Study Program Selection Recommendation System Using the Fuzzy Inference System Mamdani

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Abstract— This study presents a recommendation system for selecting study programs using the Mamdani fuzzy inference system. With the aim of assisting prospective students in making informed decisions, the system evaluates various factors including talents, UTBK scores, and school exam grades. The research utilizes the Temu Bakat test to assess talents and applies fuzzy logic to map inputs to outputs. Fuzzy rules are formulated based on the evaluation of antecedents, and aggregation combines multiple rules into a single output. Defuzzification converts fuzzy outputs into clear recommendations. The system's effectiveness is demonstrated through testing on students at UPI Campus in Cibiru, resulting in personalized study program recommendations for each student.

Keywords—Recommendation System, Fuzzy Mamdani, Study Program Selection, Talents Mapping

I. INTRODUCTION

Decision making is something that is not detrimental in human life. This can also be felt by high school and equivalent students who will continue their studies to advanced levels such as tertiary institutions [1]. Higher education is one of the educational institutions that plays an important role in producing professional workers. A person will study based on a certain area of expertise at the tertiary level, so that graduates in the form of high-quality human resources according to their field of specialization are expected to be produced by tertiary institutions [2]. In line with this, it is very important for every prospective student to choose a study program or field of expertise that is appropriate and in line with their interests, talents and abilities [2], [3].

Mistakes in choosing a study program are generally caused by a lack of knowledge of information about existing study programs, following parents' requests, following friends' choices, prestige, and because there are no other study program options [4], [5]. This will result in the learning process during lectures being hampered due to not understanding the material presented or even not liking the things learned during the lecture and of course this will result in a low achievement index (GPA) or even dropping out of the lecture period and changing study programs in the middle of the semester [6]. Therefore, selecting a study program needs to be done as soon as possible with various considerations. Mistakes in choosing a study program will cause major losses for prospective new students later. Therefore, prospective new students need knowledge of their interests and talents [3], [7].

Based on the results of research and surveys conducted by the Indonesia Career Center Network (ICCN) which was reported on the news site iNews.id on February 7 2020, it was stated that 87% of students in Indonesia felt they had made a mistake by taking an inappropriate study program and not according to their interests [8], [9]. This large percentage indicates that errors in selecting study programs by students in Indonesia are still widespread. This phenomenon certainly requires special attention, moreover, the urgency of choosing a study program is closely related to the process of completing studies and influences post-study career paths [8].

There are various methods to overcome this problem and one way is by using a recommendation system or also commonly referred to as a decision support system (DSS) [3]. The function of the recommendation system is only to help users make choices from among the many alternatives based on predetermined variables and weightings and does not act as a substitute for decision making when users have to decide on something.

The main aim of this research is to help students who often face dilemmas and confusion in deciding to choose the right study program. Choosing the right study program when continuing your studies at university is really important because their choice now will determine their future. Thus, a system of recommendations for choosing study programs is needed so that it can help prospective students in choosing the right study program. This can provide solutions to help prospective students to get the best results [10].

The intelligent system that can make recommendations for users is called the recommendation system. In this case, the recommendation system used to get the best results based on analysis of the user's talent analysis and analysis of test scores and school grades [11], [12], [13]. Various previous studies have been carried out to provide a solution to this problem using several different methods and variables. Making a DSS for selecting major concentrations was carried out using Fuzzy Inference Mamdani using major interests and scores from various Academic Potential Tests as system input and major choice as output [1]. Apart from selecting majors, the Mamdani method has also been used as a DSS for determining diabetes drug classes. The results of this research state that the Mamdani method can be used to help determine the appropriate drug class [14].

While previous research has explored fuzzy logic-based recommendation systems for study program selection uses only two variable inputs, these studies often focus primarily on academic performance indicators and talents mapping result [1], [15]. This approach, while valuable, overlooks the critical role of individual talents and interests in shaping student success and satisfaction. This research aims to bridge this gap by incorporating a comprehensive talent assessment, utilizing the Temu Bakat test based on the Thirty Strength Typology (ST-30), alongside academic achievements. By considering both aptitudes and academic performance, our proposed system seeks to provide a more holistic and personalized approach to study program recommendation.

