Decision Support System for Major Selection in Higher Education for Multimedia Graduate Students using Fuzzy Mamdani Logic

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ABSTRACT

Students at the vocational high school level are indeed prepared to be able to work directly, but it does not rule out the possibility that vocational high school students can continue higher education such as universities. However, the problem that will be faced again if students who graduate from vocational high schools choose to continue their education in college is what major they will take. One of the vocational high school majors, namely Multimedia, has a wide scope, so grade 3 vocational high school students who want to go to college have a dilemma in deciding on a major. Decision Support System for Major Selection by using certain methods, one using fuzzy logic Mamdani and applied with Matlab. This study is based on 5 input parameters, namely Computer and Basic Networking(KJD), Graphic Design for Printing(DGP), Basic Graphic Design(DDG), Audio-Visual Techniques(TAV), and Animation(Animasi). There are outputs of 5 majors in Computer Engineering (Teknik Komputer), Visual Communication Design(DKV), Animation(Animasi), TV and Film(TV dan Film), and Photography(Fotografi). The results taken from a sample of students at SMK Negeri 7 Yogyakarta with the highest score data in the Animation will appear with a recommendation score of 79.8 in the Animation department, and on the highest student score data on the Computer and Basic Networking, a recommendation score of 79.8 will appear in the Computer Engineering. The results of this research can make it easier and provide support for grade 3 vocational high school students, especially the Multimedia department in choosing a major in higher education.

Keywords: Decision Support System, College Major, Fuzzy Mamdani.

INTRODUCTION

Decree of the Minister of National Education the Republic Indonesia No.129a/U/2004 Chapter IV Article 4 paragraph 2 concerning Minimum Service Standards (SPM), 20% of vocational school graduates must continue to college. Based on this decision, vocational school graduate students can choose to continue their studies or look for work[1]. The choice of vocational school graduates to continue their education at tertiary institutions is not accompanied by readiness and stability in determining what college and major they will take so vocational school graduates feel confused when choosing various majors and various areas of expertise in college[2].

Before deciding to continue studying in college, it's a good idea for third-grade vocational high school students to reflect on whether they are suitable for the major they are engaged in and on their interests and talents[3]. One of the vocational high school majors, namely Multimedia, has a very wide scope of knowledge. From the first grade, it has been taught computer-related, basic design. In the second grade taught photography and animation, and in the third grade taught audio-video techniques and other productive subjects. In the SMK curriculum structure majoring in multimedia, these five subjects are productive subjects that must be mastered.

The development of technology has triggered many people to solve problems using information systems[4]. A decision support system is an application of an information system that helps make decisions on a problem[5]. Many previous studies have created decision support systems to help humans determine solution options for a problem.

Purba et al, in their research, created a Decision Support System (DSS) using the

Process Network Analysis (ANP) approach and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to give weight to selection criteria and calculate the ranking of new employees, with the hope of increasing. objectivity and efficiency in the process of accepting new employees in the company[6]. Putra et al, in their research, created a Decision Support System that uses the Preferences Selection Index (PSI) method to select the best employees at CV. Adiguna. This research aims to increase the objectivity of employee assessments and efficiency in giving awards, by processing performance evaluations based on 5 criteria set by CV Adiguna management[7]. Akmaludin et al, in their research, created a Decision Support System for Smartphone Selection with AHP-VIKOR Method Recommendations. The method used is a combination of the Analytic Hierarchy Process (AHP) and the VIKOR elimination method by considering eleven assessment criteria, such as Operating System, Processor, Internal Memory, Camera, Battery, and others. This research aims to increase user knowledge in choosing a Smartphone with various features and functions[8]. González et al, in their research, created a Decision Support System (DSS) developed as part of the S4AllCities project, which is designed to be integrated with legacy systems in Smart Cities. This research aims to implement a pedestrian and vehicle evacuation system in an urban environment, with predictive models to anticipate arson and shooting attacks, as well as probabilities for threat assessment in cases of improvised explosive devices[9]. These four studies demonstrate the importance of Decision Support Systems (DSS) in different contexts. In general, the four studies emphasize the importance of DSS in increasing user efficiency, objectivity, and knowledge in making decisions in various contexts, from employee recruitment and smartphone selection to urban security.

