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Fuzzy Conjoint Need Assessment Method for Model Development Justification

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Abstract This paper proposes a Fuzzy Conjoint Need Assessment Method (FCNAM) procedure for model development justification. The failure to select the analysis method and neglect the data when completing the needs assessment, before developing a model, leads to incorrect implementation of the justification. There is a misunderstanding in the requirements analysis, and certain elements that should be considered in the model's design and development may be overlooked. Therefore, as an alternative method in the model development justification procedure, the fuzzy conjoint analysis method together with the triangular fuzzy number is used as a data analysis medium in the need assessment survey. As an implementation and evaluation of the FCNAM procedure, a need assessment survey involving 53 mathematics teachers was conducted to justify the need for the development of a student's mathematics problem-solving ability (SMPSA) measurement model. This procedure is proven to comply with the guideline need assessment, which is to successfully confirm gaps related to mathematics problem-solving ability, describe the perspective of teachers as users and practitioners of the proposed model and synthesize the level of development needs of the model involved. This paper contributes knowledge about the application of the triangular fuzzy number-based conjoint method in perception surveys and introduces a more effective model development justification procedure.

Keywords: Fuzzy conjoint method, Triangular fuzzy number, Need assessment, Model development, Mathematics problem-solving ability.

Introduction

In an educational setting, needs assessment is a process of identifying, understanding and dealing with existing challenges to prepare proposals to overcome them. Needs assessment is defined as a systematic study of the gap that exists between the current state and the ideal state as well as relative to the factors that can be associated with the gap [1]. This needs assessment process is also an initial step in improving the effectiveness of providing beneficial interventions to students [2]. Model development is one of the interventions or recommendations to increase effectiveness when a problem arises [3]. Different models have been introduced in the context of education in general or learning in class particularly to overcome gaps, and obstacles, and also as a need [4]. The TABA Model, for example, was introduced for curriculum development, the ADDIE Model for the process of designing learning activities or interventions, the SRL Model to provide information about individual self-learning, and many other models [1, 4].

However, some criteria or prerequisites need to be met before these models are developed such as emphasizing the need and justification of the development [5]. According to Sarkar [3] need assessment is the first step that will ensure the development of the model will be successful, be on the right track and the initial measure of the suitability of the model to be used. Roberson *et al*. [6] presented issues and controversies that occur during need assessment, which are related to incorrect data analysis and ignoring data that should be interpreted. Imperfect needs analysis results due to incorrect data analysis will cause model development to not be properly justified [4]. The correct procedure of model development justification will ensure the elements in the model are effective and have a positive impact

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on the users in the future [5]. It clearly shows that there is a knowledge gap and a practical gap related to the method for analyzing data during the need assessment.

Alternatively, computational intelligence or soft computing techniques can be used to analyze data more efficiently and effectively such as the Fuzzy Conjoint Method (FCM). According to Gupta [7] and Kwok *et al*. [8], need assessment is related to human assessment, multi-criteria decision-making and judgments. Therefore, any data collection and data analysis procedure requires a system that can define ambiguity in human perception and thinking [9-12]. In some situations, fuzzy analysis models are very suitable to be used in the process of obtaining different perceptions or making decisions by measuring levels according to preferences [13,14]. FCM is increasingly applied because it can analyze in detail each survey that requires respondents to evaluate their choices using linguistic concepts [11,15-17]. According to Sri Andayani *et al*. [18] and Bakar and Ab Ghani [19], a lack of knowledge and practical gaps cause educators causing educators to less apply fuzzy analysis and multi-criteria decision-making methods. Meanwhile, educators are among the individuals who often develop a model as a work procedure, management and the more advanced are in the steps of implementing teaching and learning interventions [4, 9]. The question and a bit of confusion is, how is the needs assessment carried out and does it follow the correct model development justification procedure if soft computing methods such as FCM is not practised.

To address and fill the gap, this study presents a method for data analysis utilising a fuzzy conjoint model, which will be used during the need assessment in evaluating the justification for developing a model and is named the Fuzzy Conjoint Need Assessment Method (FCNAM). This study reveals more accurate data analysis methods in making decisions to develop models. Among the main contributions of this study are:

i. Demonstrates the suitability and application of the triangular fuzzy number-based conjoint method in analyzing data from perception surveys
ii. Introducing a more effective model development justification procedure and revealing techniques to get an initial overview of the model elements.

