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The readiness of mathematics teachers as agents of change: a recent comprehensive review

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ABSTRACT

This study scrutinizes the role of mathematics teachers as pivotal agents of change in the evolving educational landscape, focusing on their readiness to embrace pedagogical reforms. The review aims to reveal the current patterns and trends in mathematics teachers' readiness literature discussed in recent studies. Utilizing the preferred reporting items for systematic reviews and meta-analyses (PRISMA) framework, this study analyzed 31 empirical articles from the Scopus and Web of Science databases in 2023. The review process for chosen articles is examined, encompassing aspects such as publication criteria, eligibility and exclusion standards, databases, and the progression of review stages. The most striking result from the analysis is that mathematics teachers' readiness is closely related to teaching strategies and pedagogy. Moreover, inconsistencies in practice and constraints such as inadequate resources, insufficient institutional support, and teacher training program gaps hinder their ability to implement change effectively. The implications of this study extend to various stakeholders in the education ecosystem, including policymakers, educational institutions, teacher training programs, and practitioners. This review suggests strategies to enhance teachers' professional development and serve as preliminary work toward developing a pedagogy model. In conclusion, this systematic review consolidates the existing knowledge on the readiness of mathematics teachers as agents of change.

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1. INTRODUCTION

In the evolving landscape of education, mathematics teachers have increasingly become pivotal agents of change, extending beyond their traditional instructional roles to shape how students learn and engage with mathematical concepts [1]–[3]. The rapid pace of technological advancements and the growing emphasis on interdisciplinary skills have prompted a significant shift in how mathematics is taught and understood [4]. This shift necessitates a transformation in pedagogical practices, where teachers not only transmit but also create dynamic learning environments that foster critical thinking, problem-solving, and the practical application of mathematics in real-life contexts [5]. The responsibility of mathematics teachers is crucial in preparing students to meet the complex demands of the 21st century [6].

Despite the critical role of mathematics teachers in educational transformation [7], [8], there remains a notable gap in the literature concerning the readiness of mathematics teachers to embrace their roles as agents of change. While numerous studies have explored readiness for change across various sectors such as education, health, industry, and finance, only a limited number have specifically examined mathematics teachers, particularly within contexts like Malaysia, or from a global perspective [9]–[12]. This lack of

comprehensive research leaves a critical knowledge gap, as understanding teacher readiness is crucial for enhancing pedagogical approaches, fostering innovation, and driving meaningful changes in mathematics education [13], [14]. The literature highlights that mathematics teacher readiness encompasses a variety of skills and competencies, including pedagogical expertise, technological proficiency, curriculum adaptability. Frameworks like technological, pedagogical, and content knowledge (TPACK) have been instrumental in evaluating teachers' ability to integrate technology into their teaching practices, enhancing both their instructional methods and student engagement [15]. However, many mathematics teachers continue to rely heavily on traditional methods, lacking the tailored resources and professional development needed to fully adapt to modern educational demands [16]. This points to a need for focused interventions that support continuous professional growth and the adoption of innovative teaching strategies [17], [18].

Furthermore, the integration of science, technology, engineering, and mathematics (STEM) education and the shift toward online and technology enhanced learning environments present additional challenges and opportunities for mathematics teachers. Research indicates that successful adaptation to these changes requires a solid foundation of readiness, underpinned by ongoing training, access to resources, and supportive policy frameworks [19], [20]. The current landscape necessitates that mathematics teachers not only possess deep content knowledge but also the skills to deliver interdisciplinary education that prepares students for future careers in a technologically driven world. To address the gap, this study conducts a systematic review of recent empirical research, particularly focusing on studies published in 2023, to evaluate the readiness of mathematics teachers as agents of change. Building upon Fullan's multidimensional framework of change readiness [21], this review synthesizes current findings to identify patterns, trends, challenges, and best practices, providing highlight novel insights that can inform future educational reforms and professional development initiatives [22]–[27]. This approach aims to advance the discourse on teacher readiness by answering the following research question guiding this review is, what are the current patterns and trends in mathematics teachers' readiness literature discussed in the recent studies?