In decision support systems, a suitable method to use is fuzzy logic because this approach is more adaptive with a defuzzification stage so that the data output is easy to understand[10]. Fuzzy logic was developed by imitating the way humans think which often works with the principle of "approximately", this is different from Boolean logic which only recognizes two states of yes/no, and true/false, fuzzy logic allows modification of these states by level/degree certain conditions to allow conditions such as true, somewhat true, not quite true, somewhat false, and wrong[11]. A fuzzy system is modeled with steps: compiling fuzzy sets and membership functions, creating fuzzy rules (rule base), and defuzzification[12].

This research applies the fuzzy logic of the Mamdani method to help make decisions about majors in college for third-grade vocational high school students majoring in multimedia. Mamdani's Fuzzy logic is the most frequently used reasoning method for fuzzy logic control [13]. The Mamdani Fuzzy logic is employed to express human estimations or hunches[5], [14], [15]. Fuzzy Mamdani is also known for its max-min method introduced by Ebrahim Mamdani in 1975[16].The Mamdani method has the advantage of being more intuitive and simple[17].

Vitianingsih et al, in their research, create a Decision Support System using the Fuzzy Logic method. The goal is to help users determine the selling price of used computers based on specifications and length of use. In a comparison between Fuzzy Mamdani and Sugeno, Fuzzy Mamdani is more recommended because it has higher accuracy, and provides benefits in buying and selling used computers, especially assembled computers[18]. Borrero et al, in their research, created a Crowdfunding Decision Support System: Fuzzy Cognitive Maps Approach. Using the Fuzzy Cognitive Maps (FCM) method to design Decision Support System (DSS) guidelines in the crowdfunding realm. The process consists of three phases (ten steps), focusing on FCM construction, creation of FCM-based scenarios, and finally establishment of DSS guidelines in crowdfunding. This research aims to provide a useful tool for crowdfunding promoters,

financiers, and project managers by utilizing an FCM-based DSS[19]. Widodo et al, in their research, created a Decision Support System that uses the Fuzzy Multiple Attribute Decision Making Algorithm to provide recommendations for selecting monitor speakers on a Digital Audio Workstation (DAW). The method used involves consideration of price criteria, frequency response, design, and output power of the monitor speaker. The main aim of this research is to provide support to DAW users in making the right decision in choosing monitor speakers by utilizing an application that produces accurate and relevant recommendations according to their needs[20]. Novita et al, in their research, created a Decision Support System using the Fuzzy Mamdani Method in Analyzing Cholesterol Levels. This research uses the Fuzzy Mamdani method to analyze cholesterol levels with a simulation approach using Matlab software. This research aims to understand the influence of obesity and blood pressure on the risk of cholesterol disease and to apply the Fuzzy Mamdani method in calculating cholesterol levels as an analysis and prediction effort[21]. The Decision Support System with the Fuzzy method in the four studies was favored for several reasons. Fuzzy Logic can handle uncertainty and ambiguity in data, provide flexibility in knowledge representation, and process information more humanely. Other advantages include the ability to model non-linear relationships, as well as adaptability to environmental conditions and complex parameters. In the case of determining the selling price of a used computer, selecting a SmartPhone, selecting a monitor speaker, and analyzing cholesterol levels, Fuzzy Logic provides more adaptive and relevant recommendations, making it the recommended choice in building a Decision Support System.

