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Empowering Mathematics Teachers as Agents of Change: Developing a readiness model through Fuzzy Delphi insights

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Abstract
This study developed a model of mathematics teachers' readiness as agents of change using the Fuzzy Delphi Method (FDM). Thirteen experts validated the main components and elements of the model, derived from an extensive literature review. The results demonstrated that the proposed model matched the requirements and attained a high degree of expert consensus. In the analysis conducted, four primary components were identified, namely mathematics teacher readiness, professional knowledge, pedagogical skills, and teaching and learning. This model can serve as a guide and reference for mathematics teachers to make improvements in their education, ultimately enhancing the quality of their teaching.

Keywords: Readiness Model; Agents of Change; Fuzzy Delphi; Mathematics

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1.0 Introduction

The current education system faces various challenges that extend beyond the national level and involve global issues. The rapid development of technology, the demand for 21st-century skills, and changing employment patterns have altered the education landscape (Jarrah et al., 2024). In the context of Malaysia, the initial report on Malaysia's achievements in TIMSS 2023 presents a decline in Malaysia's achievements in mathematics compared to previous years, which, among other things, is linked to the effectiveness of teaching and the level of teacher readiness in the classroom (Talib et al., 2025). This situation necessitates comprehensive changes, particularly from mathematics teachers, who serve as crucial agents of change by conveying knowledge and driving and enhancing the effectiveness of teaching.

The role of mathematics teachers now requires a high level of readiness in terms of professional knowledge and pedagogical skills. However, limitations in this readiness can affect the effectiveness of pedagogical practices in the classroom and the competence of

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teacher professionalism. The mismatch between theoretical understanding and practical practice causes the teaching and learning process to be less effective, which subsequently poses a significant challenge in efforts to improve the quality of education (Jarrah, 2020). Mathematics teachers who are not fully prepared struggle to make informed decisions regarding pedagogy and face challenges in adapting teaching strategies to meet the diverse needs of their students (Pourdavood & Song, 2021).

Previous studies have demonstrated that teacher readiness for mathematics is closely related to professional knowledge, mastery of pedagogical skills, and systematic reflective practice (Livy et al., 2021). Therefore, developing a mathematics teacher readiness model as an agent of change that integrates professional knowledge and pedagogical skills is urgently needed to strengthen teacher quality and adapt to current educational changes (Talib et al., 2024). However, existing models still study these components separately or in general without specifically focusing on the field of mathematics and are not built based on expert consensus (Zulnaidi et al., 2024). Furthermore, studies in model validation based on the actual classroom context and educational environment in Malaysia are still limited.

In this regard, this study was conducted to develop and validate a model of mathematics teacher readiness as an agent of change based on professional knowledge and pedagogical skills through the expert consensus method. This model also emphasises flexibility in its approach, making it suitable for the current educational context and supporting the implementation of effective teaching and learning. This study also provides a new contribution in the form of a framework that can serve as a reference for policymakers, educational researchers, and professionals in the provision of teacher training.

2.0 Literature Review

Model development is a methodical design process that includes organising, assessing, and confirming a conceptual framework that makes it easier to understand, organise, and carry out interventions in an educational setting. In curriculum development, this model illustrates the important elements and relationships between components that support effective teaching practices (Abdullah et al., 2025). It also serves as a clear and practical guide for educators, curriculum developers, and researchers in evaluating and developing educational innovations based on empirical evidence and current needs. Therefore, the model development procedure needs to be implemented dynamically and holistically to ensure that the quality produced is guaranteed and appropriate to the current educational context (Tracey, 2007).

Mathematics teacher readiness is defined as a process that involves emotional, physical, and willingness aspects to carry out tasks or interventions in teaching (Uteuliyev et al., 2023). In general, readiness is considered a key indicator that determines the success or failure of curriculum implementation, particularly in three main stages: planning, implementation, and evaluation. Previous studies have explained that mathematics teacher readiness refers to the teacher's ability to effectively implement mathematics teaching, which involves a combination of knowledge, skills, and behaviours that align with current teaching requirements (Martinez, 2022).