As a result, the next section will explain some of the definitions used. The methodology section will cover the study design and procedure, present the FCNAM procedure, and clarify how FCNAM is utilised to justify the establishment of the students' mathematics problem-solving ability (SMPSA) measuring model. The scheduled results of the data analysis will be displayed in the result section. Next, the findings, outcomes, and effectiveness are going to be discussed in the discussion section.

Preliminaries

In this section, the basic concepts, definitions and operations related to the study are presented.

Fuzzy set, Triangular Fuzzy Number and Similarity Degree

Definition 2.1. [20] A fuzzy set *A* in *X* is a set of ordered pairs, $A = \{(x, \mu(x)); x \in X\}$ where $\mu(x)$ indicates the degree of membership of element *x* in the universe X.

Remark 2.1. Linguistic values are variables that use words to represent their value. Also known as a linguistic term as a representation of a fuzzy set defined in the universe of discourse in which the variable is defined.

Remark 2.2. Fuzzy numbers are fixed and generalized real numbers. It is a set of values in a connected state, i.e. each with its weight between 0 and 1. Next, fuzzy numbers are a subset of the normalized fuzzy set of the real line.

Definition 2.2. [20] A triangular fuzzy number (TFN) is a fuzzy number representation as, $A = (a_1, a_2, a_3)$ which is defined by the membership function:

$$\mu_A(x) = \begin{cases} \frac{x-a_1}{a_2-a_1} , & x \in |a_1, a_2| \\ \frac{x-a_3}{a_2-a_3} , & x \in |a_2, a_3| \\ 0 , & otherwise \end{cases} \quad (1)$$

Let $A = (a_1, a_2, a_3)$ and $B = (b_1, b_2, b_3)$ be two triangular fuzzy numbers, and *k* is a scalar. Arithmetic operations and fuzzy number equality functions will be given by the following definitions:

Definition 2.3. [21] Arithmetic operations for fuzzy numbers *A* and *B* are given as follows:

$$A + B = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \quad (2)$$

$$A - B = (a_1 - b_3, a_2 - b_2, a_3 - b_1) \quad (3)$$

$$A \times B = (a_1 b_1, a_2 b_2, a_3 b_3) \quad (4)$$

$$kA = (ka_1,\ ka_2, ka_3) \quad (5)$$

Definition 2.4. [22] The similarity degree between *A* and *B* can be calculated using the formula:

$$Sim(A, B) = \frac{1}{1 + d(A, B)} \quad (6)$$

where $d(A, B) = |P(A) - P(B)|$ with $P(A) = \frac{a_1 + 4a_2 + a_3}{6}$ and $P(B) = \frac{b_1 + 4b_2 + b_3}{6}$.

Students' Mathematics Problem-solving Ability (SMPSA)

The ability to solve mathematics problems is defined as the actions and behaviour of students in problematic situations involving mathematics [23]. Abdullah *et al*. [24] defined as knowledge and mathematical skills. Schoenfeld [25] defines it as a cognitive process where metacognitive skills are tested and is an implication of neurocognitive to mathematics problems. In several studies that have been carried out, mathematics learning and problem-solving levels are still low [24, 26-31]. According to Phonapichat *et al*. [32] and Mohd, Mahmood and Ismail [33], many factors need to be measured that affect the strengths or contribute to the weaknesses of students based on behavioural and cognitive perspectives when solving mathematics problems. Among them are related to external factors such as emotion [34], readiness [35], and motivation [36]. While internal factors are such as memory [37, 38], mathematical problem-solving mechanisms [39,40] and metacognitive coordination [41].

In addition, the mathematics learning environment itself is uncertain, unclear, vague and tied to various factors, making it difficult to measure students' abilities [42]. Factors related to students' abilities in solving mathematical problems require the most accurate platform as a calibrator [32]. This ability needs to be analyzed and interpreted as best as possible so that interventions can be given [43]. For this reason, it requires a more accurate and appropriate measurement model. Do & Chen [44] also suggest educators create a measurement model that can predict students' ability, that is, not just to implement pencil and paper tests. In addition, Hwang *et al*. [45] criticized the attitudes and actions of educators who do not emphasize the need to measure student ability. It can be concluded that the assessment of student's ability to solve mathematics problems is considered less important by some educators.

