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Research Article

An Approach of Fuzzy Delphi Method (FDM) to Develop the Risk Management Index in Special Education Mathematics

Aze Fauziah Suib[1*], Puspa Liza Ghazali[2], Noryati Alias[3], Mohamad Afendee Mohamed[1], Bahyah Abdul Halim[2]

[1] Faculty of Informatics and Computing, Universiti Sultan Zainal Abidin, 22200 Besut, Terengganu, Malaysia
[2] Faculty of Business and Management, Universiti Sultan Zainal Abidin, 21300 Kuala Nerus, Terengganu, Malaysia
[3] Faculty of Education, Languages and Psychology, SEGI University, Petaling Jaya, Kuala Lumpur, Malaysia
E-mail: azesuib@gmail.com

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Abstract: According to previous research, low self-efficacy leads to special education mathematics teachers to doubt their self-confidence and experience mathematics anxiety, affecting both the efficiency of teaching mathematics and student achievement. Many teachers, whether fresh to the teaching profession or in-service, struggled with mathematics instruction. It was unsurprising that they would prefer not to teach mathematics and would rather leave if given the option. To avoid potential losses in the future, school administrations must be aware of and identify the risk of their human resources. Thus, the purposes of this study are to identify and weight each significant risk factor in the development of a risk management index in special education mathematics using the Fuzzy Delphi Method (FDM). The risk management index can be utilized by school administrators as a guideline tool for decision making in special education mathematics. The consensus of sixteen experts from both fields in FDM confirmed and ranked seven significant factors. The newly constructed risk index formula utilizes all factors and their weightings. The findings indicated that the approach method has a high potential for dealing with the complexities of risk management in human resources.

***Keywords*:** risk factors, risk management index, special education mathematics, Fuzzy Delphi Method (FDM), decision-making, human resources management

MSC: 00A69

1. Introduction

The Malaysian Ministry of Education is constantly striving to improve these special children's learning opportunities. The ministry launched a specially designed mathematics curriculum for students with learning disabilities (LD) in 2014. With this initiative, special education has provided students with learning disabilities with knowledge in mathematics skills that are extremely important in their daily lives.

Unfortunately, special education teachers who are responsible for teaching them mathematics have been reported to have several issues. This is due to a lack of exposure to mathematics training during teacher training and in-service professional development, as well as a lack of support from the school community [1, 2]. As a result, they experienced

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mathematics anxiety, low self-efficacy, and doubts about their ability to teach the subject [2–5]. Teachers with mathematics anxiety and low self-efficacy are more likely to have difficulty in the classroom [5]. As it turns out, it is not shocking that students who were taught by special education teachers did poorly in mathematics as well [6, 7].

A significant drive for enterprise development is provided by effective human resource management [8]. Authors believed the same way goes in the school organization too. Competent human resources (HR) are the school's most important capital in providing high-quality education. Thus, the hurdles that special education mathematics teachers encounter must be addressed through an effective human resource management. It is critical for effective risk management to intervene in order to resolve the problem that arose in special education mathematics. This study aims to identify the significant risk factors that could affect the special education teachers' self-efficacy in mathematics instruction, assign the weightage for each significant risk factor and develop a new mathematical formulation for risk management index in special education mathematics.

2. Literature review

2.1 *Human resources risk management*

Risk management has always been relevant to business, marketing, and occupational health and safety [9, 10]. However, far too little attention had been paid to educational settings, particularly in special education. Previous Thai studies recommended five types of risk management at the school level [11, 12]. Regardless of the type of schools, human resources appear to be one of risk to the school management. They divided the human resources to three groups of people, administrators, teachers and students. Therefore, it is appropriate to focus only on teachers which are concerned with the issue of special education mathematics teachers in this study context. The similarities of risk factors identified in these two studies were teacher's qualification, teacher's knowledge, teacher's readiness, teacher's experience and teacher's behaviour.

The process began with the risk identification in the special education mathematics context in Malaysia. The identification of risk factors is the formulation of the organization's basic human resource risk [13]. To ensure HR quality management, it is critical to develop preventive and operational measures [14].