However, there are various issues and challenges faced by mathematics teachers. These problems can be classified into three main categories, namely pedagogical, systematic, and social. These three aspects are interrelated and provide a comprehensive picture of the readiness of mathematics teachers in classroom practice. The study by Probosari et al. (2021) revealed that the level of teacher readiness for implementing science, technology, engineering, and mathematics (STEM) teaching and learning remains at a moderate level. Meanwhile, the findings of Yean and Rahim (2021) stated that teachers are often confused in choosing the appropriate activities to implement. This limitation is frequently caused by a lack of professional knowledge and understanding, which results in the use of traditional methods that are less responsive to students' needs.

This study bases the development of a model of mathematics teacher readiness as an agent of change on the Theory of Educational Change by Fullan (2007) and the Curriculum Development Model by Hilda Taba (1962). Fullan viewed educational change as a complex process that requires continuous implementation and is in line with current needs. In this context, teachers as agents of change need to have a high level of knowledge and skills, especially in aspects such as communication, adaptation of teaching strategies, and in-depth understanding of the student context. Taba (1962) also emphasised the need for teachers to be proactive and adaptable to the teaching context through three main scopes: active teacher participation, adaptation based on student needs, and continuous assessment. Therefore, the mastery of this knowledge and these skills must be consistently improved through continuous professional development programmes supported by a clear and practical change framework.

3.0 Methodology

The Fuzzy Delphi Method (FDM) is employed in this study as an analysis method to obtain expert consensus on the components and elements of the mathematics teacher readiness model as a change agent. FDM has been employed by previous researchers and adapted to the scope of the study to obtain expert consensus through a questionnaire (Almashhour & Alzaatreh, 2025). The justification for selecting FDM is to ensure that the views of each expert are considered and that consensus among the expert group can be achieved in determining the components and elements according to priority. Unlike the Classical Delphi, FDM is faster and more effective, reducing the time allocation of experts to answer each question consistently (Yeh et al., 2024). Figure 1 displays the procedure for developing this study model:

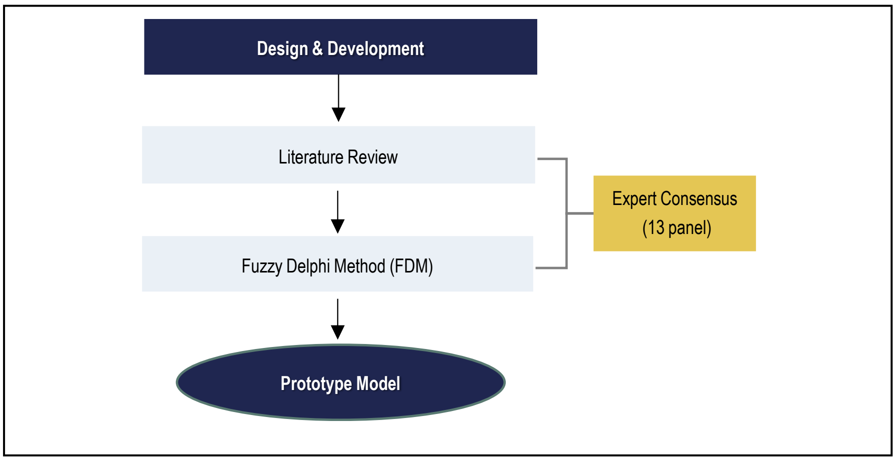

Fig. 1: Research Procedure
(Source: Researchers' data)

Expert selection is a critical component that necessitates further refinement to align with the context of this investigation. The experts involved in this study consist of senior lecturers at IPTA, lecturers at IPG, officers from the Ministry of Education of Malaysia, and experienced teachers. A total of 13 experts in the field of mathematics and curriculum were selected using purposive sampling. The selection of experts was based on established criteria, including expertise, qualifications, and length of service (Al-Rikabi & Montazer, 2023). The selected study experts have more than 15 years of service experience. Rasit et al. (2023) stated that diversity in the expert group can increase the accuracy of results, opinions, and views on an analysis or product. Table 1 presents research expert information.