Additionally, this study delves deeper into the methodological details of system design and development, providing a transparent and reproducible framework. Moreover, the evaluation of the system extends beyond accuracy assessment to encompass usability and user satisfaction, ensuring a user-centered approach. Finally, we explore potential future developments, including the incorporation of additional factors and the application of machine learning, highlighting the research's commitment to continuous improvement and its potential for further contributions to the field of educational decision support systems.

II. RESEARCH METHOD

This research uses the Design and Development (D&D) research method to create a recommendation system for selecting study programs for prospective students. The D&D approach was chosen because of its focus on the systematic design, development, and evaluation of new products or systems, which aligns with the aims of this research. The development process can be seen in Figure 1.

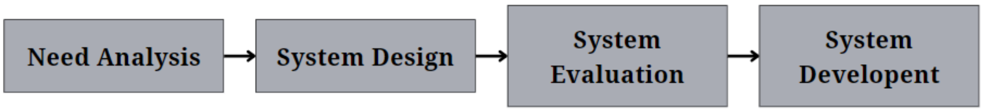

Figure 1. Proposed Methodology for Design and Development

A. Need Analysis

The initial stage of this research involved a deep dive into existing knowledge and research related to study program selection, aiming to understand the complexities and challenges faced by students during this crucial decision-making process. The literature review encompassed a wide range of topics, beginning with an exploration of research on study program selection, encompassing factors influencing student choices, the role of individual interests and aptitudes, and the impact of decision-making processes on future academic and career success.

Furthermore, the review delved into the theoretical underpinnings of fuzzy logic and the Mamdani fuzzy inference system, examining their applications in decision support systems and their suitability for handling the inherent uncertainty and subjectivity present in study program selection. Additionally, relevant literature on talent assessment models, particularly the Thirty Strength Typology (ST-30) framework utilized in the Temu Bakat test, was explored to gain a comprehensive understanding of its theoretical basis, application, and effectiveness in identifying individual strengths and talents. This thorough examination of existing research provided a solid foundation for the subsequent stages of system design and development.

In this process, a survey was also carried out on students accepted at the UPI Campus in Cibiru. Respondents from the five study programs who filled out the survey totaled 24 students with the data distribution which can be seen in Table 1.

Tabel 1.
Research Respondent Data

Study Program	Number	Science School Background	Social School Background	Vocational Major Background
PGSD	9	5	3	1
PGPAUD	2	0	1	1
PMM	3	2	0	1
RPL	4	4	0	0
TEKKOM	6	2	2	2

B. System Design

Artificial intelligence (AI), also called an intelligent system, includes fuzzy logic and aims to use human intelligence to address issues that currently exist [16], [15], [17], [18]. An suitable method for mapping an input space into an output space is fuzzy logic. As seen in Figure 2, fuzzy logic process is essentially contains of some functional blocks: fuzzification, defuzzification, rule basis, and database [19]. This architecture demonstrates how information is carefully entered by the user and processed by the system before recommendations are generated as an output. Formalized data is kept in a knowledge base. User fuzzification of the five-variable input variables is the first step in the process from crisp input to crisp output. Next, an inference engine with rule evaluation and aggregation leads to the defuzzification step [20].

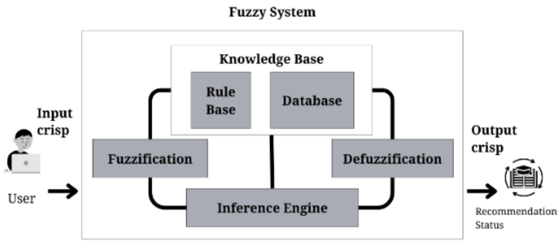

Figure 2. Fuzzy Logic process diagram architecture

1) *Fuzzification*

Creating the fuzzification process including various input variables from students is first step in this research. This stage is the initial stage where the process of mapping a true value (crisp) into a fuzzy set occurs. In other words, making a crisp value into a value that ranges from 0 to 1 in the available fuzzy sets [21], [22]. There are three categories of the input used in this study which are talent data from Temu Bakat, computer-based written test (UTBK) scores and general school subject scores. Talent data is contributed from the Thirty Strength Typology (ST-30) as shown in Table 1 which can be categorized as eight strength cluster such as headman, servicing, generating ideas, technical, elementary, reasoning, thinking and networking [23]. The input for UTBK is contributed from the average of three main score. While, the general school subject scores contributed from Mathematics, Indonesian Language and English Language Score in Highschool.