2.2 *Risk factors related to teachers' self-efficacy*

For a long time, there had been concern about teachers' self-efficacy. Previous research has identified a number of risk factors that have an impact on teachers' self-efficacy in general. Obviously, knowledge is the most important factor. Teachers who are knowledgeable can teach and manage mathematics classes [15]. They also have a strong sense of self-efficacy and experience less math anxiety [2, 3]. It is also claimed that experience is a factor. Between newly hired teachers and those who have been teaching for years, there are differences in their levels of self-efficacy [16–19]. It is a reliable predictor of special education teachers to be success in teaching mathematics [20]. Teachers' interest is another potential factor. Every subdomain of teacher self-efficacy in mathematics teaching has been found to significantly depend on the individual interests of the teacher [2]. Lack of interest will demotivate teachers from making extra efforts in their instruction of students with low performance abilities. Genuine interest towards their teaching profession enabled them to overcome difficulties and more resilient to the challenging circumstances [21].

In the context of this study, training and professional development additionally serve as risk factors. Due to limited training during pre-service and in-service training, special education teachers also demanded for training and professional development [1]. Teachers with math teaching course for special education had been proved to have appropriate degree of self-efficacy [1]. School administrators are unquestionably an imminent risk to teachers' self-efficacy. Their involvement in planning, motivating, and supervising teachers' mathematics lessons has been a key factor in raising teachers' self-efficacy [15–17, 21–24]. Furthermore, school colleagues have been identified as the next risk factor for teachers' self-efficacy. A supportive colleague environment and a professional support system are undoubtedly necessary for special education teachers, particularly during their initial stage of teaching [1, 15, 18, 22]. Previous scholars addressed the behaviour of students too. Considering the diversity of students with learning disabilities at school, teachers should at

the very least be aware of their deficits in learning mathematics [25]. This would allow the teacher to easily manage the mathematics instruction in class.

2.3 *Fuzzy Delphi Method (FDM)*

Fuzzy Delphi Method is a mixed-method approach in gathering the experts' consensus regarding an issue in a research. According to [26], the first step in fuzzy decision making (FDM) is a review of the literature or expert interviews (a qualitative method of the Delphi approach) to gain understanding of the issue and translate linguistic preferences into explicit numerical values (using fuzzy mathematics). Thus, FDM can reduce the researcher's ambiguity in interpreting the experts' original opinion [14, 27]. It can be used to establish a set of impact factors too [28].

Furthermore, one of the most popular techniques for flexible expert-based decision-making is FDM [14, 29]. FDM has been employed as a study methodology in earlier studies carried out in Malaysia and other nations. The main focus of these studies was to identify and prioritise components based on their importance in developing models, modules, and assisting in decision-making. [28] was using FDM for a model development and [30] employed FDM in developing a module. [31] from China also utilized FDM in the decision making to improve their human resources management in enterprise. Recent studies integrated FDM with other methods such as analytic hierarchy process (AHP), analytic network process (ANP), technique for order preference by similarity to ideal solution (TOPSIS) and decision-making trial and evaluation laboratory (DEMATEL) in the hybrid Multi Criteria Decision Making (MCDM) model to make the best decision [27, 32–34]. Since there is only one criterion that can be applied to address the study's problem, the researcher opted to use FDM only because integrating approaches to produce the best results involves selecting complex criteria.

2.4 *Index formulation*

Index has been widely used in many sectors. A good index will be able to identify the critical features of an organisation in order to accomplish its vision and goals [35]. Air pollution index (API), customer satisfaction index (CSI), and human resources management index (HRM index) are a few well-known index functions. A few studies had been created a HRM Index such as HRM Sustainability Index [36] and HRM Job Satisfaction Index [37]. The most significant document related to authors' interest was the [38] presented in Government at a Glance. It had employed the composite indexes for Human Resources Management Practices since it can access several variables individually. [38] also highlighted the necessity of establishing a relevant conceptual framework based on variables validated by experts in relevant fields. The HRM Index doesn't evaluate overall quality; rather, it explains trends or nature in the desired area being studied.