In this research, the results from fuzzy Mamdani will be displayed using the Matlab GUI. Matlab is an abbreviation for matrix laboratory, which was first introduced by the University of New Mexico and the University of Stanford in 1970. Matlab is a program used to analyze and calculate numerically using an advanced mathematical programming language[22]. Matlab uses a matrix-based mathematical programming language so it is generally used to analyze data, create algorithms, and create modeling and applications. Matlab has functions that can be used as a solver program ranging from simple problems to complex problems from various scientific disciplines[23]. Currently, Matlab's capabilities and features are much more complete with the addition of an extraordinary toolbox [24]. One of the Matlab toolboxes is the Fuzzy Logic Toolbox which provides Simulink functions, applications, and blocks for analyzing, designing, and simulating fuzzy logic systems. This product allows you to define and configure inputs, outputs, membership functions, and rules of fuzzy inference systems.

Research on decision support systems using the fuzzy Mamdani method and the Matlab GUI has been researched and reported by Casal-Guisande et al with the title Design and Development of an Intelligent Clinical Decision Support System Applied Towards the Diagnosis of Suspected Obstructive Sleep Apnea Patients from the Patient's Health Profile and Symptomatology [25]. Liku et al with the title The implementation of Mamdani fuzzy logic in determining student concentration in Computer Engineering program [26]. Aditya Pratama et al with the title Utilizing Mamdani's Fuzzy Logic Method in Determining the Best Location for Coffee Shop Sales Using Matlab [27]. In this research, the decision support system uses the fuzzy logic Mamdani method and will be displayed using the Matlab GUI is expected to make it easier and can provide support for third-grade vocational high school students, especially multimedia majors in choosing majors in higher education-based on abilities that have been documented in the skill scores in the report card.

METHODS

This study is based on 5 input parameters, namely Computer and Basic Networking (KJD),

Graphic Design for Printing (DGP), Basic Graphic Design (DDG), Audio-Visual Techniques (TAV), and Animation (Animasi). There are outputs of 5 majors in Computer Engineering (Teknik Komputer), Visual Communication Design (DKV), Animation (Animasi), TV and Film (TV dan Film), and Photography (Fotografi). The five subjects used as input are productive subjects that must be mastered by vocational school graduates majoring in multimedia. The five majors designated as output are college majors that suit the expertise of each subject.

The data sample for this research is students of SMK N 7 Yogyakarta majoring in multimedia for 2022/2023. The input data is processed using fuzzy Mamdani logic which is displayed with GUI Matlab so that it becomes output data for consideration in choosing a college major. This method uses fuzzy logic to determine decisions that correspond to the inputs given to the system. Mamdani's fuzzy method has several stages in carrying out the computational process, here are the stages:

A. Fuzzification Process: The fuzzification process is carried out by determining input variables and output variables. Continued by determining the range of criteria values of each variable. Then the set and degree of membership.

B. Implication function: This implication process on fuzzy mamdani uses the min function.

C. Inference: The inference process is carried out by creating fuzzy rules that connect the input with the output created. These rules are usually written in the form of if-then.

D. Defuzzification: This process aims to transform fuzzy decisions generated into numerical values that can be understood by the system. At this stage, the system uses one of the defuzzification methods, such as the centroid method or the mean of the maximum method, to convert fuzzy decisions into numerical values that can be used by the system. The centroid method is one of the popular defuzzification methods used in fuzzy control systems. This method calculates the centroid value of the area formed by the fuzzy output membership function. This centroid value is then used as the defuzzification value generated by the fuzzy control system. To calculate the centroid value, we first need to determine the boundaries of the area formed by the fuzzy output membership function. Then, we can use the formula shown in equation (1):

$$z = (\frac{\sum (a \; x \; b)}{\sum b} \qquad (1)$$

a: the lower bound value of each interval
b : the value of the fuzzy output membership function at that interval

E. After passing through all these stages, the fuzzy control system will produce decisions that correspond to the inputs displayed in the form of a GUI from Matlab. Matlab is an application that is very useful for performing mathematical calculations, data analysis, simulations, and graphing. One of the features available in Matlab is fuzzy calculations.