The students need to do a talent test from temubakat.com and take a look for the result, then choose seven most related talents from the result they got for the talent input. ST-30 is part of the Talent Mapping Assessment tool which is very suitable for use in detecting students' talents and interests [24], [25]. An example of the results of Temu Bakat test can be seen in Figure 3. When completing the Temu Bakat test, there are 4 stages that need to be completed. Each stage contains questions with various repeated statements which will ultimately determine the statement "I really" and those that say "not really me". The system will then classify the test results by talent tendencies among the 30 talents in ST-30 which are divided into 8 clusters as shown in Table 2.

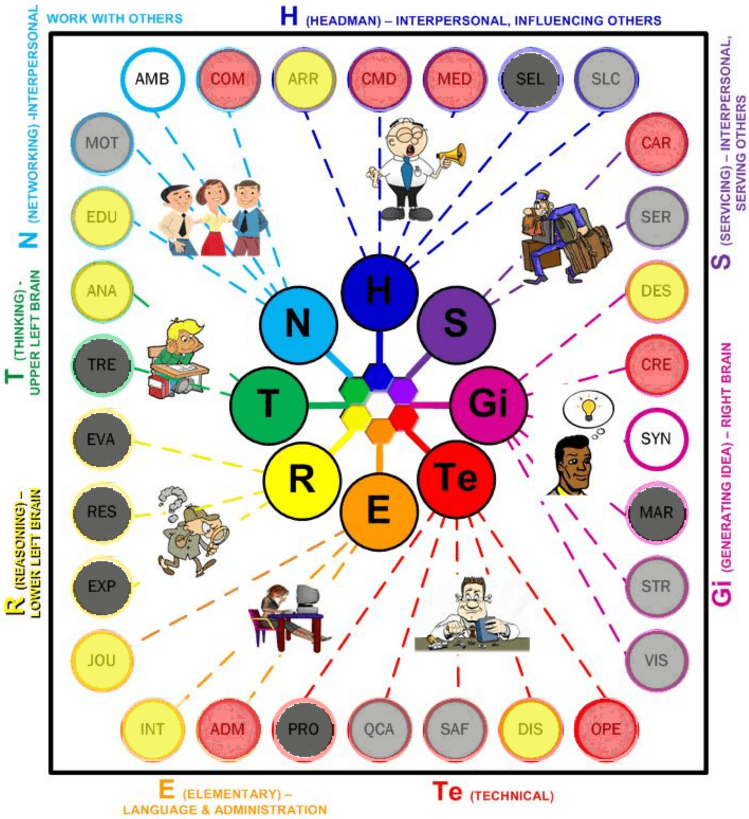

Figure 3. Result Example from Temu Bakat Test
(Source: *temubakat.com*)

The students also need to fill the form that contains average scores of UTBK, school exam scores for Indonesian language subjects, English school test scores, and mathematics school test scores. After submit di form, the student will get their recommendation for five study programs depending on their own result on talent test, UTBK test and exam score.

Whether or not a student's talent meeting test results are talented or not is determined based on the 7 most suitable typology strengths obtained after carrying out the test. Then the 7 strong typologies were categorized based on the clusters shown in Table 1 and the number of strong typologies for each cluster will be calculated. Furthermore, the results of the talent meeting will be given weight to the talents required in the five study programs at the UPI Campus in Cibiru which were obtained from interviews with each head of the study program. The percentage weighting of talent gathering results towards talent needs in the study program can be seen in Table 3. In light of this, the system will determine and classify the students' talents in each study program as either not talented, normal, or talented depending on the range displayed in Table 3. The range from 0 to 100 is divided into three sections by an overlapping graph that corresponds to the proper range of values for the categories of not talented, normal, and talented.