3. Methodology

3.1 *Fuzzy Delphi Method (FDM)*

This study employed Fuzzy Delphi Method to obtain experts' consensus towards the risk factors related to self-efficacy of special education teachers in mathematics instruction. As the beginning process, a questionnaire consists of ten risk factors that emerged through a semi structured interviews in the first phase of this research was created. The seven-point Fuzzy scale was used in this study as shown in Table 1.

The questionnaire has been distributed to 16 experts from both fields' mathematics and special education. The number of experts involved was determined due to get high uniformity among experts [39]. [39] stated that ten to fifteen specialists are required to produce adequate results. [14] backed it up, noting that having too many experts participating would lead to inconsistent results, particularly if there were too many dominating experts in the group. The experts were two mathematics lecturers, two special education lecturers and twelve special education school administrators. They were chosen purposively based on the criteria:

(a) The field of experts are special education or mathematics;

(b) The minimum level of education is Bachelor Degree in respective fields;

(c) The experts have at least 10 years' experience in their respective fields.

Table 1. 7-point fuzzy scale

Likert scale	Level of agreement	Fuzzy scale
1	Extremely strongly agree	(0.9, 1.0, 1.0)
2	Strongly agree	(0.7, 0.9, 1.0)
3	Agree	(0.5, 0.7, 0.9)
4	Moderately agree	(0.3, 0.5, 0.7)
5	Disagree	(0.1, 0.3, 0.5)
6	Strongly disagree	(0.0, 0.1, 0.3)
7	Extremely strongly disagree	(0.0, 0.0, 0.1)

Source: Mohd and Mat [14]

The FDM approach is based on triangular fuzzy numbers and fuzzy score or fuzzy evaluation. There are two prerequisites in using FDM as below [14]:

(a) Triangular Fuzzy Number (the average value of fuzzy numbers)

(i) Threshold value, d must be less or equal to 0.2 ($d \leq 0.2$):

$$d(\tilde{m},\ \tilde{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]}$$

Whereas:

• m_1 = the minimum value.

• m_2 = the reasonable value.

• m_3 = the maximum value.

(ii) The expert group consensus must be more or equal to 75% (expert consensus $\geq$ 75%).

(b) Fuzzy Evaluation Process (acceptance and ranking process of variables/elements/factors/indicators)

The fuzzy score A_{max} must be more or equal to α-cut 0.5 ($A_{max} \geq 0.5$):

$$A_{max} = \frac{1}{3} \times (m_1 + m_2 + m_3)$$

3.2 *Risk management index formulation*

After getting the weightage for each significant component, this study employs a basic formulation and composite index as follows [40]:

(a) Index number,

$$I = \frac{Q_1}{Q_0} \times 100$$

Whereas:

• Q_0 = Quantity at base time.

• Q_1 = Quantity at a given time.

(b) Composite index,

$$I^{-} = \frac{\sum(I_i W_i)}{\sum W_n}$$

Whereas:
• $i = 1, 2, \ldots, 7$ and $n = 1, 2, \ldots, 7$.
• I = index number for each component.
• W = weightage for each component.

4. Findings and discussion

This section discusses the FDM approach's results as well as the method of generating the risk management index. Researcher used a formulated Microsoft Excel that has been established by [14] to key in the data and obtain the results of FDM. Table 2 summarizes the items of risk factors that could possibly affect special education teachers' self-efficacy in mathematics instruction. The risk factors revealed emerged during the study's first phase, which included semi-structured interviews with experts in field of mathematics and special education.

Table 2. Risk factors of special education teachers' self-efficacy in mathematics instruction

Item label	Risk factors
1	Knowledge
2	Experience
3	Administrators
4	Colleagues
5	Training and professional development
6	Students' behaviour
7	Interest

Source: Authors' elaboration (emerged from the first phase of this study)

Table 3 displays the results of the expert questionnaires. All experts gave the scale for each risk factors based on their agreement on the factors.