Methodology

In this section, the Fuzzy Conjoint Need Assessment Method (FCNAM) procedure is presented. The existing procedure of the fuzzy conjoint analysis method is combined with a triangular fuzzy number (TFN) environment. Defined linguistic terms are presented in TFN form. The FCNAM procedure is specifically adapted to analyze and determine the justification of model development needs involving the views and influence of respondents in making some decisions and needs assessment. This process involves three main stages which are the aggregation of individual knowledge and skills about the problem's main point, the assessment of the group's perspective on the problem situation and finally the ranking of the need factors. The way data is collected and analyzed using this method is also refined to achieve the objective for the justification of the development of the students' mathematics problem-solving ability (SMPSA) measurement model.

Fuzzy Conjoint Need Assessment Method (FCNAM)

The general procedure of FCNAM in the context of analyzing and justifying the needs of model development is presented as follows:

Step 1: Identify the attribute set, $A = \{A_i\}$ $(i = 1,2,3 \ldots n)$ which will represent the input data for the needs assessment in the environment being studied.

Step 2: Set appropriate predefined linguistic values for evaluation as defined by TFN, $V_j = \left(b_1^j, b_2^j,\ b_3^j\right)$ where $j = 1,2,3 \ldots k$

Step 3: Get the number of responses, r_{ij} regarding linguistic values, $V_j, j = 1,2,3 \ldots k$ on attributes A_i.

Step 4: Compute the weight of attribute A_i with linguistic value V_j as:

$$w_{ij} = \frac{r_{ij}}{\sum_{j=1}^{k} r_{ij}} \tag{7}$$

Step 5: Determine the overall membership function of attribute $\tilde{A}_i = (a_1^i, a_2^i, a_3^i)$ as:

$$\tilde{A}_i = \sum_j^k w_{ij} V_j \, , i = 1,2,3, \dots n, j = 1,2,3, \dots k \tag{8}$$

Step 6: Calculate the degree of similarities between the aggregated linguistic ratings for the *i*-th attributes $\tilde{A}_i = (a_1^i, a_2^i, a_3^i), i = 1,2,3 \dots n$, and the linguistic ratings, $V_j = (b_1^j, b_2^j, b_3^j), j = 1,2,3, \dots, k$ using the similarity measure as:

$$S_{ij}(\tilde{A}_i, V_j) = \frac{1}{1 + d(P(\tilde{A}_i) - P(V_j))}, i = 1,2,3 \dots, n, j = 1,2,3, \dots, k \tag{9}$$

with $P(\tilde{A}_i) = \frac{a_1^i + 4a_2^i + a_3^i}{6}$ and $P(V_j) = \frac{b_1^j + 4b_2^j + b_3^j}{6}$.

Step 7: Identify the linguistic values that have the highest similarity degree. Each of these linguistic values will be chosen to represent the group's overall assessment of the assessed attribute. Next, the attributes will be sorted by priority.

Implementation of the FCNAM in Analyzing Teachers' Perceptions and Justifications to Determine the need for the Development of a Student's Mathematics Problem-solving Ability (SMPSA) Measurement Model

A survey using a fuzzy questionnaire was carried out to investigate teachers' perceptions and justifications to determine the need for the development of the students' mathematics problem-solving ability (SMPSA) measurement model. Before that, a content analysis was carried out first to see the problems and gaps in SMPSA through the literature review and detailing the issues that lead to the need for model development. In this regard, based on research gaps, several past studies suggest the development of alternative measurement models to overcome problems in SMPSA. Therefore, a need assessment study should be conducted to see if this happens in the researcher's local environment. This study focuses specifically on the perception of teachers' knowledge and the level of SMPSA which consists of thirteen attributes that use symbols with (A_1-A_{13}), teachers' perspectives on SMPSA which consists of seven attributes represented as (A_{14}-A_{20}) as well as needs for the development of alternative assessment models denoted as (A_{21}-A_{26}) which consist of six attributes. The questionnaire was randomly distributed to secondary school Mathematics Teachers in Pasir Gudang, Johor, Malaysia where the total number of respondents was 53 teachers. The respondents involved are male and female teachers who teach mathematics subjects and can make choices and decisions based on their respective experiences. The list of attributes for this survey is presented in Table 1 below.

