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Fuzzy Logic in Education: Profile of Students' Readiness to Prepare for Test-Based National Selection in Study Centers

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ABSTRACT

Test-Based National Selection demands students' readiness not only in material mastery, but also in critical thinking skills and high-level problem solving. Tutoring institutions have become a popular choice to improve students' readiness to face the selection, but evaluating students' readiness objectively and adaptively is still a challenge. This research develops a decision support system model based on Mamdani type fuzzy inference system to evaluate students' readiness for Test-Based National Selection. Two main indicators are used as linguistic input variables, namely study frequency and try out results. The modeling process is carried out qualitatively with the stages of fuzzification, IF-THEN rule base formulation, Mamdani inference, and defuzzification using the centroid method. Data is processed with the help of Microsoft Excel as a fuzzy logic processing tool. The results of the implementation on 30 students showed that the system was able to classify the level of readiness into three categories: not ready, moderately ready, and ready, with high precision and flexibility to data uncertainty. The findings suggest that fuzzy models can be used as adaptive and contextualized evaluation tools in tutoring environments, and support data-driven instructional decision-making.

Keyword: Fuzzy Logic, Fuzzy Inference System, Test-Based National Selection, Study Centers

1. Introduction

The entrance selection pathway in Indonesia has been regulated in the Regulation of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 48 of 2022 concerning Acceptance of New Students for Diploma Programs and Undergraduate Programs at State Universities. One of the pathways used nationally is the National Test-Based Selection. National Test-Based Selection is open to all graduates of SMA/MA/SMK or equivalent, including graduates of the previous year. Test-Based National Selection aims to provide fair and equal opportunities for all prospective students, with an objective, standardized, and intervention-free selection system. Test-Based National Selection demands not only mastery of subject matter, but also critical thinking skills and analytical abilities in facing the exam [1]. The varied and problem-solving-based question formats require careful preparation that goes far beyond mere memorization of concepts [2], [3]. Therefore, a systematic approach is needed to assess students' overall readiness.

In order to prepare for Test-Based National Selection, not a few students choose to join programs at tutoring institutions. This institution not only provides additional materials, but also provides a more intensive learning structure and rhythm [4]. Students with more frequent study frequency (more study sessions per week) showed improvements in knowledge retention and understanding, compared to participants who studied less frequently but longer per session [5]. With more frequent and systematic study intensity, students have the opportunity to better understand question patterns, deepen difficult concepts, and correct errors in solving problems.

In addition, regular try out programs held by tutoring institutions are a means of realistic exam simulation. Try outs provide a real picture of the real exam atmosphere, both in terms of the format of the questions, the level of difficulty, and the time limit for working [6]. Through try outs, students can measure their progress periodically, recognize the parts of the material that are still weak, and learn to manage time and emotional pressure while working on questions.

Several previous studies have highlighted the importance of tutoring and try outs as a strategy to improve readiness for national exams and college entrance selection [1]. However, most of these studies only examine program effectiveness from a qualitative or descriptive statistical perspective. There have not been many approaches that systematically integrate student readiness indicators into a fuzzy logic-based decision-making system. Therefore, the novelty of this research lies in the application of Mamdani fuzzy inference system to measure students' readiness for Test-Based National Selection based on concrete data, namely study frequency and try out results.

A fuzzy logic approach can be an effective solution to handle diversity and uncertainty in student readiness [7]. Fuzzy logic is different from binary logic, fuzzy logic allows assessment on a multilevel scale, not limited to ready or not ready categories only. Fuzzy logic was first initiated by Lofti A. Zadeh in 1965. Fuzzy logic is an extension of binary logic that only recognizes true (1) and false (0) values. Fuzzy logic allows for a truth value between the two poles. This concept is realized through fuzzy sets that aim to expand the scope of the characteristic function to include real numbers in the range of $0 - 1$.

The membership value in a fuzzy set indicates that an element in the universe of speech not only has a membership value of 0 or 1, but can also have a value between the two [9]. In other words, the degree of truth of an element is not limited to two absolute conditions, but is relative. A value of 0 expresses a false condition, a value of 1 expresses a true condition, and a value between the two indicates a certain degree of truth. In its application, the process of the fuzzy logic system can be done through three main approaches, namely the Tsukamoto method, the Mamdani method, and the Sugeno method [8].

