

A FUZZY-BASED EXPERT SYSTEM FOR DETERMINANTS OF TEACHER PERFORMANCE

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Abstract

Performance is the level of success achieved by a person in carrying out their duties and responsibilities as well as their ability to achieve the goals and standards that have been set. Teachers' performance is evaluated on a regular basis at each school. Teacher performance evaluation is carried out to identify flaws in task execution and to gain an overview of the results to be achieved in the future. So far, teacher performance appraisal is done manually, which is very difficult and time-consuming and feels less objective. Therefore, a fuzzy-based assessment system needs to be designed so that it helps in making decisions more quickly, precisely, and objectively. Rules are designed and tested using the Mamdani fuzzy logic method, which is implemented through the Matlab Toolbox software. To produce a more accurate performance rating, more membership function output is needed so that a more accurate performance rating can be produced.

Keywords: *Expert System, Fuzzy Logic, Teacher Performance, Determinant*

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1. INTRODUCTION

Technological developments at this time have affected all aspects of human life and have had a positive influence on work productivity in companies, government offices, and educational institutions[1][2]. The school, as an institution engaged in the field of education, should be able to properly serve and provide the information needed by each individual. The teacher is one of the key elements in the education system in a school; therefore, the teacher's performance needs to be a concern. Teacher performance can be seen and measured based on competency specifications or criteria that must be possessed by each teacher. Teacher performance evaluation is still done manually, and the results are not objective.

Fuzzy logic is a branch of modern artificial intelligence, along with neural networks, genetic algorithms, and several other branches. Fuzzy logic has been applied to linear regression (Michael O'hagan). In the uncertainty predicted by Hesmaty and Kandel, knowledge represented in the fuzzy expert system is used by using linguistic variables, linguistic values, linguistic terms, membership functions, and fuzzy IF-THEN rules. Fuzzy logic (or vague logic)

itself is a logic that deals with the concept of partial truth, where classical logic states that everything can be expressed in binary terms (0 and 1)[3][4][5]. Fuzzy logic is considered capable of mapping an input into an output without ignoring the existing factors. The function of the fuzzy system is then used as a tool in decision-making. The fuzzy logic system can be used to determine teacher performance, which is supported by the MATLAB toolbox software[6][7]. With fuzzy logic, we can handle fuzzy sets such as low, medium, and high, which are very meaningful parts of sentences in everyday language. This system can handle precise and precise values, fuzzy values, and combined consideration types, and it allows for the free description of fuzzy and normal terms in rules and facts.

2. RESEARCH METHOD

2.1. Framework

In the research methodology, there is a sequence of frameworks that must be followed; this framework sequence is an illustration of the steps to be followed so that this research can run smoothly. The following framework is used:

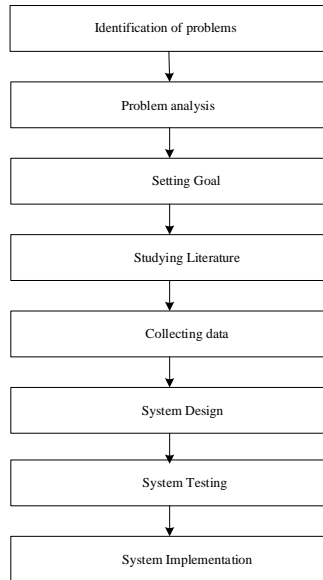


Figure 1. Research Framework[8]

2.2. System Overview

In determining the design of the system, there are 4 input variables, namely: pedagogic competence, professional competence, personality competence, and social competence, and 1 output variable, namely the performance variable. This can be seen in the following Figure:

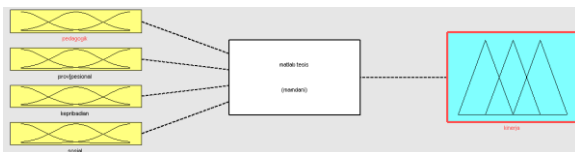


Figure 2. Input and output variables in the Mamdani method

2.3. System Analysis for Pedagogic Competency

Variables Pedagogic competency variables are average values of pedagogic variables such as: (1) understanding learning theory; (2) understanding students' potentials; (3) mastering how to apply ICT in learning; (4) designing comprehensive learning; and (5) assessing all students' progress. The value of the pedagogic competency variable is divided into 3 criteria, namely:

Table 1. A Fuzzy Set of Pedagogic Competency Variables

The universe of speech	The name of the set of fuzzy	Domain
0-100	Not enough	0-70
	Enough	50-90
	good	70-100

The membership function diagram for pedagogic competency variables can be seen in the following Figure:

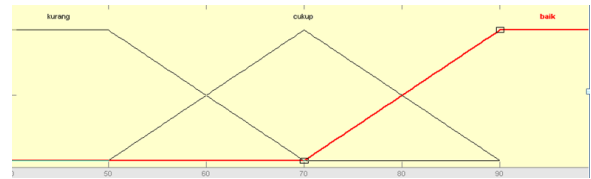


Figure 3. Membership function for Pedagogic Competency Variables

On the pedagogic competency variable, the data possessed can be divided into 3 fuzzy sets, namely, insufficient, sufficient, and good. The less fuzzy set will have the domain [0–70], with a lower degree of membership; the highest (=1) is located at 50. If the value of the pedagogic competency variable is more than 50, then the value is getting closer to sufficient. The left shoulder membership function represents the fuzzy set, and the membership function for the less set can be seen in the following equation:

$$\mu_{\text{not enough}} [X_1] = \begin{cases} 1; & X_1 \leq 50 \\ \frac{70 - X_1}{20}; & 50 \leq X_1 \leq 70 \\ 0; & X_1 \geq 70 \end{cases} \quad (1)$$

A sufficient fuzzy set will have a domain [50–90], with a sufficient degree of membership; the highest (= 1) is located at 70. If the value of the pedagogic competency variable exceeds 70, then the value is getting closer to "good." The fuzzy set is sufficiently represented by a triangular membership function, with the degree of membership getting better the closer the value is to 70. The membership function for a sufficient fuzzy set can be seen in the following equation:

$$\mu_{\text{enough}} [X_1] = \begin{cases} 0; & X_1 \leq 50 \text{ atau } X_1 \geq 90 \\ \frac{X_1 - 50}{20}; & 50 \leq X_1 \leq 70 \\ \frac{90 - X_1}{20}; & 70 \leq X_1 \leq 90 \end{cases} \quad (2)$$

A good fuzzy set will have a domain of [70–100], with the highest degree of good membership (= 1) located at [70–100]. If the value of the pedagogic competency variable is less than 90, then the value is getting closer to sufficient. The fuzzy set is well represented by the right-shoulder membership function. The membership function for a good fuzzy set can be seen in the following equation:

$$\mu_{\text{good}} [X_1] = \begin{cases} 0; & X_1 \leq 70 \\ \frac{X_1 - 70}{20}; & 70 \leq X_1 \leq 90 \\ 1; & X_1 \geq 90 \end{cases} \quad (3)$$

2.4. System Analysis for Professional Competency

Variables Professional competency variables are inputs that are the average value of professional variables, including: (1) the ability to master subject matter, which is an area of expertise; (2) the ability to master the learning resources needed in the learning process; (3) the ability to process learning resources from the environment so that they can be used to

support learning; (4) the ability to apply information technology in an effort to increase children's learning activities; and (5) the ability to prepare lesson plans that package content, media technology, and values in each learning process.

The value of the professional competency variable is divided into 3 criteria, namely:

Table 2. A Fuzzy Set of Professional Competency Variables

The universe of speech	The name of the set of fuzzy	Domain
0-100	Not enough	0-70
	Enough	50-90
	good	70-100

The membership function diagram for professional competency variables can be seen in the following Figure:

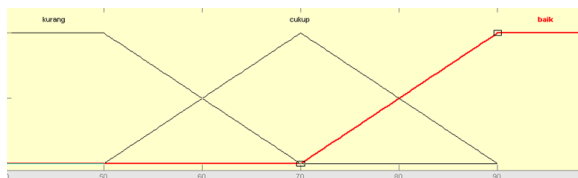


Figure 4. Membership Function for Professional Competency

Variables In the professional competence variable, the owned data can be divided into 3 fuzzy sets, namely, insufficient, sufficient, and good. Less fuzzy sets will have a domain of [0–70], with a lower degree of membership; the highest (= 1) is located at a value of 50. If the value of the professional competence variable is more than 50, then the value is getting closer to sufficient. The left shoulder membership function represents the fuzzy set, and the membership function for the less set can be seen in the following equation:

$$\mu_{not\ enough} [X_2] = \begin{cases} 1; X_2 \leq 50 \\ \frac{70 - X_2}{20}; 50 \leq X_2 \leq 70 \\ 0; X_2 \geq 70 \end{cases} \quad (4)$$

A sufficient fuzzy set will have a domain [50–90], with a sufficient degree of membership; the highest (=1) is located at 70. If the value of the professional competence variable exceeds 70, then the value is getting closer to "good." It is sufficient to represent the fuzzy set with a triangular membership function, with the degree of membership getting better the closer the value is to 70. The membership function for a sufficient fuzzy set can be seen in the following equation:

$$\mu_{enough} [X_2] = \begin{cases} 0; X_2 \leq 50 \text{ atau } X_2 \geq 90 \\ \frac{X_2 - 50}{20}; 50 \leq X_2 \leq 70 \\ \frac{90 - X_2}{20}; 70 \leq X_2 \leq 90 \end{cases} \quad (5)$$

A good fuzzy set will have a domain [70–100] with a good membership degree; the highest (=

1) is located at 90–100. If the value of the professional competence variable is less than 90, then the value is getting closer to sufficient. The fuzzy set is well represented by the right-shoulder membership function. The membership function for a good fuzzy set can be seen in the following equation:

$$\mu_{good} [X_2] = \begin{cases} 0; X_2 \leq 70 \\ \frac{X_2 - 70}{20}; 70 \leq X_2 \leq 90 \\ 1; X_2 \geq 90 \end{cases} \quad (6)$$

2.5. System Analysis for Personality Competency

Variables Professional competency variables are inputs that are the average values of personality variables, such as: (1) the ability to have high commitment and willingness in carrying out their duties as professional teachers; (2) the ability to have compassion for students without discrimination; (3) the ability to have a strong sense of responsibility in carrying out its function as a teacher; and (4) the ability to have a strong sense of independence in carrying out its function as a teacher. having a noble character, and (5) having the ability to motivate students.

The value of the personality competency variable is divided into 3 criteria, namely:

Table 3. A Fuzzy Set of Personality Competency Variables

The universe of speech	The name of the set of fuzzy	Domain
0-100	Not enough	0-50
	Enough	25-75
	good	50-100

The membership function diagram for personality competency variables can be seen in the following Figure:

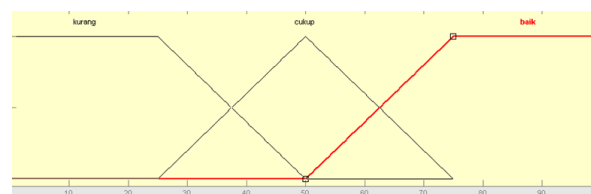


Figure 5. Membership function for personality competency

Variables In the personality competency variable, the data possessed can be divided into 3 fuzzy sets, namely, insufficient, sufficient, and good. The domain of the less fuzzy set will be [0-50], with the highest degree of less membership (=1) located at a value of 25. If the value of the personality competency variable is greater than 25, then the value is getting closer to being enough. The left shoulder membership function represents the fuzzy set, and the membership function for the less set can be seen in the following equation:

$$\mu_{not\ enough} [X_3] = \begin{cases} 1; X_3 \leq 25 \\ \frac{50 - X_3}{25}; 25 \leq X_3 \leq 50 \\ 0; X_3 \geq 50 \end{cases} \quad (7)$$

The sufficient fuzzy set will have the domain [25–75], with the highest degree of sufficient membership (=1) located at a value of 50. If the value of the personality competence variable exceeds 50, then the value is getting closer to "good." It is sufficient to represent the fuzzy set with a triangular membership function, with the degree of membership getting better the closer the value is to 50. The membership function for a sufficient fuzzy set can be seen in the following equation:

$$\mu_{enough} [X_3] = \begin{cases} 0; X_3 \leq 25 \text{ atau } X_3 \geq 75 \\ \frac{X_3 - 25}{25}; 25 \leq X_3 \leq 50 \\ \frac{75 - X_3}{25}; 50 \leq X_3 \leq 75 \end{cases} \quad (8)$$