2. RESEARCH METHOD

In accordance with preferred reporting items for systematic reviews and meta-analyses (PRISMA), suitable research methodologies are suggested in order to generate systematic literature highlights. The selection of articles for this study was facilitated using PRISMA as a guide [28]. Furthermore, including a substantial amount of data and adherence to a relatively rigorous and meticulous procedure contributes to enhancing the quality of systematic literature reviews (SLR). Pertaining to the readiness of mathematics teachers to act as catalysts for transformation, this research employed a qualitative methodology to gather comprehensive data. Furthermore, documents sourced from the database are incorporated into this study to address the research questions.

2.1. Identification

Numerous crucial stages of the systematic review were employed to identify a substantial amount of pertinent literature for this study. Initially, keywords were chosen, followed by the exploration of associated terms through dictionaries, thesauruses, encyclopedias, and prior research. In order to mitigate the influence of retrieval bias, the researchers decided to utilize multiple databases [29]. Once the search terms for the Scopus and Web of Science databases were formulated, as in Table 1, all relevant terms were chosen. In the initial phase of the systematic review process, a total of 4,266 papers were gathered successfully for the present study project from both databases.

Table 1. Article search for SLR

Database	The search string
Scopus	TITLE-ABS-KEY ((keenness OR preparation OR willingness OR readiness OR dexterity) AND mathematic* AND (teachers OR instructor OR educator OR tutor)) AND (LIMIT-TO (PUBYEAR, 2023)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SUBJAREA, "MATH") OR LIMIT-TO (SUBJAREA, "SOCI"))
Web of Science	(keenness OR preparation OR willingness OR readiness OR dexterity) AND mathematic* AND (teachers OR instructor OR educator OR tutor) (Topic) and 2023 (Publication Years) and Article (Document Types) and English (Languages) and Social Sciences Other Topics or Mathematics (Research Areas)

2.2. Screening

The screening process involves evaluating a set of potentially relevant research items to determine if they are in line with the predetermined research topic or questions. Here, the screening phase often employs content-related criteria, such as categorizing study items according to mathematics teachers' readiness as change agents. Duplicate papers will be removed from the initial list of searched papers. The initial screening

stage resulted in the exclusion of 4,199 publications, followed by a secondary screening stage, which scrutinized 147 papers based on specific inclusion and exclusion criteria outlined in this study, as seen in Table 2. These selection criteria are essential for ensuring the relevance of the chosen articles to the study [30]. Since research articles are the main source of useful recommendations, the literature was the first criterion to be applied. Not included in the most current study are reviews, meta-analyses, meta-synthesis, book series, books, chapters, as well as conference proceedings. Moreover, the review was limited to English-language publications. This study uses previous studies in the year 2023. Most recently, these studies delineate and discuss the readiness of mathematics teachers to act as change agents, advocating for proactive measures. This period is sufficient and relevant for identifying concepts and study gaps related to the readiness of mathematics teachers as agents of change [29], [31]. Due to duplicate criteria, one paper was rejected overall.

2.3. Eligibility

In the third stage, termed the eligibility assessment, a total of 146 articles were assembled. During this phase, a meticulous examination of both titles and crucial content of all articles occurred to confirm their alignment with the inclusion criteria and their pertinence to the research goals of the current study. As a result, 115 articles were eliminated for reasons such as being out of scope, lacking significant titles, having abstracts unrelated to the study's objectives, and having no full-text access based on empirical evidence. As a consequence, a total of 31 articles are retained for the forthcoming review.

2.4. Data abstraction and analysis

This study utilized an integrative analysis as one of its assessment strategies, focusing on examining and synthesizing various research designs, particularly utilizing quantitative methods. The initial phase of theme development entailed gathering data. Figure 1 depicts the authors' thorough examination of a collection of 31 publications to identify statements or content relevant to the topics of the present study. Consequently, the authors assessed existing significant studies related to the readiness of mathematics teachers. Additionally, an examination was conducted on the methodologies employed across all studies, as well as the research results.