Table 1. Demographic Information of Research Experts (N=13)

Item	Demographic Data	Frequency	Percentage (%)
Race	Malay	11	85
	Chinese	2	15
Profession	Lecturer in Public Universities (IPTA)	2	15
	Lecturer in Teaching College (IPG)	2	15
	Ministry of Education Officers	2	15
	Experienced Teachers	7	55
Work Experience	11 to 15 years	1	8
	Above 16 years	12	92
Field of Expertise	Curriculum Development	1	8
	Mathematics	12	92

(Source: Researchers' data)

The questionnaire used in this study consists of three parts and applies a seven-point Likert scale. The first part is designed to obtain information about the experts' background, such as race, profession, work experience, and field of expertise. The second part, labelled as FDM 1, is presented to identify and obtain expert consensus on the main components (main dimensions), constructs, and elements required for developing a mathematics teacher readiness model as an agent of change, based on professional knowledge and pedagogical skills. The third part, FDM2, is presented to experts for the evaluation and prioritisation of the elements required for each principal component in developing a mathematics teacher readiness model as an agent of change.

The formation of the questionnaire elements is based on an extensive literature review. The recommendations of Koskinen and Pitkäniemi (2022) guided the synthesis of the main components and model elements. Research is conducted on the main components to ensure that the elements coincide with the selected scope and to improve the questionnaire developed. Accordingly, Table 2 below provides details of the study instrument, which consists of four main components, 15 constructs, and 167 elements derived from a literature review.

Table 2. Details of Questionnaire Item Construction

Main Component	Number of Construct	Number of Elements
Mathematics Teacher Readiness	3	35
Professional Knowledge	6	63
Pedagogical Skills	3	36
Teaching and Learning Mathematics	3	33
Total		167 Element

(Source: Researchers' data)

After the questionnaire was developed, the face and content validity process was carried out by involving five experts. The purpose of validity was to ensure that the questionnaire instrument developed was able to measure what was intended to be measured and could achieve the objectives of this study. The appointed experts inspected the aspects of language use and questionnaire content and provided suggestions for improving the questionnaire of this study. After the improvements were made, the questionnaire was distributed to the FDM experts appointed and agreed to participate in this study.

Based on the data obtained, the researcher will convert all the Likert scales to fuzzy scales. The data collected will then be analysed using Fudelo software developed by Ramlan Mustapha. In the FDM, two steps need to be considered by the researcher, namely the numbering of fuzzy triangles (triangular fuzzy number) and the average of fuzzy numbers or average response (defuzzification process). The first step is the triangular fuzzy number. This process involves converting all linguistic variables to a triangular fuzzy number (Hsieh et al., 2004). Where the linguistic scale resembles the Likert scale, it is converted to a fuzzy scale (Noh et al., 2019). In this step, there are also two basic considerations that need to be followed to determine the acceptance of a component or element being studied based on expert consensus. The first requirement is that the threshold value (d) must be less than or equal to 0.2 (Cheng & Lin, 2002). The second requirement is that the percentage of expert consensus must exceed 75% (Chang et al., 2011).

The next stage in analysing the data for this study involves calculating the average of fuzzy numbers, referred to as the average response (defuzzification process). This step involves determining the priority or ranking of each primary component and element within the model. This process helps researchers assess the level of need, agreement, importance, suitability, and level of a main component and element required in this study. The element that obtains the highest fuzzy score average value (Amax) is considered the most important element and is placed in the first position (Tang & Wu, 2009). This process also enables researchers to determine the priority level of an element, thereby facilitating its placement in the model according to the priorities established by the expert panel (Abdullah et al., 2025). Additionally, this process enables researchers to determine the priority level of an element, thereby facilitating its placement in the model according to the priorities established by the expert panel.

4.0 Findings

Table 3 presents the study's findings on the main components of the model for mathematics teacher readiness as change agents, which were derived from the literature review.

Table 3. The main components of the model are based on a literature review

Num.	Main Component
1	Mathematics Teacher Readiness
	Mathematics teachers' readiness for educational change consists of three aspects, namely: a. New materials that have been reviewed and introduced. b. New teaching approaches. c. Teachers' belief in the appropriateness, support, and value of a change.
2	Professional Knowledge
	The six components of professional knowledge in model construction consist of the following: a. Common Content Knowledge b. Specific Content Knowledge c. Horizon Content Knowledge d. Knowledge of Content and Student e. Knowledge of Content and Teaching f. Knowledge of Content and Curriculum
3	Pedagogical Skills
	The three pedagogical skills in the context of this model consist of: a. Communication Skills b. Teaching Skills c. Visualization Skills
4	Mathematics Teaching and Learning
	The process of teaching and learning mathematics involves three stages, namely: a. Planning Stage b. Implementation Stage c. Evaluation and Assessment Stage.