In this research, fuzzy logic, especially the Mamdani method, is used to help the decision-making process related to student readiness. Values such as study frequency and try out results are processed into linguistic information, so as to classify students into the categories of not ready, moderately ready, or ready with a certain membership level $(0 - 1)$. This approach allows for a more flexible and adaptive assessment to students' real conditions.

From this description, it is important to develop a Mamdani fuzzy inference system model to evaluate student readiness for Test-Based National Selection. The focus is given on two main indicators, namely the frequency of learning and try-out results obtained by students during the study centers program.

2. Research Methodology

This research uses qualitative type with fuzzy inference system modikeling method. The research was conducted at one of the Tutoring Institutions in Batu City. In data processing, researchers used Microsoft Excel software by utilizing the IF-THEN logic formula. The fuzzy logic model applied is the Mamdani type using the maximum-minimum (*max-min*) composition method. For the defuzzification process, researchers used the centroid method, which is a technique that converts the fuzzy set into a crisp value output [8]. The stages of data analysis are visually presented in Figure 1 below.

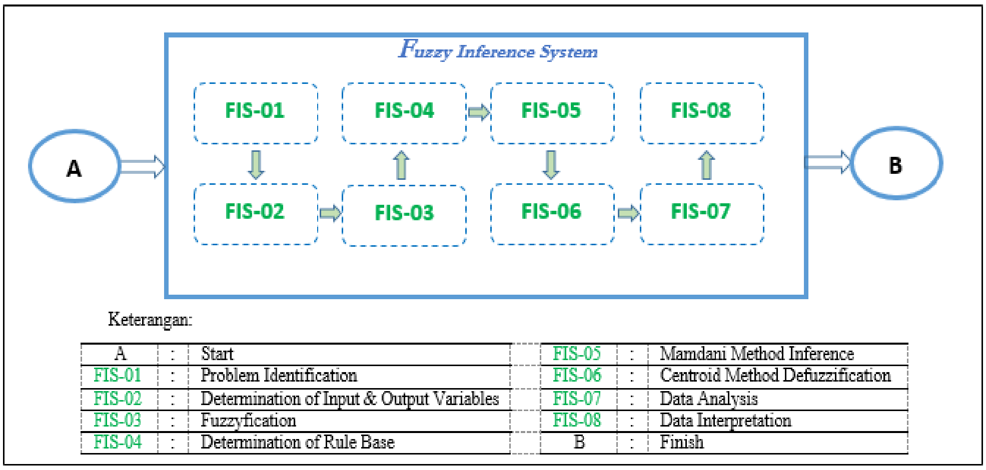


Figure 1. Process Fuzzy Inference System

It is the first part in scientific article. It comprises summary of the whole content of scientific article. Figure 1 illustrates the stages in applying a fuzzy inference system with the Mamdani model. The process starts from the problem identification stage, which is the initial step to formulate the problem to be solved through a fuzzy system. After the problem is formulated, the next stage is to determine the variables involved in the system, both as input and output. These variables become the basis for the fuzzification process and rule building.

Fuzzification is the process of converting crisp values from inputs into fuzzy values through membership functions. This stage allows the system to handle uncertainty and ambiguity in the input data. Next is fuzzy rule generation, which is the creation of IF-THEN logic-based rules that logically link input and output variables. In the inference stage, the system uses the Mamdani model to execute the fuzzy rules that have been designed previously. This process produces outputs in the form of fuzzy values obtained from the combination of input values and relevant rules.

Furthermore, the fuzzy output is converted to crisp through the defuzzification process. The defuzzification method used is the centroid method, which is by determining the center of mass point of the output fuzzy area. The final stage in this process is the analysis and interpretation of defuzzification results as a basis for decision-making or problem solving. This interpretation considers the context of the problem and the main objectives of the system being built.

3. Result and Discussion

The decision-making process for student readiness in facing Test-Based National Selection is carried out systematically through several steps. The initial stage includes determining linguistic variables, namely input and output variables, followed by a fuzzification process that converts numerical data into degrees of membership in fuzzy sets. Next, fuzzy rules are compiled based on the combination of inputs to form a rule base. These rules are processed using the Mamdani inference method to produce fuzzy outputs, then converted into final (crisp) values through defuzzification with the centroid method. The crisp value is the basis for deciding whether students are declared ready, moderately ready, or not ready to prepare for Test-Based National Selection.