Table 1. The attributes of the survey towards teachers' knowledge and the level of SMPSA, teachers' perspectives about SMPSA and needs for the development of an alternative assessment model

Elements	Attributes	Statement
Teachers' knowledge and the level of SMPSA	A_1	What is your level of knowledge about SMPSA?
	A_2	What is the level of importance of SMPSA in mathematics learning?
	A_3	What is the level of strength of the relationship between SMPSA and students' ways and thinking processes?
	A_4	What is the level of student motivation towards solving mathematics problems?
	A_5	What is the level of student interest in solving mathematics problems?
	A_6	What is the level of a student's ability to understand mathematics problems?
	A_7	What is the level of student's mastery of mathematics concepts in solving problems?
	A_8	What is the level of implementation of students' mathematics operations in solving problems?
	A_9	What is the level of the student's ability in writing and showing

Elements	Attributes	Statement
		solutions?
	A_{10}	What is the level of the student's ability to re-evaluate the solution?
	A_{11}	What is the level of student memory for solving mathematics problems?
	A_{12}	What is the level of proficiency of students in solving mathematics problems?
	A_{13}	What is the level of student's ability to coordinate their way of thinking when solving problems?
Teachers' perspectives on SMPSA	A_{14}	SMPSA determines the success of learning mathematics
	A_{15}	Teachers need to have an understanding of SMPSA
	A_{16}	SMPSA is determined by the student's way and thinking process
	A_{17}	SMPSA assessment needs to be more frequent
	A_{18}	Conventional approaches are less effective at measuring the real level of SMPSA.
	A_{19}	Assessing SMPSA using mathematics formulas is more accurate
	A_{20}	Computerized analysis can help assessment of SMPSA more accurately
Needs for the development of alternative assessment model	A_{21}	Teachers need to assess SMPSA more often
	A_{22}	Teachers need to increase their knowledge about solving mathematics problems
	A_{23}	Teachers need to increase their knowledge of SMPSA assessment methods
	A_{24}	Mathematics methods or formulations are required to assess SMPSA
	A_{25}	More accurate factors or attributes are needed to assess SMPSA
	A_{26}	Need a more practical and flexible method for assessing SMPSA

In this study, the fuzzy set used to represent the linguistic values of the Likert Scale is defined as V_j where *j* = 1, 2, 3, 4, 5, 6, 7. Table 2 shows the fuzzy set consisting of three survey goals which are based on level, agreement and necessary.

Table 2. The membership function of linguistic values in triangular fuzzy numbers form

	Linguistic values		**Rating**	**Triangular fuzzy number**
Extremely poor	Very strongly disagree	Extremely unnecessary	1	(0.0, 0.0, 0.1)
Very poor	Strongly disagree	Strongly unnecessary	2	(0.0, 0.1, 0.3)
Poor	Disagree	Unnecessary	3	(0.1, 0.3, 0.5)
Neither good or poor	Neutral	Neutral	4	(0.3, 0.5, 0.7)
Good	Agree	Necessary	5	(0.5, 0.7, 0.9)
Very good	Strongly agree	Strongly Necessary	6	(0.7, 0.9, 1.0)
Excellent	Very strongly agree	Very strongly Necessary	7	(0.9, 1.0, 1.0)

In this study, 26 attributes need to be considered. The procedure for this method is detailed as follows:

Step 1: Collect the teachers' responses for each attribute A_i.

Step 2: Calculate the weight for each attribute w_{ij} by using Equation (7).

Step 3: Calculate the overall membership function of attribute $\tilde{A}_i$ using Equation (8).

Step 4: Find the similarity degree between two set which is set $\tilde{A}_i$ and set V_j which *j* refer to linguistics value, *j* = 1, 2, 3, 4, 5, 6, 7 by using Equation (9).