Table 2. The selection criterion is searching

Criterion	Inclusion	Exclusion
Literature type	Journal (article)	Conference, book, review
Language	English	Non-English
Timeline	2023	<2023
Publication stage	Final	N press
Subject area	Social science and mathematics	Besides social science and mathematics

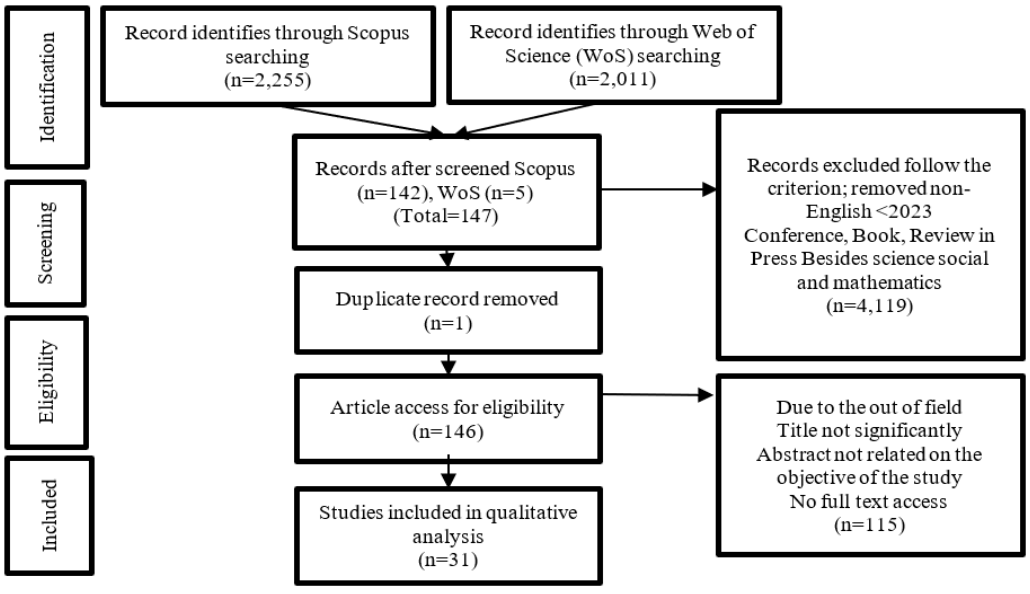

Figure 1. Flow diagram of the proposed searching study

Subsequently, we identify themes rooted in the study's evidence within its context. A log was consistently maintained during the data analysis phase to document analyses, viewpoints, questions, and any significant considerations relevant to interpreting the data. Eventually, we compared the findings to identify any inconsistencies in the theme design process. The produced themes underwent adjustments to ensure coherence. For the validation of the analysis, two experts were involved—one specializing in curriculum and pedagogy, with a focus on teacher competency, and the other in mathematics education. Their collaborative effort determined the issue's validity. The expert review phase aimed at ensuring clarity, significance, and appropriateness with respect to every subtheme and establishing domain validity.

3. RESULTS AND DISCUSSION

This section presents the key findings from the literature review and thematic analysis, highlighting the significance of the study's contributions. Thematic analysis of the reviewed literature identified three main themes: mathematics teaching strategies and pedagogy, factors affecting mathematics learning, and the integration of STEM education with teacher readiness. Table 3 provides a summary of these themes and the corresponding studies.

Table 3. Themes with author(s)

Themes	Studies
Mathematics teaching strategies and pedagogy	[32]–[47]
Factors affecting mathematics learning	[11], [48]–[54]
STEM education and teacher readiness	[55]–[61]

3.1. Mathematics teaching strategies and pedagogy

Mathematics teaching strategies and pedagogy are critical to achieving successful educational outcomes. Seventeen studies specifically address the readiness of mathematics teachers, emphasizing the importance of effective instructional strategies [32]–[47]. Józsa *et al*. [32] used the diagnostic assessment systems for development (DIFER) test as an assessment tool to gauge readiness at the school level. The findings include comprehensive data on several aspects, including country, age, and gender. This extensive study offers insights for teachers and school leadership on enhancing classroom strategies. In addition, Sass *et al*. [47] also propose that future studies should investigate the impact of teacher instructional strategies on these changes and explore the extent to which they are impacted.