3.1 Linguistik Variable

There are two linguistic variables that serve as inputs, namely learning frequency and average Try Out results. Meanwhile, the linguistic variable used as the output variable is the students' exam readiness in prepare for Test-Based National Selection. The value of the learning frequency variable is classified into three linguistic categories, namely rarely, fairly often, and often. The value of the average Try Out result variable is classified into three linguistic categories, namely low, middle, and high. In addition, the value of the exam readiness variable is classified into three categories, namely not ready, fairly ready, and ready

3.2 Membership Function

The input and output variable parameters are grouped into several domains using a membership function. The learning frequency variable is categorized into three: rarely (J), fairly often (CS), and often (S), with a value range of 0 to 48. The tryout results are also divided into three categories: low (R), medium (S), and high (T), with a range of 0 to 700. The exam readiness variable is classified into not ready (TS), fairly ready (CS), and ready (S), with a range of 0 to 1. The membership functions for each category are shown in Table 1.

Table 1. Fuzzy Set of Input and Output Variables

Fuction	**Variables**	**Linguistic Variables**	**Conversation Universe**
Input	Learning Frequency	Rarely	$[0 - 48]$
		Fairly often	
		Often	
	Try Out	Low	$[0 - 700]$
		Medium	
		High	
Output	Exam Readiness	Not ready	$[0 - 1]$
		Fairly ready	
		Ready	

3.3 Fuzzifikasi

Fuzzification is the initial stage in a fuzzy logic system that converts numerical data (crisp values) in input variables into fuzzy sets using membership functions (Saatchi, 2024). This process is important because fuzzy systems operate based on membership degrees, not exact values. In this stage, learning frequency values and tryout results are mapped to membership ranges between 0 and 1. The results of this fuzzification serve as the basis for rule formulation and inference processes in determining exam readiness.

3.3.1 Fuzzyfication of Learning Frequency (LF)

$LF_{(J)} = \mu_1 = (0,0,18,30)$

$LF_{(CS)} = \mu_2 = (12,22,34,44)$

$LF_{(S)} = \mu_3 = (26,36,48,48)$

The representation of the Learning Frequency membership function in graph form is presented in Figure 2 below.

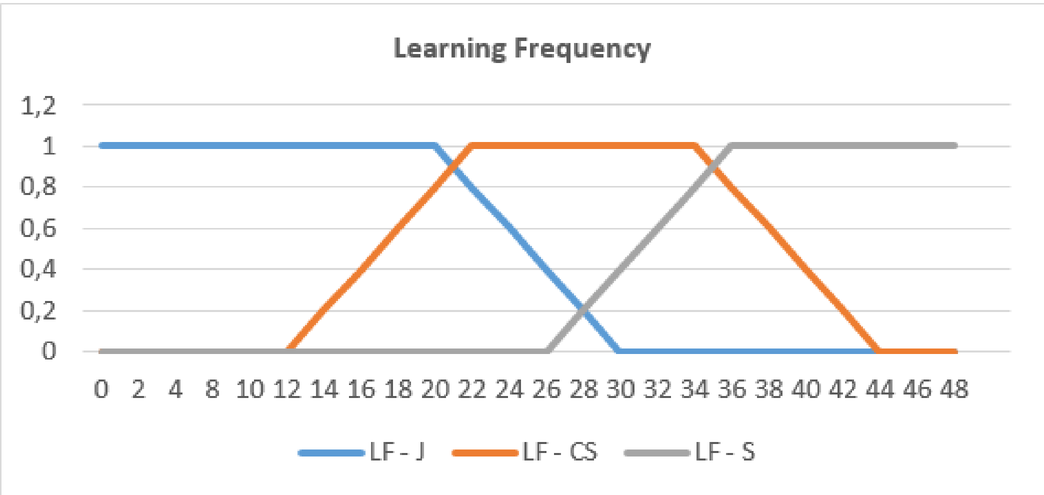


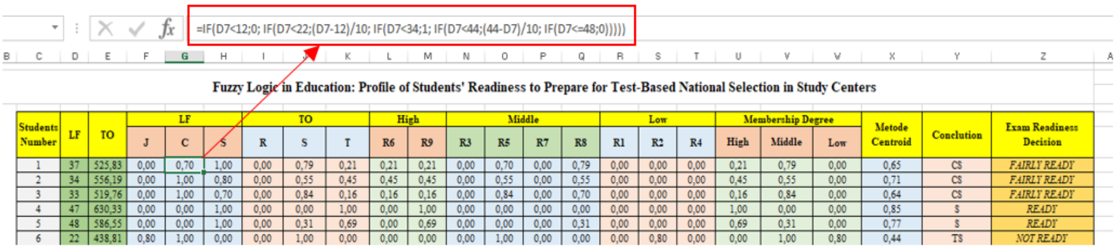
Figure 2. Representation of Learning Frequency Membership Function