Table 3. Scales given by experts for the risk factors

Experts	Item						
	1	2	3	4	5	6	7
1	6	6	6	6	6	6	7
2	7	5	5	5	6	5	5
3	7	5	5	5	5	5	6
4	7	7	7	6	6	5	6
5	7	6	7	5	7	6	7
6	7	6	5	5	6	5	7
7	6	7	6	5	5	5	6
8	7	6	6	6	6	4	5
9	6	7	6	7	6	6	7
10	7	6	7	6	6	4	5
11	6	7	6	5	5	4	6
12	7	5	7	5	5	4	7
13	7	6	7	6	6	4	7
14	6	6	7	5	4	5	5
15	6	6	6	5	4	4	6
16	6	7	7	5	5	4	6

4.1 *The significant risk factors that could affect the special education teachers' self-efficacy in mathematics instruction*

In order to meet the first objective of this study, the prerequisites of FDM need to be met, the threshold value, d must be less or equal to 0.2, the experts' consensus must be more or equal to 75 percent and Fuzzy score, A_{max} need to be more or equal to 0.5. Table 4 presents the summary of prerequisites for FDM.

Table 4. Threshold value (d), percentage of experts' consensus and Fuzzy score A_{max}

Number	Item/Risk factors	Triangular fuzzy numbers prerequisite		Fuzzy evaluation process prerequisite			
		Threshold value (d)	Percentage of experts' consensus (%)	m_1	m_2	m_3	Fuzzy score (A)
1	Knowledge	0.075	100.00	0.813	0.956	1.000	0.923
2	Experience	0.105	100.00	0.725	0.894	0.981	0.867
3	Administrators	0.119	100.00	0.750	0.906	0.981	0.879
4	Colleagues	0.129	100.00	0.588	0.781	0.938	0.769
5	Training and professional development	0.174	87.50	0.600	0.794	0.931	0.775
6	Students' behaviour	0.191	81.25	0.450	0.650	0.831	0.644
7	Interest	0.129	100.00	0.725	0.888	0.975	0.863

Source: Authors' elaboration (based on Microsoft Excel)

This table indicates clearly that all sixteen experts accept that all items are major risk factors for special education teachers' self-efficacy in teaching mathematics, with five factors obtaining 100% expert agreement. The findings were consistent with earlier research. As an outcome, all risk elements will be considered when making the formulation of a risk management index. The current study found out that knowledge is the key risk for non-optional teachers such as special education mathematics teacher. These result corroborates the ideas of [1, 41]. It is due to the same reason as [2] that

special education teachers had less mathematical exposure during their teacher training and even during their in-service positions.

It has also been proven that experience is an important concern for special education teachers' self-efficacy. This finding was consistent with previous research, which found that novice teachers and experienced teachers in special education mathematics had different levels of self-efficacy [17–19, 42]. Another identified factor was the role of administrators, which shows up to be at the forefront of scholars' attention these days, including in Malaysia. The Malaysia Education Blueprint (2013-2025) as well emphasised a new paradigm for promoting high performance administrators in schools, recognising the significance of a good school leader in influencing teachers, students, and the school community. Experts agreed that other risk factors included teacher training and professional development. Those who received additional training, particularly in special education mathematics, seem to be more competent than those who did not [1].

However, little is known about two potential risk factors which are students' behaviour and teacher interest. It is not surprising given that the students in special education have a variety of disabilities. [43] claimed students' positive behaviour decreased when learning mathematics. Thus, SE teachers need to identify the learning deficits and behaviour to teach the subject to maximize the learning time [25, 28]. Teacher's interest in teaching mathematics towards students with learning disabilities should be taken into measures too because it has been found dominant in each subdomain of teachers' self-efficacy [2]. Unfortunately, the lack of supporting evidence for this component has been investigated in past study.