F. After making a computational process with the fuzzy Mamdani method on Matlab, a calculation will be carried out to check using a case example of the scores taken by vocational high school students in SMK N 7 Yogyakarta majoring in multimedia for 2022/2023.

RESULT AND DISCUSSION

A. *Fuzzification Process*

The calculation process using fuzzy Mamdani is obtained from a predetermined range of criteria values. This study is based on 5 input parameters, namely Computer and Basic Networking (KJD), Graphic Design for Printing (DGP), Basic Graphic Design (DDG), Audio-Visual Techniques (TAV), and Animation (Animasi). There are outputs of 5 majors in Computer Engineering (Teknik Komputer),

Visual Communication Design (DKV), Animation (Animasi), TV and Film (TV dan Film), and Photography (Fotografi). The input and output parameters are shown in Figure 1.
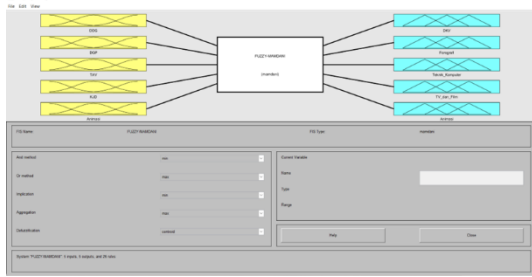

Figure 1. Input and output parameters

After determining the input and output variables the the range of kriteria values used can be seen in Table 1:

Table 1. Range of criteria values

Function	Variable	Value Range
Input	Nilai DDG(Basic Graphic Design)	[0-100]
	Nilai DGP	
	Nilai KJD	
	Nilai TAV	
	Nilai Animasi	
Output	Animasi	[0-100]
	TV dan Film	
	DKV	
	Fotografi	
	Teknik Komputer	

After determining the range of values, the fuzzy set can be determined.

1. Set Input
   Set inputs are shown in Table 2 and Figure 3.

Table 2. Set Input

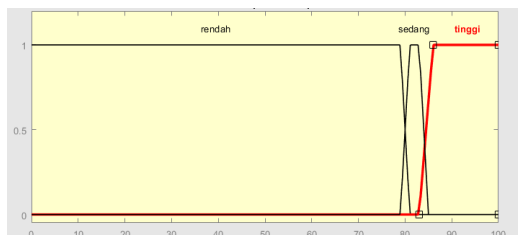| Set Name	Interval	Fuzzy Set
Rendah(Low)	0-79	0-79
Sedang(Medium)	79-81	79-85
Tinggi(High)	83-100	86-100

Figure 2. Fuzzy set

2. Degree of Membership of the input variable
- Input membership degree "rendah" (Low), is shown in equation 2.

$$\mu\ rendah\ [x] = \{0;\ \frac{81-x}{81-79};\ 1;\ x \geq 81\ 79 < x < 81\ x \leq 79$$

(2)

- Input membership degree "sedang" (Medium), is shown in equation 3.

$$\mu\ sedang\ [x] = \{0;\ \frac{x-79}{82-79};\ 1;\ x \leq 79\ or\ x \leq 85\ 79 < x < 82\ 82 < x < 85$$

(3)

- Input membership degree "tinggi"(High) is shown in equation 4.

$$\mu\ tinggi\ [x] = \{0;\ \frac{x-82}{86-82};\ 1;\ x \leq 82\ 82 < x < 86\ x \geq 86$$

(4)

3. Set Output
   The Set Output is shown in Table 3 and Figure 4.

Table 3. Set output

Range	Set Name	Domain
0-100	**Tidak direkomendasikan (Not recommend)**	0-50
	Direkomendasikan (recommend)	70-100
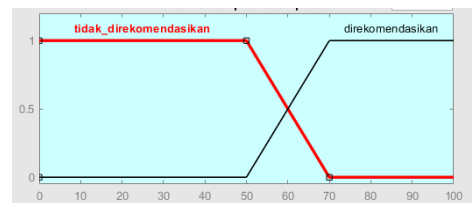
Figure 3. Set Input