$$\mu_J(x) = \begin{cases} 1 & if\ 0 \le x < 20 \\ \frac{-x+30}{10} & if\ 20 \le x < 30 \\ 0 & if\ 30 \le x \le 48 \end{cases}$$

$$\mu_{CS}(x) = \begin{cases} 0 & if\ 0 \le x < 12 \\ \frac{x-12}{10} & if\ 12 \le x < 22 \\ 1 & if\ 22 \le x < 34 \\ \frac{-x+44}{10} & if\ 34 \le x < 44 \\ 0 & if\ 44 \le x \le 48 \end{cases}$$

$$\mu_S(x) = \begin{cases} 0 & if\ 0 \le x < 26 \\ \frac{x-26}{10} & if\ 26 \le x < 36 \\ 1 & if\ 36 \le x \le 48 \end{cases}$$

To determine the degree of membership, the Learning Frequency is presented in Figure 3 below.


=IF(D7<12;0; IF(D7<22;(D7-12)/10; IF(D7<34;1; IF(D7<44;(44-D7)/10; IF(D7<=48;0)))))

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Students Number	LF	TO	LF			TO			High		Middle				Low			Membership Degree			Metode Centroid	Conclution	Exam Readiness Decision
			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	FAIRLY READY
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	FAIRLY READY
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	FAIRLY READY
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	READY
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	READY
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	NOT READY

Figure 3. Level of Membership Learning Frequency

The formulas in Excel are presented in the following Table 2.

Table 2. Excel Formula for Learning Frequency (LF) Degree

Category	**Excel Formula**
$LF_{(J)}$	=IF(D7<20;1;IF(D7<30;((-D7+30)/10);0))
$LF_{(CS)}$	=IF(D7<12;0; IF(D7<22;(D7-12)/10; IF(D7<34;1; IF(D7<44;(44-D7)/10; IF(D7<=48;0)))))
$LF_{(S)}$	=IF(D7>=36;1; IF(D7<26;0; IF(D7<36;(D7-26)/10)))

3.3.2 Fuzzyfikasi of Try Out (TO)

$TO_{(R)} = \mu_1 = (0, 0, 300, 425)$

$TO_{(S)} = \mu_2 = (300, 425, 500, 625)$

$TO_{(T)} = \mu_3 = (500, 625, 700)$

The representation of the membership function of the Try Out results in graph form is presented in Figure 4 below.

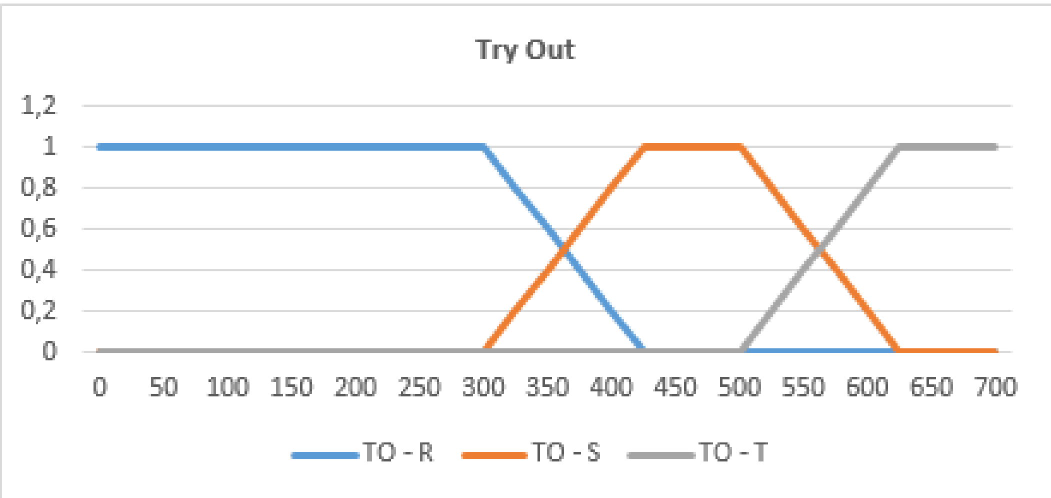

Figure 4. Representation of membership function Try Out Results

$$\mu_R(x) = \begin{cases} 1 & if\ 0 \le x < 300 \\ \frac{-x+425}{125} & if\ 300 \le x < 425 \\ 0 & if\ 425 \le x \le 700 \end{cases}$$