A good fuzzy set will have a domain of [50–100], with the highest degree of good membership (= 1) located at a value of [75–100]. If the value of the personality competence variable is less than 75, then the value is getting closer to sufficient. The fuzzy set is well represented by the right-shoulder membership function. The membership function for a good fuzzy set can be seen in the following equation:

$$\mu_{good} [X_3] = \begin{cases} 0; X_3 \leq 50 \\ \frac{X_3 - 50}{25}; 50 \leq X_3 \leq 75 \\ 1; X_3 \geq 75 \end{cases} \quad (9)$$

2.6. Variable System Analysis for Social Competence

Social competency variables are inputs that are the average value of social variables, including: 1. Be able to understand various factors that influence the creation of a child's learning environment. 2. Understand various socio-cultural, social, and economic factors that influence the educational process of students. 3. Be able to understand the importance of the relationship between the school and parents and community leaders who influence the child's education process. 4. Can understand the norms and values that apply and are upheld by the community. 5. Be able to understand the approaches that apply in schools.

The value of the social competency variable is divided into 3 criteria, namely:

Table 4. A Fuzzy Set of Social Competency Variables

The universe of speech	The name of the set of fuzzy	Domain
0-100	Not enough	0-50
	Enough	25-75
	good	50-100

The membership function diagram for social competence variables can be seen in the following Figure:

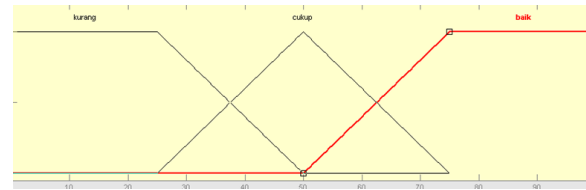


Figure 6. Membership function for Social Competency

Variables In the social competence variable, the owned data can be divided into 3 fuzzy sets, namely, insufficient, sufficient, and good. The domain of the less fuzzy set will be [0-50], with the highest degree of less membership (=1) located at a value of 25. If the value of the social competency variable is greater than 25, then the value is getting closer to being enough. The left shoulder membership function represents the fuzzy set, and the membership function for the less set can be seen in the following equation:

$$\mu_{not\ enough} [X_3] = \begin{cases} 1; X_3 \leq 25 \\ \frac{50 - X_3}{25}; 25 \leq X_3 \leq 50 \\ 0; X_3 \geq 50 \end{cases} \quad (10)$$

The sufficient fuzzy set will have the domain [25–75], with the highest sufficient degree of membership (= 1) located at 50. If the value of the social competence variable exceeds 50, then the value is getting closer to "good." It is sufficient to represent the fuzzy set with a triangular membership function, with the degree of membership getting better the closer the value is to 50. The membership function for a sufficient fuzzy set can be seen in the following equation:

$$\mu_{enough} [X_3] = \begin{cases} 0; X_3 \leq 25 \text{ atau } X_3 \geq 75 \\ \frac{X_3 - 25}{25}; 25 \leq X_3 \leq 50 \\ \frac{75 - X_3}{25}; 50 \leq X_3 \leq 75 \end{cases} \quad (11)$$

A good fuzzy set will have a domain of [50–100], with the highest degree of good membership (= 1) located at a value of [75–100]. If the value of the social competence variable is less than 75, then the value is getting closer to sufficient. The fuzzy set is well represented by the right-shoulder membership function. The membership function for a good fuzzy set can be seen in the following equation:

$$\mu_{good} [X_3] = \begin{cases} 0; X_3 \leq 50 \\ \frac{X_3 - 50}{25}; 50 \leq X_3 \leq 75 \\ 1; X_3 \geq 75 \end{cases} \quad (12)$$

2.7. System Analysis for Performance Variables

The performance variable is the output variable, which is the work of a teacher provided by the school, namely the principal and his staff or the teacher performance appraisal team. In this study, the value of teacher performance variables was divided into 3 criteria, namely:

Table 5. Fuzzy Set of Performance Variables

The universe of speech	The name of the set of fuzzy	domain
0-100	Not enough	0-70
	Enough	50-90
	good	70-100

The membership function diagram for performance variables can be seen in the following Figure:

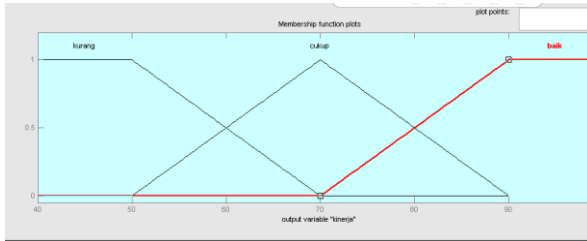


Figure 7. Performance Variables Membership Function

3. RESULT AND DISCUSSION

3.1. Fuzzy System Implementation

In building the system implementation, there are four input variables, namely pedagogic competency variables, professional competence variables, personality competency variables, and social competency variables, and one output variable, namely performance variables. This can be seen in Figure 10 below:

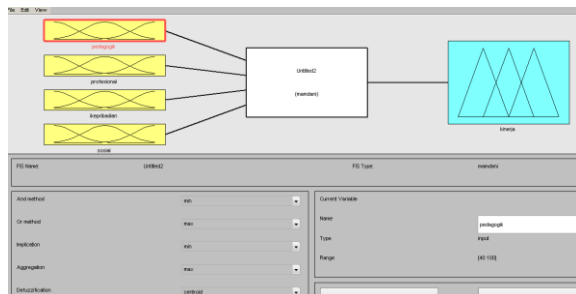


Figure 10. Fuzzy Parameters in Matlab

3.2. Implementation of the Formation of Fuzzy Sets

Next, a fuzzy set will be formed for each input and output parameter.

1. Pedagogic Competency Variables

The Pedagogic Variable is the input variable, which is the average value of the Pedagogic Competency variable. The value of pedagogic variables is divided into 3 criteria, namely: lack, enough, and good. The division of these criteria can be seen in Figure 11 below:

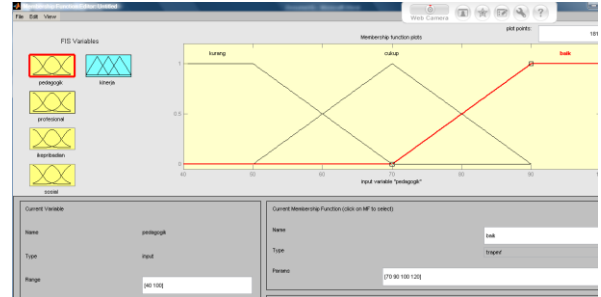


Figure 11. Fuzzy Set for Pedagogic Competency Variables

2. Professional Competency Variables

Professional Variable is an input variable that is the average value of the Professional Competency variable. The value of the professional variable is divided into 3 criteria, namely, less, enough, and good. The division of these criteria can be seen in Figure 12 below:

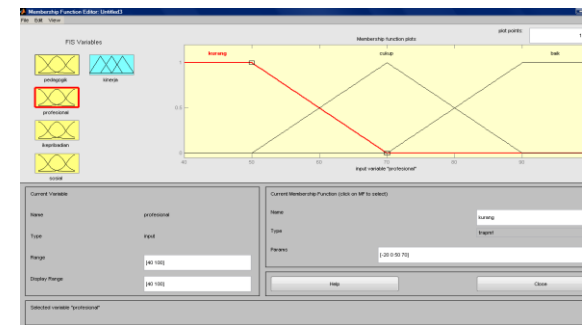


Figure 12. Fuzzy Set for Professional Competency Variables

3. Personality Competency Variables

The personality variable is the input variable, which is the average value of the personality competency variable. The value of the personality variable is divided into 3 criteria, namely: lack, enough, and good. The division of these criteria can be seen in Figure 5.4 below:

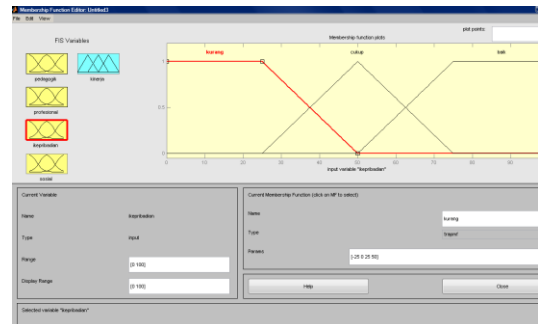


Figure 13. Fuzzy Set for Personality Competency Variables

4. Social Competency Variables

Social variables are input variables that are the average values of the social competency variables. The value of the social variable is divided into 3 criteria, namely, less, enough, and good. The division of these criteria can be seen in Figure 14 below:

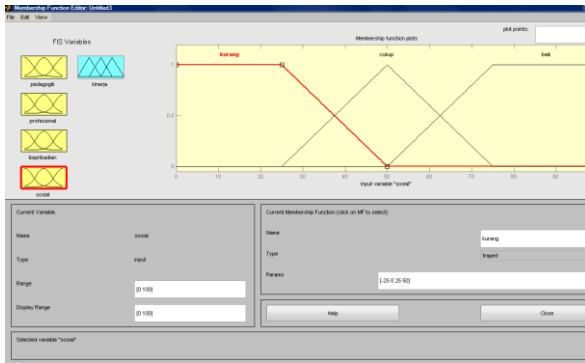


Figure 14. Fuzzy Set for Social Competency Variables

5. Performance Variables

The performance variable is the output variable, which is the variable that determines the performance of a teacher. Performance scores are divided into 7 criteria, namely: very poor, poor, less, enough, very enough, good, and very good. The membership function diagram for performance variables can be seen in Figure 15 below:

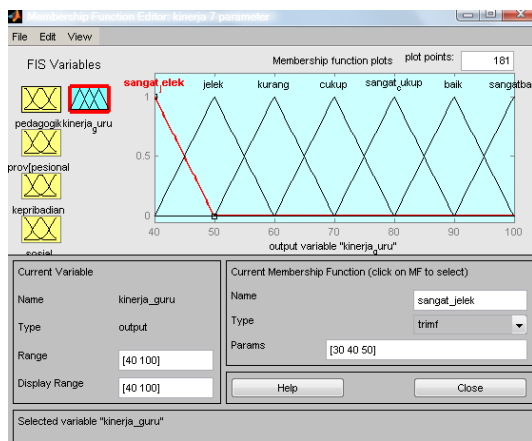


Figure 15. Fuzzy Sets for Performance Variables

The definition of a fuzzy set of performance variables in Matlab can be seen in the following description:

```
[Output1]
Name='teacher_performance'
Range=[40 100]
NumMFs=7
MF1='very_bad':trimf,[30 40 50]
MF2='bad':trimf,[40 50 60]
MF3='less':trimf,[50 60 70]
MF4='enough':trimf,[60 70 80]
MF5='very_enough':trimf,[70 80 90]
MF6='good':trimf,[80 90 100]
MF7='very good':trimf,[90 100 110]
```

6. Implementation of the Implication Function

In the Mamdani method, the implication function used for each rule is the min function, and the operator used is and, as shown below:

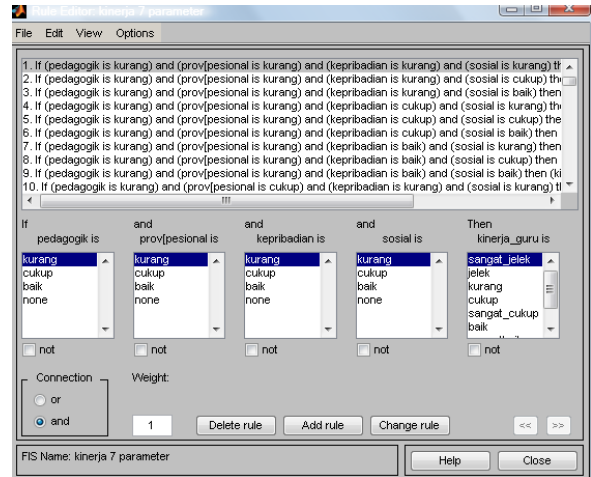


Figure 16. (Rule Editor): If Then Rule Matrix Process

From the picture above, it can be seen that the rules are designed, and the results will be obtained as follows: If the pedagogy is less and less professional and has less personality and is less social, then the performance is very poor.