The system will also calculate and classify UTBK results and also the average school exam scores into poor, medium and good based on the ranges that is shown in Table 4. The range for UTBK results is between 0 and 1000 and the range for average school exam results is between 0 and 100 which are divided into three sections with overlapping graphs that follow the pecified suitable range of values stated as poor, medium and good.

Table 2.
Input for Talent Part

Cluster	Strength Typology	Typology Code
Headman	Arranger	ARR
	Commander	CMD
	Mediator	MED
	Seller	SEL
	Selector	SLC
Servicing	Care Taker	CAR
	Server	SER
Generating Idea	Designer	DES
	Creator	CRE
	Synthesizer	SYN
	Marketer	MAR
	Strategist	STR
	Visionary	VIS
Technical	Operator	OPE
	Distributor	DIS
	Safekeeper	SAF
	Quality Controller	QCA
	Producer	PRO
Elementary	Administrator	ADM
	Interpreter	INT
	Journalist	JOU
Reasoning	Explorer	EXP
	Restorer	RES
	Evaluator	EVA
Thinking	Treasury	TRE
	Analyst	ANA
Networking	Educator	EDU
	Motivator	MOT
	Ambassador	AMB
	Communicator	COM

Table 3.
Weighting of Study Program Match Results with Talent Clusters in the Temu Bakat Test

Cluster	PGSD (%)	PGPAUD (%)	PMM (%)	RPL (%)	TEKKOM (%)
Headman	10	7	5	10	5
Service	15	20	5	5	3
Generating Idea	20	16	25	10	13
Technical	5	5	10	15	15
Elementary	15	17	5	2.5	2
Reasoning	10	10	15	20	20
Thinking	10	10	10	35	35
Networking	15	15	25	2.5	7

When fuzzy inference must decide whether overlapping graphs will truly be counted as inference output, overlapping graphs serve as a gray area. This will occur as the following subsection explains the rule assessment procedure. For example, the range of

Temu Bakat test results with a match percentage in the TEKKOM study program is 50. Then the user's linguistic variables will overlap with the non-talented or normal graph. Therefore, inference will select the solution with a higher fuzzy value to solve problems such as these, for example in this case the higher fuzzy value tends to be a normal talent graph.

Table 4.
Linguistic Variable of Input

Input	Linguistic Variable	Range
Temu Bakat in PGSD	{Not Talented, Normal, Talented}	{0 – 40, 20 – 80, 60 – 100}
Temu Bakat in PGPAUD	{Not Talented, Normal, Talented}	{0 – 40, 20 – 80, 60 – 100}
Temu Bakat in PMM	{Not Talented, Normal, Talented}	{0 – 40, 20 – 80, 60 – 100}
Temu Bakat in RPL	{Not Talented, Normal, Talented}	{0 – 40, 20 – 80, 60 – 100}
Temu Bakat in TEKKOM	{Not Talented, Normal, Talented}	{0 – 40, 20 – 80, 60 – 100}
UTBK Average Score	{Poor, Medium, Good}	{0 – 400, 200 – 800, 600 – 1000}
School Exam Average Score	{Poor, Medium, Good}	{0 – 40, 20 – 80, 60 – 100}

Table 5.
Linguistic Variable of Output

Input	Linguistic Variable	Range
Recommendation	{Not Recommended, Recommended, Highly Recommended}	{0 – 400, 200 – 800, 600 – 1000}