(Source: Researchers' data)

The data analysis conducted in this section aims to examine expert consensus on the main components and elements suggested by the literature review conducted. Table 4 displays the main components of the mathematics teacher readiness model as a change agent based on expert consensus and analysed using the FDM. The threshold value (d) and the expert group's agreement percentage are included in the data.

Table 4. Main components of the model based on Fuzzy Delphi (FDM) Analysis

Num.	Expert	Main Component			
		Mathematics Teacher Readiness	Professional Knowledge	Pedagogical Skills	Mathematics Teaching and Learning
1	Expert 01	0.018	0.022	0.036	0.036
2	Expert 02	0.018	0.022	0.022	0.036
3	Expert 03	0.040	0.036	0.036	0.022
4	Expert 04	0.018	0.022	0.022	0.036
5	Expert 05	0.018	0.022	0.022	0.036
6	Expert 06	0.040	0.036	0.036	0.022
7	Expert 07	0.018	0.022	0.022	**0.253**

8	Expert 08	0.018	0.022	0.022	0.036
9	Expert 09	0.040	0.036	0.036	0.036
10	Expert 10	0.018	0.022	0.022	0.036
11	Expert 11	0.018	0.036	0.022	0.036
12	Expert 12	0.040	0.036	0.036	0.022
13	Expert 13	0.018	0.022	0.022	0.036
Threshold Value (d) of Each Main Component		0.025	0.027	0.027	0.049
Total item received, d<0.2		13	13	13	12
Percentage of Expert Consensus (%)		100	100	100	92
Fuzzy Score (A)		0.969	0.962	0.962	0.938
Ranking		1	2	2	3

(Source: Researchers' data)

Cheng and Lin (2002) and Chu and Hwang (2007) suggested that if the average threshold value (d) is less than 0.2, then each item is concluded to have obtained consensus among the expert panel. Based on Table 5.4, the overall construct yields a threshold value of d = 0.032 (≤ 0.2). However, there are items with a threshold value (d) exceeding 0.2 (≥ 0.2) that are obscured. This value suggests that some experts disagree on certain items. Next, based on FDM analysis, it indicates that the percentage of expert agreement on the main components of this model exceeds 75%. Therefore, conditions 1 and 2 have been met, and all components are accepted. Overall, all main components have obtained expert agreement, had a good consensus value, and met the specified conditions. Figure 2 illustrates the main components of the developed model of mathematics teachers' readiness as agents of change.