Step 5: Choose the highest similarity degree.

Step 6: Propose the rank for each group's specifications and justification of model development needs is determined.

Results

The number of responses, r_{ij} concerning linguistic values, V_j on the attributes A_i are as presented in Table 3.

Table 3. The frequency of respondents' preferences based on linguistic values

Elements	Attributes	V_1	V_2	V_3	V_4	V_5	V_6	V_7	Total
Teachers' knowledge and the level of SMPSA	A_1	5	8	12	14	10	3	1	53
	A_2	2	2	2	4	19	14	10	53
	A_3	2	0	8	8	11	17	7	53
	A_4	3	14	15	14	5	2	0	53
	A_5	7	12	17	10	4	3	0	53
	A_6	6	13	11	15	5	3	0	53
	A_7	8	11	14	11	7	2	0	53
	A_8	6	6	17	14	8	2	0	53
	A_9	2	9	19	14	5	4	0	53
	A_{10}	3	18	15	9	4	4	0	53
	A_{11}	7	10	14	17	1	4	0	53
	A_{12}	6	12	15	14	4	2	0	53
	A_{13}	6	11	19	12	3	2	0	53
Teachers' perspectives on SMPSA	A_{14}	0	1	1	6	9	14	22	53
	A_{15}	3	0	3	12	7	16	12	53
	A_{16}	0	0	0	10	14	15	14	53
	A_{17}	0	1	1	15	17	8	11	53
	A_{18}	1	3	8	15	10	11	5	53
	A_{19}	1	1	0	21	13	11	6	53
	A_{20}	0	1	4	14	18	12	4	53
Needs for the development of alternative assessment model	A_{21}	0	0	0	8	17	16	12	53
	A_{22}	0	0	1	3	8	21	20	53
	A_{23}	0	0	0	10	8	17	18	53
	A_{24}	0	0	4	9	17	8	15	53
	A_{25}	0	0	5	7	14	11	16	53
	A_{26}	0	0	2	13	9	16	13	53

Next, Table 4 shows a list of each weight, w_{ij} for all attributes, A_i which has been calculated using the Equation (7).

Table 4. The weight w_{ij} for attribute A_i related to linguistic values, V_j

Elements	Attributes	V_1	V_2	V_3	V_4	V_5	V_6	V_7
Teachers' knowledge and the level of SMPSA	A_1	0.0943	0.1509	0.2264	0.2642	0.1887	0.0566	0.0189
	A_2	0.0377	0.0377	0.0377	0.0755	0.3585	0.2642	0.1887
	A_3	0.0377	0	0.1509	0.1509	0.2075	0.3208	0.1321
	A_4	0.0566	0.2642	0.2830	0.2642	0.0943	0.0377	0
	A_5	0.1321	0.2264	0.3208	0.1887	0.0755	0.0566	0
	A_6	0.1132	0.2453	0.2075	0.2830	0.0943	0.0566	0
	A_7	0.1509	0.2075	0.2642	0.2075	0.1321	0.0377	0
	A_8	0.1132	0.1132	0.3208	0.2642	0.1510	0.0377	0
	A_9	0.0377	0.1698	0.3585	0.2642	0.0943	0.0755	0
	A_{10}	0.0566	0.3396	0.2830	0.1698	0.0755	0.0755	0
	A_{11}	0.1321	0.1887	0.2642	0.3208	0.0189	0.0755	0
	A_{12}	0.1132	0.2264	0.2830	0.2642	0.0755	0.0377	0
	A_{13}	0.1132	0.2075	0.3585	0.2264	0.0566	0.0377	0