4.2 *Assign the weightage for each significant risk factor as a basis for developing the risk management index formulation in special education mathematics*

The weighting for each element represents how much a risk factor is contributing to the overall risk [40]. Giving weightage is the key when developing a risk management index on the basis of a composite index. Table 5 provides the position of risk factors that been referred to assign the weightage in developing the index.

Table 5. The weightage for each significant factor

Item/Risk factors	Fuzzy score (A)	Position/Rank	Weightage
Knowledge (K)	0.923	1	7
Administrators (A)	0.879	2	6
Experience (E)	0.867	3	5
Interest (I)	0.863	4	4
Training and professional development (T)	0.775	5	3
Colleagues (C)	0.769	6	2
Students' behaviour (S)	0.644	7	1

Interestingly, the risk factor involving school administrator ranks second on the list. The result was accurate with the current situation because previous research revealed that they lacked knowledge in special education [4]. Thus, the rejection among school administrators towards special education has existed [20]. They frequently disregard the welfare of SE teachers [4]. Without their assistance, special education teachers, particularly novice teachers, are at risk [16].

In contrary, despite not being addressed much in prior studies, interest is placed fourth among key risk factors and has 100% consensus from experts. This result is consistent with [2], claiming that interest has an impact on all subdomains of self-efficacy. Students' behaviour was ranked last because of unanticipated student behaviours that teachers may not be able to predict. However, this element should be considered because if the teacher is unable to control the student's behaviour, it will be impossible for the teacher to continue the mathematics lesson smoothly.

4.3 *To develop a new mathematical formulation for risk management index in special education mathematics*

A questionnaire was set after the process of identifying the significant factors and assigning weightages. All the questions were either adapted and adopted from previous scholars or elaborated from the interview data with the participants. The risk factors are the independent variables in this study. The questionnaire was being sent out for methodology expert's validation and pilot test with the special education mathematics teachers. Ten-point Likert scale was utilized from 1 (strongly disagree) to 10 (strongly agree). Table 6 presents a summary of the questionnaires and the formulation of index for every factor.

Table 6. Questionnaire of risk factors with weightage and index formulation

Factors	Statements	Sources	Weightage (W)	Formulation of risk index
Knowledge	I am able to properly transmit my mathematics knowledge to students. My existing mathematical knowledge helps me to teach students with learning difficulties (LD) effectively. I have ample knowledge in maths education for students with learning disabilities (LD).	Lin & Mohd [44]	7	$\sum_{i=1}^{5} ai$
	I am well-versed in the techniques for teaching mathematics to students with learning disabilities. I am knowledgeable with the Special Education Mathematics Curriculum.	Tembren & Tahar [45]		
Role of administrators	My administrators work directly with teachers who are struggling to improve their mathematics instruction. My administrators actively monitor the quality of mathematics instruction. My administrators participate in instructional planning with teams of teachers. My administrators actively monitor the quality of mathematics instruction. Administrators know what is going on in my classroom.	Jin [46]	6	$\sum_{i=1}^{5} bi$
Experience	I believe that I can teach mathematics well as time passed by. I learn my mistakes and reflect for better tomorrow from my daily teaching. I am not confident with my mathematics teaching in the beginning of my career. I am able to apply different technique to teach maths due to my experience for a long time.	Author's elaboration (from interview data)	5	$\sum_{i=1}^{4} ci$
Interest	I am interested in teaching maths for students with learning disabilities.	Grigg et al. [47]	4	$\sum_{i=1}^{3} di$
	My interest has led me to commit in teaching maths towards my students. My persistence in pursuing knowledge to improve my teaching stems from my passion in maths.	Author's elaboration (from interview data)		

Table 6. (cont.)