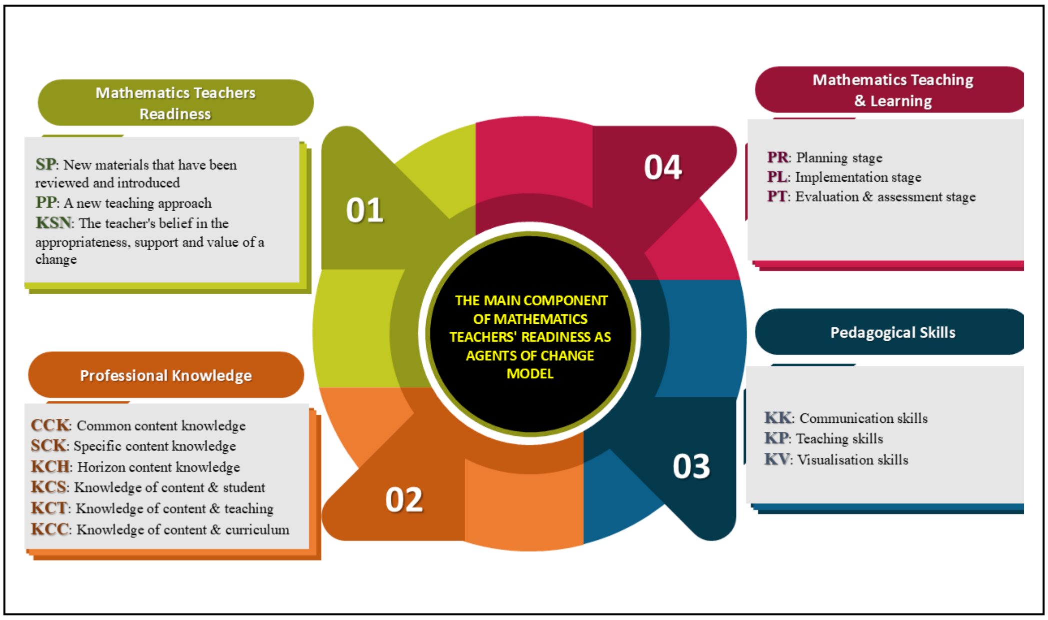

Fig. 2: Main Components of the Mathematics Teachers Readiness as Agents of Change Model
(Source: Researchers' data)

5.0 Discussion

The mathematics teacher readiness as an agent of change model in this study describes four main components, namely 1) mathematics teacher readiness, 2) professional knowledge, 3) pedagogical skills, and 4) mathematics teaching and learning. These four components play a crucial role in forming a comprehensive model that can meet the needs of mathematics education in Malaysia. The integration between professional knowledge and pedagogical skills is the primary focus of this model, due to its significance in enhancing teacher professionalism and contributing to teacher readiness as an agent of change. This finding is consistent with the study by Jarrah et al. (2024), which emphasises that being a professional teacher entails possessing extensive knowledge and practical teaching skills, particularly in a constantly evolving learning environment.

This model also differs from those created by other researchers in terms of its focus and scope. Although earlier models are usually broad and straightforward (Gess-Newsome et al., 2017), this one focuses more on the practical and epistemological aspects of teaching mathematics. This more specific emphasis is crucial for mathematics teachers, as teachers need conceptual understanding and practical guidance that can be directly applied in the classroom (Talib et al., 2024b).

In addition to emphasising aspects of professional knowledge and pedagogical skills, this model also details flexible teaching activities in three main teaching stages: planning, implementation, evaluation, and assessment. Each stage is organised based on established priorities to make it easier for teachers to understand and apply this model comprehensively. In contrast to previous models that emphasised uniformity in teaching approaches, this model prioritises flexibility and the ability to adapt approaches according to the needs of the classroom context (Uteuliyev et al., 2023). This finding also reinforces the recommendation of Chirinda and Barmby (2018), who stated that effective teaching needs to be supported by a transparent yet flexible teaching structure to enable teachers to respond responsively to students' needs. With this model, mathematics teachers now have practical guidance that can be embodied as a checklist to evaluate and improve their teaching processes, from planning to evaluation.

6.0 Conclusion & Recommendation

This study has successfully identified and analysed the main components and important elements in the mathematics teacher readiness model as an agent of change using the FDM. The study findings reveal four key components, namely mathematics teacher readiness, professional knowledge, pedagogical skills, and mathematics teaching and learning. All the main components and their respective elements received high agreement from the expert panel, indicating that elements such as language proficiency, effective teaching methods, and the use of visual aids are essential in mathematics teaching. FDM proved effective in gathering comprehensive expert input, ensuring that the findings are both relevant and practical. These results provide practical guidance for the training and development of mathematics teachers, particularly in enhancing communication, instructional quality and visualisation strategies to improve student outcomes. However, the study is limited by its small sample of experts and its focus on the secondary mathematics context in Malaysia, which may affect its broader generalizability. This study makes a notable contribution to the field of curriculum development, providing a solid foundation for future research and applications. In essence, further research suggestions include evaluating the model's applicability in different contexts and involving more samples of experts from diverse backgrounds to enhance the generalizability of the findings.

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Paper Contribution to Related Field of Study

This study can contribute to the body of knowledge and provide valuable insights to researchers, particularly in curriculum design and development. The findings of this study can be used as a guide and reference for curriculum developers and training providers, including local public and private universities, and adapted according to educational developments from time to time.

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