Elements	Attributes	V_1	V_2	V_3	V_4	V_5	V_6	V_7
Teachers' perspectives on SMPSA	A_{14}	0	0.0189	0.0189	0.1132	0.1698	0.2642	0.4151
	A_{15}	0.0566	0	0.0566	0.2264	0.1321	0.3019	0.2264
	A_{16}	0	0	0	0.1887	0.2642	0.2830	0.2642
	A_{17}	0	0.0189	0.0189	0.2830	0.3208	0.1509	0.2075
	A_{18}	0.0189	0.0566	0.1509	0.2830	0.1887	0.2075	0.0943
	A_{19}	0.0189	0.0189	0	0.3962	0.2453	0.2075	0.1132
	A_{20}	0	0.0189	0.0755	0.2642	0.3396	0.2264	0.0755
Needs for the development of alternative assessment model	A_{21}	0	0	0	0.1509	0.3208	0.3019	0.2264
	A_{22}	0	0	0.0189	0.0566	0.1509	0.3962	0.3774
	A_{23}	0	0	0	0.1887	0.1509	0.3208	0.3396
	A_{24}	0	0	0.0755	0.1698	0.3208	0.1509	0.2830
	A_{25}	0	0	0.0943	0.1321	0.2642	0.2075	0.3019
	A_{26}	0	0	0.0377	0.2453	0.1698	0.3019	0.2453

Using Equation (8) overall membership function or aggregated TFNs for each A_i was obtained as indicated in Table 5 below.

Table 5. Overall membership functions of attribute A_i

Elements	Attributes	Overall membership function, A_i
Teachers' knowledge and the level of SMPSA	A_1	(0.248, 0.424, 0.616)
	A_2	(0.628, 0.792, 0.900)
	A_3	(0.556, 0.740, 0.868)
	A_4	(0.132, 0.284, 0.476)
	A_5	(0.120, 0.276, 0.468)
	A_6	(0.148, 0.312, 0.508)
	A_7	(0.160, 0.320, 0.508)
	A_8	(0.168, 0.332, 0.524)
	A_9	(0.172, 0.344, 0.536)
	A_{10}	(0.124, 0.276, 0.464)
	A_{11}	(0.164, 0.324, 0.512)
	A_{12}	(0.140, 0.304, 0.500)
	A_{13}	(0.116, 0.280, 0.476)
Teachers' perspectives on SMPSA	A_{14}	(0.664, 0.820, 0.908)
	A_{15}	(0.644, 0.808, 0.908)
	A_{16}	(0.652, 0.824, 0.936)
	A_{17}	(0.488, 0.672, 0.832)
	A_{18}	(0.620, 0.804, 0.936)
	A_{19}	(0.520, 0.704, 0.852)
	A_{20}	(0.636, 0.824, 0.952)
Needs for the development of alternative assessment model	A_{21}	(0.604, 0.784, 0.912)
	A_{22}	(0.732, 0.884, 0.956)
	A_{23}	(0.676, 0.844, 0.940)
	A_{24}	(0.612, 0.780, 0.900)
	A_{25}	(0.660, 0.820, 0.920)
	A_{26}	(0.620, 0.792, 0.904)

Then, the most critical process is to determine the similarity degree respectively using Equation (9) for the three elements that will be used as a basis for the justification of model development, namely teachers' knowledge and the level of SMPSA, teachers' perspectives on SMPSA and need for the development of alternative assessment model. Next, the similarity degree is ranked to identify each attribute according to the element. Table 6, Table 7 and Table 8, respectively, show the similarity degree and ranking of the attributes.

Teachers' Knowledge and the Level of SMPSA

Table 6 above shows that the range of similarity degree values is between 0.9236 to 0.9908. Attribute A_{12} has the highest similarity degree value of 0.9908 with a linguistic value of V_3 rating. While the lowest similarity degree value is for attribute A_2 the linguistic value rating is V_5. The high similarity degree value for most attributes is at the respective V_3 linguistic value rating, which is for attributes A_4-A_{13}.

Table 6. Similarity degree $S(\tilde{A}_i, V_j)$ for teachers' knowledge and the level of SMPSA element