4. Degree of Membership of the output variable
   - Output membership degree "tidak direkomendasikan"(not recommend), is shown in equation 5.

$$\mu\ tidak\ direkomendasikan\ [x] = \{0;\ \frac{x-50}{70-50};\ 1;\ x \geq 70\ 50 < x < 70\ x \geq 50$$ (5)

   - Output membership degree "direkomendasikan"(recommend), is shown in equation 6.

$$\mu\ direkomendasikan\ [x] = \{0;\ \frac{70-x}{70-50};\ 1;\ x \leq 50\ 50 < x < 70\ x \geq 70$$ (6)

B. *Inference System*

The inference process on Mamdani's fuzzy, is carried out after determining the input variables and membership functions, followed

by determining the fuzzy rules that will be used to determine decisions. The fuzzy rule consists of a number of premises and conclusions expressed in the form of fuzzy. A premise is a condition that must be met, while a conclusion is a decision made based on a met premise. Here is the rule/rule collection in the form of an if-then statement used shown in Table 4:

Table 4. Rule

No	Jurusan	DDG	DGP	TAV	KJD	Animasi
1	DKV	Tinggi	Rendah	Rendah	Rendah	Rendah
2	DKV	Tinggi	Sedang	Sedang	Sedang	Sedang
3	DKV	Tinggi	Tinggi	Rendah	Rendah	Rendah
4	DKV	Tinggi	Tinggi	Sedang	Sedang	Sedang
5	DKV	Sedang	Sedang	Rendah	Rendah	Rendah
6	DKV	Sedang	Sedang	Rendah	Rendah	Sedang
7	Fotografi	Rendah	Tinggi	Rendah	Rendah	Rendah
8	Fotografi	Sedang	Tinggi	Sedang	Sedang	Sedang
9	Fotografi	Rendah	Tinggi	Tinggi	Rendah	Rendah
10	Fotografi	Sedang	Tinggi	Tinggi	Sedang	Sedang
11	Fotografi	Rendah	Sedang	Sedang	Rendah	Rendah
12	Fotografi	Sedang	Sedang	Sedang	Rendah	Rendah
13	TV dan Film	Rendah	Rendah	Tinggi	Rendah	Rendah
14	TV dan Film	Sedang	Sedang	Tinggi	Sedang	Sedang
15	TV dan Film	Rendah	Rendah	Tinggi	Rendah	Tinggi
16	TV dan Film	Sedang	Sedang	Tinggi	Sedang	Tinggi
17	TV dan Film	Rendah	Rendah	Sedang	Rendah	Sedang
18	TV dan Film	Rendah	Sedang	Sedang	Rendah	Sedang
19	Teknik Komputer	Rendah	Rendah	Rendah	Tinggi	Rendah
20	Teknik Komputer	Sedang	Sedang	Sedang	Tinggi	Sedang
21	Animasi	Rendah	Rendah	Rendah	Rendah	Tinggi
22	Animasi	Sedang	Sedang	Sedang	Sedang	Tinggi
23	Animasi	Tinggi	Rendah	Rendah	Rendah	Tinggi
24	Animasi	Tinggi	Sedang	Sedang	Sedang	Tinggi
25	Animasi	Sedang	Rendah	Sedang	Rendah	Sedang
26	Animasi	Sedang	Rendah	Rendah	Rendah	Sedang