$$\mu_S(x) = \begin{cases} 0 & if\ 0 \le x < 300 \\ \frac{x-300}{125} & if\ 300 \le x < 425 \\ 1 & if\ 425 \le x < 500 \\ \frac{-x+625}{125} & if\ 500 \le x < 625 \\ 0 & if\ 625 \le x \le 700 \end{cases}$$

$$\mu_T(x) = \begin{cases} 0 & if\ 0 \le x < 500 \\ \frac{x-500}{125} & if\ 500 \le x < 625 \\ 1 & if\ 625 \le x \le 700 \end{cases}$$

To determine the degree of membership, the Try Out is presented in Figure 5 below.

=IF(E7<300;0; IF(E7<425;(E7-300)/125; IF(E7<500;1; IF(E7<625;(625-E7)/125; IF(E7<=700;0)))))

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Students Number	LF	TO	LF			TO			High		Middle				Low			Membership Degree			Metode Centroid	Conclution	Exam Readiness Decision
			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	*FAIRLY READY*
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	*FAIRLY READY*
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	*FAIRLY READY*
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	*READY*
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	*READY*
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	*NOT READY*

Figure 5. Try Out Membership Levels

The formulas in Excel are presented in the following Table 3 below.

Table 3. Excel Formula for Try Out (TO) Results

Category	Excel Formula
$TO_{(R)}$	=IF(E7<300;1; IF(E7<425;(-E7+425)/125; IF(E7<=700;0)))
$TO_{(S)}$	=IF(E7<300;0; IF(E7<425;(E7-300)/125; IF(E7<500;1; IF(E7<625;(625-E7)/125; IF(E7<=700;0)))))
$TO_{(T)}$	=IF(E7<500;0; IF(E7<625;(E7-500)/125; IF(E7<=700;1)))

3.3.3 *Fuzzyfikasi of Exam Readiness (ER)*

$ER_{(TS)} = \mu_1 = (0, 0, 0.4, 0.5)$

$ER_{(CS)} = \mu_2 = (0.4, 0.5, 0.7, 0.8)$

$ER_{(S)} = \mu_3 = (0.7, 0.8, 1, 1)$

The representation of the membership function of the exam readiness results in graph form is presented in Figure 6 below.

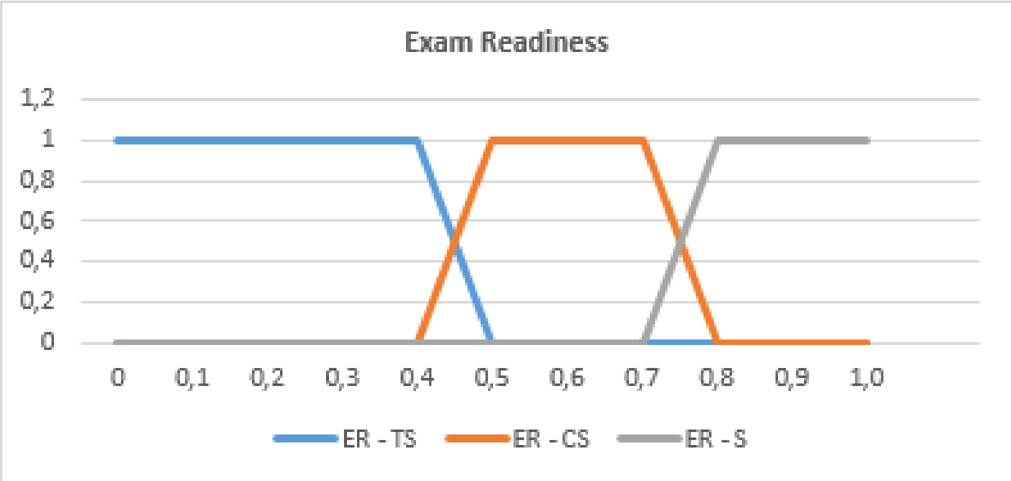

Figure 6. Representation of the membership function of exam readiness results

$$\mu_{TS}(x) = \begin{cases} 1 & if\ 0 \le x < 0{,}4 \\ \frac{-x+0{,}5}{0{,}1} & if\ 0{,}4 \le x < 0{,}5 \\ 0 & if\ 0{,}5 \le x \le 1 \end{cases}$$