TFN A_i	V_1	V_2	V_3	V_4	V_5	V_6	V_7	S_{max}	$V(S_{max})$	Rank
A_1	0.7092	0.7634	0.8876	0.9317	0.7853	0.6865	0.6424	0.9317	V_4	12
A_2	0.5663	0.6002	0.6745	0.7796	0.9236	0.9085	0.8329	0.9236	V_5	13
A_3	0.5834	0.6196	0.6990	0.8126	0.9702	0.8676	0.7983	0.9702	V_5	9
A_4	0.7849	0.8518	0.9908	0.8269	0.7096	0.6279	0.5908	0.9908	V_3	2
A_5	0.7903	0.8581	0.9823	0.8210	0.7052	0.6245	0.5878	0.9823	V_3	5
A_6	0.7688	0.8329	0.9830	0.8455	0.7232	0.6386	0.6002	0.9830	V_3	4
A_7	0.7645	0.8278	0.9759	0.8508	0.7271	0.6416	0.6029	0.9759	V_3	7
A_8	0.7576	0.8197	0.9646	0.8596	0.7335	0.6466	0.6073	0.9646	V_3	10
A_9	0.7515	0.8126	0.9548	0.8676	0.7393	0.6510	0.6112	0.9548	V_3	11
A_{10}	0.7903	0.8581	0.9823	0.8210	0.7052	0.6245	0.5878	0.9823	V_3	6
A_{11}	0.7622	0.8251	0.9721	0.8537	0.7292	0.6432	0.6044	0.9721	V_3	8
A_{12}	0.7736	0.8385	0.9908	0.8399	0.7191	0.6353	0.5974	0.9908	V_3	1
A_{13}	0.7882	0.8557	0.9855	0.8233	0.7069	0.6258	0.5889	0.9855	V_3	3

Teachers' perspectives on SMPSA

For this element, attribute A_{19} shows the highest value of similarity degree, 0.9980 while attribute A_{18} with a value of 0.9191 has the lowest value. While for the linguistic value, is only rated V_5 and V_6, which means that the respondents agree and strongly agree.

Table 7. Similarity degree $S(\tilde{A}_i, V_j)$ for teachers' perspectives about SMPSA element

TFN A_i	V_1	V_2	V_3	V_4	V_5	V_6	V_7	S_{max}	$V(S_{max})$	Rank
A_{14}	0.5580	0.5910	0.6628	0.7641	0.9020	0.9305	0.8513	0.9305	V_6	5
A_{15}	0.5616	0.5950	0.6679	0.7708	0.9113	0.9208	0.8432	0.9208	V_6	6
A_{16}	0.5564	0.5892	0.6605	0.7610	0.8977	0.9352	0.8552	0.9352	V_6	3
A_{17}	0.6056	0.6446	0.7310	0.8562	0.9690	0.8228	0.7603	0.9690	V_5	2
A_{18}	0.5622	0.5957	0.6687	0.7720	0.9130	0.9191	0.8418	0.9191	V_6	7
A_{19}	0.5948	0.6324	0.7153	0.8347	0.9980	0.8436	0.7780	0.9980	V_5	1
A_{20}	0.5564	0.5892	0.6605	0.7610	0.8977	0.9352	0.8552	0.9352	V_6	4

Needs for the Development of an Alternative Assessment Model

In Table 8 below, the highest similarity degree value is for attribute A_{22} with a value of 0.9875 which is in V_6 rating. The lowest value is for attribute A_{26} in the V_5 rating with a value of 0.9242. Next, the similarity degree value in descending order is for A_{23} (0.9512), A_{24} (0.9328), A_{25} (0.9317), and A_{21} (0.9300) respectively.

Table 8. Similarity degree $S(\tilde{A}_i, V_j)$ for needs for the development of alternative assessment model element

TFN A_i	V_1	V_2	V_3	V_4	V_5	V_6	V_7	S_{max}	$V(S_{max})$	Rank
A_{21}	0.5686	0.6029	0.6778	0.7841	0.9300	0.9025	0.8278	0.9300	V_5	5
A_{22}	0.5394	0.5701	0.6367	0.7296	0.8542	0.9875	0.8987	0.9875	V_6	1
A_{23}	0.5509	0.5830	0.6527	0.7508	0.8834	0.9512	0.8686	0.9512	V_6	2
A_{24}	0.5697	0.6041	0.6793	0.7862	0.9328	0.8998	0.8255	0.9328	V_5	3
A_{25}	0.5576	0.5906	0.6623	0.7634	0.9009	0.9317	0.8523	0.9317	V_6	4
A_{26}	0.5665	0.6005	0.6748	0.7800	0.9242	0.9080	0.8324	0.9242	V_5	6