After determining the rule with the if-then statement, the following are the results of the Rule created in the Matlab application is shown in figure 4 and 5.
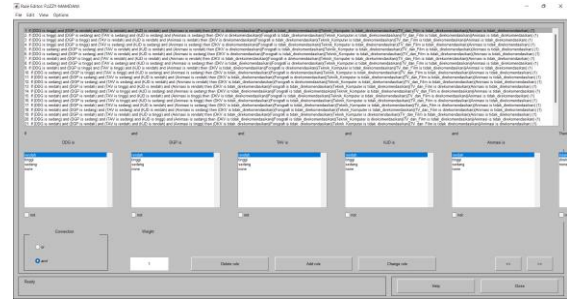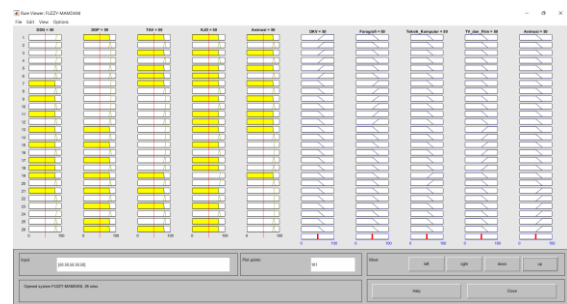

Figure 4. Rule

Figure 5. Result of rule

C. Defuzzifikasi

Defuzzification is the process of converting a fuzzy value into a non-fuzzy numerical value. Defuzzification is often used in fuzzy control systems to turn decisions made by fuzzy control systems into concrete actions that can be performed by the system. There are several defuzzification methods that can have their use, such as the centroid method, the mean of the maximum method, and the bisector of area method. Each method of defuzzification has its own advantages and disadvantages, and the selection of the right method depends on the conditions and needs of the application being worked on.

The centroid method is one of the popular defuzzification methods used in fuzzy control systems. This method calculates the centroid value of the area formed by the fuzzy output membership function. This centroid value is then used as the defuzzification value generated by the fuzzy control system. To calculate the centroid value, we first need to determine the boundaries of the area formed by the fuzzy output membership function. Then, we can use the formula shown in equation 7.

$$z = (\frac{\sum \quad (a \times b)}{\sum \quad b} \quad (7)$$

Where a is the lower limit value of each interval, b is the value of the fuzzy output membership function at that interval, and Σ is the summation operator. After calculating the centroid value, we can use it as the defuzzification value generated by the fuzzy control system. This centroid method has the advantage that it is easy to calculate and gives accurate results.

D. Creation of a GUI Decision Support System using Matlab

After finishing creating the fuzzy logic Mamdani rule on Matlab. So a GUI was created. A GUI (Graphical User Interface) is a user interface that uses graphical elements such as buttons, menus, and icons to facilitate user interaction with an application or system. In MATLAB, creating a GUI can use a tool called GUIDE (Graphical User Interface Development Environment). The decision support system applies the program code and interface, which are shown in Figures 6 and 7.

Figure 6. Program code

Figure 7. Interface

E. Substantiation with case examples and calculations

To prove that the making of fuzzy on this Matlab can function in accordance with fuzzy Mamdani, a calculation was made with one of the cases taken from the skill report card value of vocational high school students in Yogyakarta.

1. One of the third-grade students at a vocational high school in Yogyakarta is still confused in determining a major in higher education. The student has a skill score on the report card in the subjects of grade 10 to grade 12 is shown in Table 5.

Table 5. Report card 1

DDG	: 78
DGP	: 77
TAV	: 79
KJD	: 75
Animasi	: 90

The value is then entered into the system is shown in figure 8

Figure 8. Result 1

From the results of the calculation of the decision support system, the recommended major result is "**Animasi**". This is in accordance with rule number 21 that has been created.

[R21] IF (DDG IS Rendah) AND (DGP IS Rendah) AND (TAV IS Rendah) AND (KJD IS Rendah) AND (Animasi IS Tinggi) THEN (Animasi IS direkomendasikan)

α-predikat = μ[(DDG Rendah) ∩ (DGP Rendah) ∩ (TAV Rendah) ∩ (KJD Rendah) ∩ (Animasi Tinggi)]
= min [μDDG(78), μDGP(77), μTAV(79), μKJD(75), μAnimasi(90)

$$\mu(z) = \min [1 ; 1 ; 1 ; 1 ; 1]$$
$$= 1$$

$$\mu(z) = \max (1 ; 1 ; 1 ; 1 ; 1)$$
$$= 1$$
$$Z = \frac{(78 \ x \ 1)+(77 \ x \ 1)+(79 \ x \ 1)+(75 \ x \ 1)+(90 \ x \ 1)}{(1+1+1+1+1)}$$
$$= \frac{399}{5} = 79,8$$

2. One of the vocational high school graduates in Yogyakarta, namely alumni of three Multimedia students, has continued their studies at universities with a major in **Teknik Komputer**. The data on the student's report card value is shown in Table 6.

