaj, 2019; Tang, 2018; Yildiz & Akyuz, 2019; Yilmaz & Demir, 2021), seminar/ workshops/ in-service training (Ansah et al., 2020; Chang et al., 2020; Kurt-Birel et al., 2020; Moh'd et al., 2021), educational course/ pedagogy course (Lau, 2019; Lee et al., 2018), school based continuous professional development/ on-site professional training (lesson study) (Helmbold et al., 2021; Mhakure, 2019), structured interventions/ professional learning workshops (Hilton & Hilton, 2018), regular meetings (Taylan et al., 2022), microteaching course/ microteaching/ teaching practicums (Setyaningrum et al., 2018) and a two-week summer institute (Schoen et al., 2019) were implemented to enhance mathematics teachers' PCK level effectively. Notably, terms such as model, professional training, teacher training and collaboration program were frequently used to represent professional development in most of the studies.

In a nutshell, it is concluded that professional development may highly contribute to the improvement of mathematics teachers' PCK. PCK skills derived from professional development provide an opportunity for mathematics teachers to better understand student learning (Jacob et al., 2017), know student development, and subsequently apply those skills according to students' cognitive development (Jamaludin & Rosli, 2021). In other words, the role of professional development programs focusing on mathematics is able to improve PCK (Fischman & Rigss, 2021), content knowledge (Hwang & Cho, 2021; Sevis et al., 2017) and teaching quality (Sevis et al., 2017).

Organizational factor

School management

Only a few studies, 5 out of 31 research publications, explore the impact of school management on PCK among mathematics teachers (Table 9). According to a study, school management has a positive impact on PCK. For example, the study from Helmbold et al. (2021) applied the school management's full cooperation, who were specifically supportive of adjusting the timetable for demonstration lessons to enhance teachers' PCK levels. Tang (2018) further stressed that educational leadership and management significantly impact the PCK of mathematics teachers, which has become a primary indication and a key success factor in achieving mathematics teachers' vision. Furthermore, Ekmekci et al. (2019) emphasized

that school districts should provide chances for mathematics teachers to enhance their PCK by various methods, such as providing opportunities to participate in professional development programs focused on mathematical PCK. If continuous professional development is school-based, it is the schools' responsibility to create a favorable environment for teachers' professional learning in the form of mechanisms that promote instructional change on an organizational level (Mhakure, 2019). A decision taken in collaboration with the school administration by the teachers has an impact on teachers' attitudes and competence, as well as the PCK levels (Hilton & Hilton, 2018).

In conclusion, depending on the results obtained from the studies mentioned above, the school management role focusing on mathematics is to improve PCK. School management possesses a critical role in enhancing mathematics teachers' practices, as well as their PCK levels. This involves school environment and climate (organizational structure and climate), management roles, administrative support, work environment (Hong & Ismail, 2015), collaboration among staff and instructional leadership. According to Soorya et al. (2017), educational leadership and management have a significant impact on the PCK of mathematics teachers. Therefore, they have surfaced as a growing indicator as well as a vital success element in attaining teachers' objectives.

Conclusion

In developing countries, particularly Malaysia, PCK in primary and secondary school mathematics subjects has not been explored in depth. PCK in those schools is discouraging, which has become a source of concern for various stakeholders. Various research, including systematic reviews, was carried out in order to get insight into the problem of low levels of PCK among primary and secondary school mathematics teachers. Moreover, the previous research in Malaysia recommended focusing on factors that influence mathematics teachers' PCK (William & Maat, 2020). Therefore, this article attempts to fill that gap by exploring the variables that influence mathematics teachers' PCK. According to the research, PCK has a positive effect on the TnL of mathematics. The developmental trend of PCK may be seen through an analysis of study findings.

For the present 5-year study period, this systematic review analyzed 31 papers based on factors impacting mathematics teachers' PCK. The increase in articles connected to PCK may be seen by the year of publication, notably in 2019, qualitative research design and country, such as Turkey. This demonstrates that the role of PCK in mathematics education has been recognized. According to a systematic review, a range of factors may impact the PCK of mathematics teachers. As per the similarities and qualities in regards to the factors determined, they are divided into individual, professional and organizational factors. Accordingly, it may be claimed that no single factor influences mathematics teachers' PCK; on the other hand, there are several.

This study has found that professional factors (there are two factors, namely belief and professional development) show the highest rate of influencing mathematics teachers' PCK compared to other factors. Next, the individual factors (teaching experience, educational level, self-efficacy and motivation) are the second leading factor affecting mathematics teachers' PCK. Lastly, the organizational factor, which focuses on school management, gives at least one factor contributing to PCK among mathematics teachers. In detail, the results obtained show that professional development and teaching experience are the two factors with the highest frequency. This includes professional development (28 studies), school management (5 studies), educational level (12 studies), teaching experience (16 studies), self-efficacy and motivation (3 studies) and belief (2 studies).

This is in accordance with outcomes of research from Saputra et al. (2019), which claimed that teaching experiences and teacher engagement in professional development programs are examples of main cultural capital that enhance the development of mathematics teachers' PCK. Moreover, professional development has influenced mathematics teachers in previous SLRs (William & Maat, 2020). Consequently, the importance of professional development and teaching experience has been briefly discussed in guiding and contributing to upcoming research knowledge. The results of this research are hoped to be able to provide a diversity of relationships between these factors and PCK on learning practices conducted by prospective Malaysian mathematics teachers.

Recommendations

In the future, the researcher advises that, in light of the aforementioned limitations, more types of publications are included and a longer period of time be used in literature review studies. This is meant to provide a more comprehensive picture of scientific evidence about factors influencing mathematics teachers' PCK. Furthermore, as a result, more extensive research has to be performed in the future to grasp a better understanding of the influence of the highlighted elements among mathematics teachers. For example, it may be possible to determine if these elements have a direct impact on PCK among teachers or whether they operate as moderators or mediators. Further in-depth study is also needed since a number of variables, especially in the context of teachers and their respective fields, that has to be investigated.

Limitation

Only primary and secondary school mathematics teachers who adopted the mathematics approach in the mathematics

TnL process were the subject of this paper. Since only two search engines, WoS and Scopus databases, were used to look for literature within the last five years, fewer publications were found. As for future research, the researchers suggest that more databases should be used to increase the quantity of quality articles.

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