$$\mu_{CS}(x) = \begin{cases} 0 & if\ 0 \le x < 0{,}4 \\ \frac{x-0{,}4}{0{,}1} & if\ 0{,}4 \le x < 0{,}5 \\ 1 & if\ 0{,}5 \le x < 0{,}7 \\ \frac{-x+0.8}{0{,}1} & if\ 0{,}7 \le x < 0{,}8 \\ 0 & if\ 0{,}8 \le x \le 1 \end{cases}$$

$$\mu_{S}(x) = \begin{cases} 0 & if\ 0 \le x < 0{,}7 \\ \frac{x-0{,}7}{0{,}1} & if\ 0{,}7 \le x < 0{,}8 \\ 1 & if\ 0{,}8 \le x \le 1 \end{cases}$$

3.4 Rule Base

The rule base is a key component in fuzzy logic-based decision-making systems. In it, the relationship between input and output variables is formulated in the form of *IF-THEN* statements. This system uses two inputs, namely learning frequency (rarely, fairly often, often) and tryout results (low, medium, high). Meanwhile, the output, which is the level of exam readiness, is classified into three categories: not ready, fairly ready, and ready. The rule base for student preparation for the Test-Based National Selection exam is presented in Table 4 below.

Table 4. Rule Base

No	Input		Rule Code	Output	Exam Readiness Decision	Symbol
	LF	TO		ER		
1	J	R	J-R	TS	Not Ready	R1
2	J	S	J-S	TS	Not Ready	R2
3	J	T	J-T	CS	Fairly Ready	R3
4	C	R	C-R	TS	Not Ready	R4
5	C	S	C-S	TS	Not Ready	R5
6	C	T	C-T	T	Ready	R6
7	S	R	S-R	CS	Fairly Ready	R7
8	S	S	S-S	CS	Fairly Ready	R8
9	S	T	S-T	T	Ready	R9

3.5 Inferensi

The determination of student exam readiness in this system uses the Mamdani fuzzy inference approach. The Mamdani method allows decision-making based on linguistic rules while considering uncertainty (Pujaru et al., 2024). In the process, the minimum (min) operator is used to express AND logic in the premise section, and the maximum (max) operator is used to combine the results of several applicable rules.

The system evaluates all rules in the rule base, calculates the minimum value of the membership degree for each condition, and uses it as a reference to determine how much influence the rule has on the fuzzy output. The minimum principle is used as the basis for calculation, as shown in Figure 7.

=MIN(G7;J7)

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			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	*FAIRLY READY*
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	*FAIRLY READY*
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	*FAIRLY READY*
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	*READY*
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	*READY*
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	*NOT READY*

Figure 7. Aggregation Process (Minimum)

After evaluating all the rules, the system performs an aggregation process using the maximum operator, which takes the highest membership value from all the fuzzy outputs generated. The result is a new fuzzy set representing the students' readiness level for the exam, based on the membership degrees in the categories ‘not ready’, ‘fairly ready’, and ‘ready’ according to the rule base. An example of the formula's application in Excel is shown in Figure 8.

=MAX(N7:Q7)

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			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	*FAIRLY READY*
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	*FAIRLY READY*
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	*FAIRLY READY*
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	*READY*
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	*READY*
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	*NOT READY*

Figure 8. Aggregation Process (Maximum)

The inference process forms the basis for the next stage, defuzzification, which aims to convert fuzzy outputs into crisp values as the final result of the system's decision.