Table 6. Report card 2

DDG	: 79
DGP	: 76
TAV	: 78
KJD	: 88
Animasi	: 77

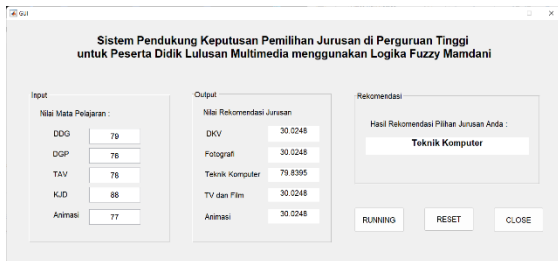The value is then entered into the system is shown in figure 9.

Figure 9. Result 2

From the results of the calculation of the decision support system, the recommended major result is "**Teknik Komputer**" in accordance with the major currently undertaken by the student and in accordance with rule number 19 that has been made.

[R19] IF (DDG IS Rendah) AND (DGP IS Rendah) AND (TAV IS Rendah) AND (KJD IS Tinggi) AND (Animasi IS Rendah) THEN (Teknik Komputer IS direkomendasikan)

α-predikat = μ[(DDG Rendah) $\cap$ (DGP Rendah) $\cap$ (TAV Rendah) $\cap$ (KJD Tinggi) $\cap$ (Animasi Rendah)]
= min [μDDG(79), μDGP(76), μTAV(78), μKJD(88), μAnimasi(77)
= min [1 ; 1 ; 1 ; 1 ; 1]
= 1

$$\mu(z) = \max (1 ; 1 ; 1 ; 1 ; 1)$$
$$= 1$$
$$Z = \frac{(79 \ x \ 1)+(76 \ x \ 1)+(78 \ x \ 1)+(88 \ x \ 1)+(77 \ x \ 1)}{(1+1+1+1+1)}$$
$$= \frac{399}{5} = 79,8$$

CONCLUSION

From the creation of a Decision Support System for Major Selection in Higher Education for Multimedia Graduate Students using Fuzzy Mamdani Logic, the following conclusions can be drawn:

1. The decision support system for choosing a major in this college uses 5 input parameters, Computer and Basic Networking (KJD), Graphic Design for Printing (DGP), Basic Graphic Design (DDG), Audio-Visual Techniques (TAV), and Animation (Animasi). There are outputs of 5 majors in Computer Engineering (Teknik Komputer), Visual Communication Design (DKV), Animation (Animasi), TV and Film (TV dan Film), and Photography (Fotografi).

2. The decision support system for choosing majors in universities is made using the fuzzy logic Mamdani method which is applied using the Matlab application and GUI on Matlab as an interface to facilitate user interaction with the system.

3. The scores data of vocational high school students in SMK N 7 Yogyakarta majoring in multimedia for 2022/2023 that were piloted have shown that the decision support system for choosing this major is following the skill scores on the report card and. With the highest student score data in Animasi, a recommendation score of 79.8 will appear in the Animasi department, and in the highest student score data on a Komputer dan Jaringan Dasar, a recommendation score of 79.8 will appear in the Teknik Komputer major following the major taken and lived by the current student.

4. This decision support system for choosing a major in higher education can make it easier

and can provide support for third-grade vocational high school students, especially multimedia majors in choosing a major in college based on the abilities that have been documented in the skill scores in the report card.

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