7. System Testing

For the system that has been built, it is necessary to carry out system testing. At this testing stage, the value of membership function 3 and the value of membership function 7 have been taken, so the result is that the value of membership function 7 will be more accurate than the value of membership function 3, because the value of membership function 7 will not have mutually exclusive values. overlapping. In this test, there are 7 membership functions assigned to the performance output, namely: very poor, bad, less, enough, very enough, good, and very good. Input pedagogic competency (x_1) = 67, professional competency (x_2) = 77, personality competency (x_3) = 73, and social competency (x_4) = 86. The actual performance output is sufficient. Before making inferences, first look for the degree of membership in the value of each variable in each set by using a predetermined equation.

$$\begin{aligned} \mu_{(enough)}[67] &= 0,85 \\ \mu_{(good)}[67] &= 0 \\ \mu_{(notenough)}[77] &= 0 \\ \mu_{(enough)}[77] &= 0,65 \\ \mu_{(good)}[77] &= 0,35 \\ \mu_{(notenough)}[73] &= 0 \\ \mu_{(enough)}[73] &= 0,08 \\ \mu_{(good)}[73] &= 0,92 \\ \mu_{(notenough)}[86] &= 0 \\ \mu_{(enough)}[86] &= 0 \\ \mu_{(good)}[86] &= 1 \end{aligned}$$

-predicates that are not equal to zero lie in the rules.

By using the defuzzy weighted average method, the teacher's performance is as follows:

$$Z = \frac{\alpha_{18}Z_{18} + \alpha_{24}Z_{24} + \alpha_{27}Z_{27} + \alpha_{42}Z_{42} + \alpha_{51}Z_{51} + \alpha_{54}Z_{54}}{\alpha_{18} + \alpha_{24} + \alpha_{27} + \alpha_{42} + \alpha_{51} + \alpha_{54}}$$

$$Z = \frac{(0,15)(70) + (0,08)(70) + (0,15)(80) + (0,08)(70) + (0,08)(80) + (0,35)(90)}{0,15 + 0,08 + 0,15 + 0,08 + 0,08 + 0,35}$$

$$Z = \frac{71,6}{0,89}$$

$$Z = 80,44 \tag{13}$$

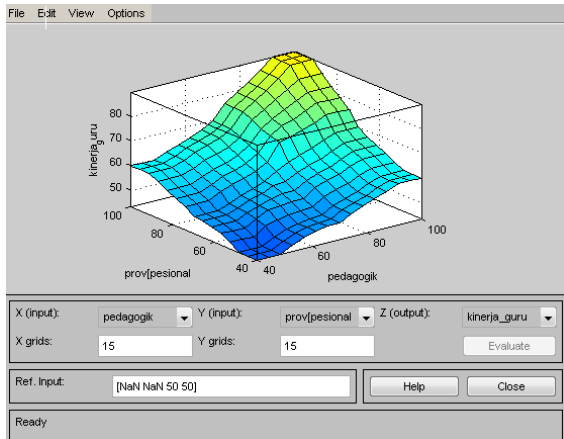


Figure 18: Surface Rule Display (Surface Viewer) From Performance

4. CONCLUSION

From the research that has been done, some conclusions can be drawn as follows: In the use of the Fuzzy Method it is more effective and efficient to use in determining teacher performance which is more objective, precise, fast and efficient. The rules used in the fuzzy system are adjusted to the software used and the needs of the school as well as the rules that apply at the government level. If the number of membership functions is greater, the results obtained will be more valid because there are no overlapping values, resulting in a more accurate assessment. more precise and accurate. In order to develop the system in the future, the use of a fuzzy system in determining teacher performance will produce better output if it uses input variables other than pedagogic competence, professional competence, personal competence and social competence. For those who wish to do further research, they can develop it into more complex applications, this research is only limited to a fuzzy-based system design that helps in the process of assessing teacher performance and can be developed by making specific programs, so there are still many ideas that can be further developed to be implemented into more specific programs for the future.

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