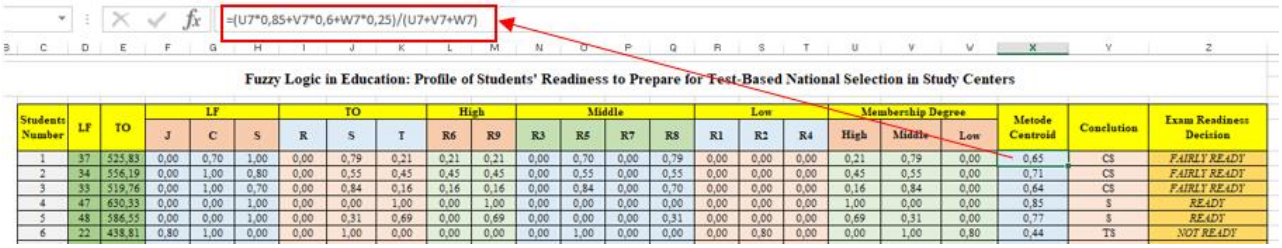
3.6 Defuzzifikasi

Defuzzification is the stage that converts linguistic fuzzy outputs containing uncertainty into crisp values for real decision making (Peckol, 2021). In this system, the output variable indicates the level of student readiness for an exam, classified into three categories: not ready, sufficiently ready, and ready. Decision outcomes are determined using the centroid method, which involves calculating the center point of the fuzzy area resulting from the aggregation of all rules. This center point is obtained through the integration of the output membership function and produces a numerical value as the basis for the final decision. Calculations can use:

Centroid method formula : $\boldsymbol{z} = \frac{\int \boldsymbol{\mu(z) z\, dz}}{\int \boldsymbol{\mu(z)\, dz}}$

or excel formula : $= (U7 * 1 + V7 * 0{,}5 + W7 * 0)/(U7 + V7 + W7)$

As shown in Figure 9 below.


=(U7*0,85+V7*0,6+W7*0,25)/(U7+V7+W7)

Fuzzy Logic in Education: Profile of Students' Readiness to Prepare for Test-Based National Selection in Study Centers

Students Number	LF	TO	LF			TO			High		Middle				Low			Membership Degree			Metode Centroid	Conclution	Exam Readiness Decision
			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	FAIRLY READY
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	FAIRLY READY
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	FAIRLY READY
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	READY
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	READY
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	NOT READY

Figure 9. Results of the Centroid Method

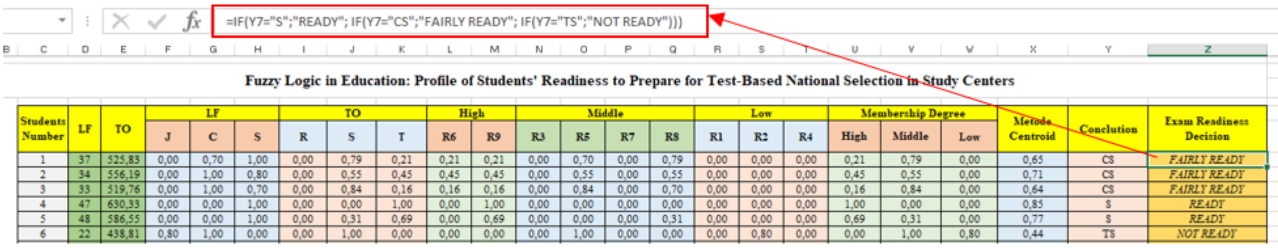
The defuzzification results using the centroid method produce systematic decisions on the level of student readiness for exams, namely: not ready, fairly ready, or ready. The centroid values for each category are shown in Table 5 below.

Table 5. Table of Student Readiness Categories Based on Centroid Values

Centroid value	Conclusion	Exam Readiness Decision
$0 \leq x < 0,5$	TS	Not Ready
$0,5 \leq x < 0,75$	CS	Fairly Ready
$0,75 \leq x \leq 1$	S	Ready

Using formula excel: $= IF(Y7 = "S"; "READY"; \ IF(Y7 = "CS"; "FAIRLY\ READY"; \ IF(Y7 = "TS"; "NOT\ READY")))$

As shown in Figure 10 below.


=IF(Y7="S";"READY"; IF(Y7="CS";"FAIRLY READY"; IF(Y7="TS";"NOT READY")))

Fuzzy Logic in Education: Profile of Students' Readiness to Prepare for Test-Based National Selection in Study Centers