Some scholars argue that a pedagogical approach that focuses on the product of mathematics rather than the process can affect student learning. The way teachers teach affects the learning process of students [19]. The selection and consideration of teaching techniques and materials appropriate for student needs must be refined. This condition necessitates the development of support materials that can serve as a guideline for mathematics teachers in meeting educational objectives while developing their personal abilities and knowledge [33]. The current study's findings further suggest that support for mathematics teachers should include lesson preparation, media selection and use, material production, and activity design that considers students' requirements [40]–[42].

A further consideration to consider is the impact of ongoing professional development and reflection on the quality of mathematics teacher education. This dynamic field of education requires collaborative efforts, such as continuous research and development, especially in the areas of pedagogy and curriculum. Committed mathematics teachers are always proactive in enhancing their skills through ongoing professional development, workshops, conferences, and participation in collaborative learning communities [62], [63]. By considering multiple points of view and experiences, teacher educators can better educate trainee teachers to face the challenges of teaching mathematics and promote an inclusive learning environment. According to studies, utilizing digital worksheets and instructional videos in mathematics classes can boost student engagement and lead to a deeper understanding of math concepts [43]. Williams *et al*. [46] convincingly suggest that proper initiatives for teachers can positively affect their behavior and motivation to teach mathematics.

Finally, bridging the gap in mathematics education between secondary and university levels should be emphasized. Today, students need to be instilled with a variety of knowledge and skills that are more up-to-date. For example, providing students with higher programs and courses such as advanced mathematics courses [45]. The importance of improving the competence of teachers to keep pace with the changes that occur. The study's findings reveal that the outcomes of the analysis of the relationship between high school grades and university achievement highlight the importance of comprehensive assessment and collaborative practices among educators at all levels [37], [39]. In conclusion, the readiness of mathematics

teachers to adapt to the changing educational paradigm and maintain a good learning environment is important to improve mathematics education and prepare students to succeed in an increasingly complex world [38], [47].

3.2. Factors affecting mathematics learning

Several factors influence mathematics learning, which in turn affects mathematics teachers' readiness. Key factors include the level of student ability [48], [49], the transition to online teaching and learning [11], [50], the integration of various learning disciplines [51], [52], limited teaching skills and professional teacher training [53], [54]. The study emphasizes the crucial demand for mathematics teachers to enhance their skills to properly address kids' arithmetic difficulties, underscoring that unresolved math anxiety can severely influence children's motivation and academic performance. Utilizing formative assessments is advised as an effective approach for teachers to determine students' understanding and challenges, thus allowing them to create customized support systems to improve learning outcomes [48]. Hence, using this approach helps identify areas of difficulty and guides the development of specific instructional strategies to assist student learning [64].

Furthermore, the utilization of technology in mathematics education emphasizes the importance of teacher readiness when using a new instructional approach. Teachers must be proactive and adaptable when using visual aids and transition to technology-enhanced teaching approaches [11], [50]. Fujita *et al.* [11] researched the problems and positive attitudes of Japanese mathematics teachers toward online education during the pandemic, emphasizing the necessity of readiness, positive attitudes, and support systems. The present finding also supports Fahrurozi *et al.* [15] who concluded that to navigate the changing educational landscape, mathematics teachers must engage in ongoing professional development and self-directed learning to improve their technological competencies and instructional approaches, ensuring they are well-prepared to use technology in the classroom.

To foster effective mathematics instruction, teachers must blend creativity with integrating diverse disciplines, a necessity underscored by Kirwan *et al.* research [52], which identifies six educational activities crucial for integrating information in teacher development programs. This integration is fundamental for enhancing mathematical understanding. Additionally, developing tailored modules, models, methods, and strategies is essential for optimizing student outcomes in mathematics. However, a gap exists in practice, particularly in senior high schools, where many teachers rely heavily on textbooks due to a lack of prepared material [19]. Addressing this gap by developing and adopting comprehensive models and materials tailored to mathematics education can significantly impact teacher readiness and effectiveness, ultimately improving student learning outcomes.