Discussion

The tables above display the calculation results from the fuzzy conjoint model analysis using Microsoft Excel. In this study, the researcher introduced a procedure called the Fuzzy Conjoint Need Assessment Method (FCNAM) to determine the justification for the development of the students' mathematics problem-solving ability (SMPSA) measurement model. This study was carried out involving 53 mathematics teachers. Judgments and decisions made about the level of knowledge, gaps, and perspectives on mathematics problem-solving ability as well as the level of need for alternative models are used as a basis for model development. This procedure complies with the steps in need assessment recommended by Cuiccio and Husby-Slater [1], which is to analyze the level of knowledge and gaps, review perspectives and then get direct feedback from potential users or parties involved about the needs of the model. In the context of this study, the need is to develop a student's mathematics problem-solving ability (SMPSA) measurement model.

Attribute A_1-A_{13} is to review the level of knowledge and gaps in SMPSA. Attributes with the highest similarity degree value position are A_{12}, A_4, A_{13} and A_5 which are rated at the low level ($V3$). Each is related to the level of proficiency of students in solving mathematics problems, the level of student motivation towards solving mathematics problems, the level of student's ability to coordinate their way of thinking when solving problems and, the level of student interest in solving mathematics problems. This finding is consistent with previous research [34-36,39-41], which shows that motivational factors, ways of thinking (cognitive and metacognitive), and interest in the problem-solving process influence students' competence. This gap and factor can be used indirectly to calibrate mathematics problem-solving abilities.

Next, Table 7 which is the analysis of A_{14}-A_{20} shows the perspective of mathematics teachers towards SMPSA. Through the highest similarity degree values A_{19}, A_{17} and A_{16}, the teachers agree (rating of V_5) with the statement that assessing SMPSA using mathematics formulas is more accurate, SMPSA assessment needs to be more frequent and, SMPSA is determined by the student's way and thinking process. This indicates to the researcher that the measurement model to be developed should employ a mathematical formula capable of measuring the way and the student's thinking process when solving mathematics problems. SMPSA can be examined more frequently if this model is efficient and convenient.

Meanwhile, decision-making and judgments directly to the needs of alternative models are administered through attributes A_{21}-A_{26}. The results of the analysis show that attributes A_{22}, A_{23} and A_{24} obtained the highest similarity degree values at the rating positions of V_6 (very necessary) and V_5 (necessary) respectively. This shows that teachers must increase their knowledge about solving mathematics problems and assessment methods. In addition, it is also necessary to mathematics formulations to assess SMPSA. The position and difference of the similarity degree value are not only employed as a ranking in the context of fuzzy conjoint analysis, but the value also has other implications [46]. The similarity degree value in this study is greater than 0.9, indicating that the respondents' decisions are in compliance and equivalence. As a result, additional attributes can be employed as a secondary revelation in the justification process. Attributes A_{25} and A_{26}, for example, record a substantial similarity degree value, indicating the need for more accurate factors and practical methods in assessing SMPSA.

Overall, the introduced FCNAM approach can be used as a procedure in the justification of determining model development. Starting from confirming the existence of the problem (gap) being studied in the researcher's environment, evaluating the perspective or criteria of the model to be developed and then directly analyzing the opinion of whether it is necessary or not for the proposed model. This procedure is in line with the management and needs assessment guidelines as recommended by Gupta [7].

Conclusions

In conclusion, this study successfully demonstrated that the application of the fuzzy conjoint analysis method is suitable for use in a need assessment survey. This result illustrates the credibility of the combination of fuzzy conjoint and triangular fuzzy numbers as a very useful and flexible computerized analysis method. The justification process is to determine whether or not it is necessary to develop a model to be fairer and more efficient. It is hoped that this procedure will be a backup or alternative to the existing model development procedure. Further studies can also improve the consistency of this proposed procedure. Among the things that need to be emphasized is that the highlighted attributes must be the ones that correctly measure the "need" in the situation of the needs study being carried out. Rating linguistic values should also be varied, for example, using a scale of 3, a scale of 5, or a scale of

10. This study, on the other hand, presented an example of best practice using the fuzzy conjoint analysis method.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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