Students Number	LF	TO	LF			TO			High		Middle				Low			Membership Degree			Metode Centroid	Conclution	Exam Readiness Decision
			J	C	S	R	S	T	R6	R9	R3	R5	R7	R8	R1	R2	R4	High	Middle	Low			
1	37	525,83	0,00	0,70	1,00	0,00	0,79	0,21	0,21	0,21	0,00	0,70	0,00	0,79	0,00	0,00	0,00	0,21	0,79	0,00	0,65	CS	FAIRLY READY
2	34	556,19	0,00	1,00	0,80	0,00	0,55	0,45	0,45	0,45	0,00	0,55	0,00	0,55	0,00	0,00	0,00	0,45	0,55	0,00	0,71	CS	FAIRLY READY
3	33	519,76	0,00	1,00	0,70	0,00	0,84	0,16	0,16	0,16	0,00	0,84	0,00	0,70	0,00	0,00	0,00	0,16	0,84	0,00	0,64	CS	FAIRLY READY
4	47	630,33	0,00	0,00	1,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,85	S	READY
5	48	586,55	0,00	0,00	1,00	0,00	0,31	0,69	0,00	0,69	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,69	0,31	0,00	0,77	S	READY
6	22	438,81	0,80	1,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,80	0,00	0,00	1,00	0,80	0,44	TS	NOT READY

Figure 10**.** Results of the Exam Readiness Decision

3.7 Analysis and Implementation for Other Students

The fuzzy theory was implemented on 30 other students. Data from these students was analyzed to draw conclusions about their level of readiness for the exam. The analysis process began by entering two main variables, namely learning frequency (FB) and tryout results (TO). The values of these two variables became the basis for decision-making regarding student exam readiness. The results of the analysis of the implementation on these students are presented in Table 6 below.

Table 6. Data Analysis and Implementation for Other Students

Student Number	FB	TO	Membership Degree			Metode Centroid	Exam Readiness Decision
			High	Middle	Low		
1	37	525,83	0,21	0,79	0,00	0,65	*FAIRLY READY*
2	34	556,19	0,45	0,55	0,00	0,71	*FAIRLY READY*
3	33	519,76	0,16	0,84	0,00	0,64	*FAIRLY READY*
4	47	630,33	1,00	0,00	0,00	0,85	*SIAP*
5	48	586,55	0,69	0,31	0,00	0,77	*SIAP*
6	22	438,81	0,00	1,00	0,80	0,44	*NOT READY*
…..	…..	…..	…..	…..	…..	…..	…..
…..	…..	…..	…..	…..	…..	…..	…..

…..	…..	…..	…..	…..	…..	…..	.....
22	43	622,98	0,98	0,02	0,00	0,85	*READY*
23	43	550,12	0,40	0,60	0,00	0,70	*FAIRLY READY*
24	39	560,64	0,49	0,51	0,00	0,72	*FAIRLY READY*
25	48	685,83	1,00	0,00	0,00	0,85	*READY*
26	45	631,07	1,00	0,00	0,00	0,85	*READY*
27	38	545,48	0,36	0,64	0,00	0,69	*FAIRLY READY*
28	32	515,95	0,13	0,87	0,00	0,63	*FAIRLY READY*
29	27	444,88	0,00	1,00	0,30	0,52	*FAIRLY READY*
30	29	456,08	0,00	1,00	0,10	0,57	*FAIRLY READY*

Based on Table 6, each student is classified into one of three categories of exam readiness: not ready, sufficiently ready, or ready. The final decision for students deemed not ready for the exam includes 2 students, namely student numbers 6 and 15. There are 17 students classified as sufficiently prepared for the exam, namely student numbers 1, 2, 3, 7, 9, 11, 12, 13, 16, 17, 19, 23, 24, 27, 28, 29, and 30. Meanwhile, there are 11 students deemed ready for the exam, namely student numbers 4, 5, 8, 10, 14, 18, 20, 21, 22, 25, and 26.

The application of fuzzy logic in the context of education, particularly for profiling students' readiness for the Test-Based National Selection, provides a more flexible and adaptive approach compared to conventional assessment. Through the fuzzy system, classification can be based on membership degrees within linguistic categories determined by combinations of input values [10] such as not ready, fairly ready, and ready, which are determined based on combinations of input values such as study frequency and mock exam results.

The Mamdani inference approach is used to process linguistic rules, while the centroid method is applied to perform defuzzification, which is converting fuzzy outputs into definite values that can be used as the basis for final decision making [11]. Thus, this system enables a more objective, measurable, and contextual analysis of student readiness, which is highly relevant in a tutoring environment that faces diversity in student readiness levels.

4. Conclution

The fuzzy approach offers flexibility in decision making, including student exam readiness. With the application of fuzzy theory, it is hoped that it can help tutors in designing more adaptive lessons and provide information on student exam readiness in prepare for the Test-Based National Selection based on the frequency of learning and student tryout results.

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