Factors	Statements	Sources	Weightage (W)	Formulation of risk index
Training and professional development	My exposure in maths training helps to increase my confidence in teaching mathematics. I think I am able to teach maths because of my professional development. I believe that I can teach well if I receive specific training in special education maths.	Author's elaboration (from interview data)	3	$\sum_{i=1}^{3} ei$
Colleagues	I often meet my colleagues regularly to further my knowledge in mathematics or pedagogical approaches. I collaborate with my colleagues to do co-teaching. I have been exposed by my colleagues to many examples of the kinds of work that is expected of my students. I receive mentoring lead teaching in one-on-one situation by my senior colleague.	TIMSS-R [48]	2	$\sum_{i=1}^{4} fi$
Students' behaviour	I can manage the students to learn despite their difficulties in mathematics learning. I am able to adapt my mathematics instruction to individual needs of my students.	Brickman & Olsson [49]	1	$\sum_{i=1}^{5} gi$
	I can deliver the maths lessons smoothly by holding students' attention. I manage to analyse the learning styles of each student to teach maths. I am confident in increasing student achievement in maths.	Shah & Bhattarai [50]		

Assuming that $\sum W_i = W_i$ [51], the basic mathematical formulation for risk management index is defined as follows based on the index number and composite index formula:

$$I^{-} = \frac{W_1 \sum(K) + W_2 \sum(R) + W_3 \sum(E) + W_4 \sum(I) + W_5 \sum(T) + W_6 \sum(C) + W_7 \sum(S)}{W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7}$$

$$I^{-} = \frac{7\sum_{i=1}^{5} ai + 6\sum_{i=1}^{5} bi + 5\sum_{i=1}^{4} ci + 4\sum_{i=1}^{3} di + 3\sum_{i=1}^{3} ei + 2\sum_{i=1}^{4} fi + \sum_{i=1}^{5} gi}{7+6+5+4+3+2+1}$$

$$I^{-} = \frac{7\sum_{i=1}^{5} ai + 6\sum_{i=1}^{5} bi + 5\sum_{i=1}^{4} ci + 4\sum_{i=1}^{3} di + 3\sum_{i=1}^{3} ei + 2\sum_{i=1}^{4} fi + \sum_{i=1}^{5} gi}{28}$$

5. Summary and recommendation

This study attempts to achieve three purposes. The first and second aims were to identify significant risk factors and to assign weightage for each factor that could affect special education teachers' self-efficacy by employing the Fuzzy Delphi Method (FDM). The FDM had been proved as the effective way in making decision based on the experts' consensus about an issue [14]. Researchers chose to utilize FDM in order to achieve two objectives of this study, identifying the

most significant risk factors and assign its weightage. Since there was only one criterion to be rank which was the self-efficacy factors, FDM is more suitable to be applied due to its simplicity and expert-based opinion than the other methods for multiple and complex criteria such as simple additive weighting (SAW), analytic hierarchy processes (AHP), analytic network processes (ANP), technique for order preference by similarity to ideal solution (TOPSIS) and decision-making trial and evaluation laboratory (DEMATEL).

Researchers had finally made decision to use seven significant risk factors namely knowledge, administrators, colleagues, interest, training and professional development, students' behavior and experience for the development of risk management index. The use of all risk factors will be based on its weightage that made up from the FDM approach for the third purpose, which is to develop a new mathematical formulation for risk management index. The mathematical approach using a composite index based formulation is needed to reduce the risk of human resources in special education mathematics for better school management in future. The findings of this study offer a new perspective of risk management at school level, specifically into special education mathematics. The risk indicators that have been discovered can serve as a roadmap for effective human resource management by school administrators. By using this new mathematical formula, school administrators can reduce the likelihood of additional problems relating to the management of their teachers and increase the quality of their decision-making process.

Still, further investigation on this topic is required; including the use of fuzzy with simple additive weighting method (FSAW), as there were insufficient comparisons done in the FDM to identify the optimal procedure, aggregate, and condition to yield the best results in comparison to alternative approaches. Besides, this study relied on the opinions of experts rather than special education mathematics teachers as respondents. A future study may also focus on the special education teachers as the respondents and determine what risk factors have the greatest impact on them. A large-scale survey adopting the generated questionnaire to assess special education mathematics teachers at risk according to their location and length of service would expand the research too.

Conflict of interest

There is no conflict of interest for this study.

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