3.3. STEM education and teacher readiness

Table 3 presents that the relationship between STEM education and teacher readiness is an important part of education today, prompting the investigation of this topic in several studies. There are seven published studies that expressly address this theme [44], [53]–[58]. Kazakhstan's study integrates digital educational resources to help teachers learn mathematics [55]. The findings prove that using digital resources improves learning effectiveness and academic performance, indicating the need to incorporate this technology into classroom practices. In addition, Martinez and Ellis [56] underline that confidence in one's academic ability is a strong predictor of academic performance. Previous scholars also emphasized the importance of teachers' attitudes and beliefs since they include epistemic practices that are difficult to change [65], [66].

Our findings indicate that research is being performed to investigate the complexities of STEM teacher identity and how it influences classroom practice. To include STEM in elementary school education, teachers must have a sophisticated grasp of self-efficacy and STEM career awareness [57]. Furthermore, the issue of secondary school teachers being prepared to teach STEM subjects emphasizes the necessity of having a solid teaching knowledge base and being aware of STEM opportunities when determining one's readiness for STEM education [58]. To teach effectively, teachers must cultivate the ability to structure topic knowledge and skills around fundamental principles. These findings suggest the need for personalized professional development and instructional models that can help teachers better execute STEM instruction.

Another study evaluating teachers' readiness to deliver STEM education has led to the development of validated scales, such as the TRi-STEM scale [59]. This assessment, encompassing emotional factors, mental states, belief in one's abilities, and dedication to STEM education, is an excellent instrument for precisely evaluating teacher readiness. Consequently, surveys conducted among STEM educators in Taiwan also indicate positive attitudes toward integrative STEM education [60]. The findings of these surveys highlight the need for sufficient resources and support to promote interdisciplinary teaching

methods. Moreover, a study in China assesses the influence of behavioral and psychological factors concerning the children academic achievement in STEM disciplines from kindergarten to 12th grade [61]. This study emphasizes the significance of utilizing interventions to improve psychological characteristics such as confidence in using the internet and offering guidance to students on the effective use of information and communications technologies. The findings of this study highlight the significance of teacher interventions in enhancing students' performance in STEM disciplines and their problem-solving skills.

4. CONCLUSION

Evidently, the recent comprehensive review synthesizes existing knowledge regarding the readiness of mathematics teachers to act as agents of change. As education evolves, identifying and addressing the challenges that mathematics teachers encounter is crucial to providing a dynamic and effective learning environment for students. Moreover, this study on the readiness of mathematics teachers as change agents using PRISMA is unique in that it takes a complete and transparent approach to gathering, filtering, as well as reporting current research. The findings are intended to contribute to the current discussion regarding mathematics teacher readiness and promote evidence-based techniques for improving flexibility, innovation, and resilience in mathematics teachers. Based on the analysis of 31 recent articles, our main key findings can be summarized: i) mathematics teaching strategies and pedagogy; ii) factors affecting mathematic learning; and iii) STEM education and teacher readiness.

This study is expected to offer researchers insights for further developing this understanding, especially within the context of Malaysia. More broadly, research is also needed to focus on mathematics teachers' readiness as change agents, which may be used as guides and checklists specifically with regard to the pedagogical dimension. Collectively, these results indicate that mechanisms may contribute to the teacher's professional development and function as an initial step toward developing pedagogical models, notably within the Malaysian setting. Consequently, additional investigation and development of an integrated model pertaining to the readiness of mathematics teachers to act as agents of change for academicians and practitioners in mathematics education are required. Overall, this study has implications for the field of knowledge and relevant parties such as stakeholders and mathematics teachers. Stakeholders can use these findings to formulate policies concerning continuing professional development (CPD) for mathematics teachers and teacher training institutes to devise effective strategies for graduate readiness.

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