2) Rule Evaluation

Designing fuzzy rules comes next after the fuzzification procedure is finished [26]. In this stage, the fuzzified input is taken and applied to the fuzzy rules' antecedents. If a fuzzy rule contains more than one antecedent, then fuzzy operators (AND or OR) need to be applied. To obtain a single number that represents the evaluation findings, this must be performed. Following that, the acquired numbers will be used for the subsequent membership function. In this case, the fuzzy OR operation used is the max method. The formula for calculating the maximum OR operation is as follows:

$$\mu(A \cup B)\ (X) = \max(\mu A(X), \mu B(X)) \quad (1)$$

Where $\mu A \cup B\ (X)$ is combined membership level of fuzzy sets A and B at point X, max operation used to retrieve the maximum value, $\mu A(X)$ and $\mu B(X)$ is the membership level of fuzzy set A and set B at point X. Apart from the OR method, Fuzzy inference also supports the AND method. In this research, the AND method used was min. The formula for calculating the minimum AND operation is as follows:

$$\mu(A \cap B\ )(X) = \min(\mu A(X), \mu B(X)) \quad (2)$$

Where $\mu A \cup B\ (X)$ is membership level of the intersection of fuzzy sets A and B at point X and min operation used to retrieve the minimum value between $\mu A(X)$ and $\mu B(X)$. Many fuzzy AND and OR operators have been created and implemented by Fuzzy researchers. Naturally, the outcomes from these many operators will vary. These days, most fuzzy packages let users customize the fuzzy AND and OR operations.

The membership function of the consequent can then make use of the results of evaluating the antecedents. This suggests that the membership function of the consequent is scaled or modified to correspond with the antecedent's degree of truth. Usually, minimum correlation or clipping is used since the arithmetic involved is less complicated and takes less time than scaling. It also generates a combined output surface that is easier to defuzzify.

The fuzzy variables studied in this project are related to study program recommendations, which are determined based on the suitability of the Temu Bakat test results with five study programs at the UPI Campus in Cibiru as well as the average UTBK score and the average school exam in mathematics, Indonesian and English subjects. Each study program is associated with a fuzzy output in the form of a recommendation level for that study program. Table 5 outlines some of the rules regarding recommendations for study programs based on several inputs that have been explained previously which comes from 27 rules that have been designed.

Table 6.
Several Rules Fuzzy Inference System

No	Rule
Rule 1	IF Temu Bakat Test is Talented AND UTBK Score is Good AND Exam Score is Good THEN Recommendation is Highly Recommended
Rule 2	IF Temu Bakat Test is Normal AND UTBK Score is Medium AND Exam Score is Medium THEN Recommendation is Recommended
Rule 3	IF Temu Bakat Test is Talented AND UTBK Score is Medium AND Exam Score is Poor THEN Recommendation is Recommended
Rule 4	IF Temu Bakat Test is Not Talented AND UTBK Score is Medium AND Exam Score is Medium THEN Recommendation is Recommended
…	…
Rule 27	IF Temu Bakat Test is Not Talented AND UTBK Score is Poor AND Exam Score is Poor THEN Recommendation is Not Recommended

3) Aggregation

Aggregating the output results from each rule is the third stage in the Mamdani style inference process. We call this process "aggregation." Usually, a single fuzzy set is created by combining all of the membership functions that were previously scaled or clipped. As a result, a list of clipped or scaled consequent membership functions makes up the input to the aggregation process, and the output is a single fuzzy set for each output variable.

The fuzzy inference in this study case will produce a single aggregated rule output that represents the recommendation level for each of the five study programs offered on the UPI Campus in Cibiru.

4) Defuzzification

Although fuzziness helps the rule evaluation process, the final output of a fuzzy system must be clear numbers or also called crisp numbers. The final step in this process to determine the crisp number is defuzzification [27]. The aggregate output from the fuzzy set is the input for the defuzzification process, and the output is a single number. There are various ways to defuzzify aggregate fuzzy collections; in this case study, the centroid technique was employed. The centroid technique is a method that works by finding the point where a vertical line will cut a collection of aggregates into two equal masses [28].

III. RESULT AND ANALYSIS

A. Calculation of Temu Bakat Test Results

As stated in the previous section. One of the input variables used in this case study is the Temu Bakat test, where the results of the test are classified based on each cluster and then the level of match of the talent with the five study programs on the UPI Campus in Cibiru is calculated. The results of calculating the suitability of the Temu Bakat test for 24 students at the UPI Campus in Cibiru can be seen in Table 7.

Table 7.
Student Temu Bakat Test Data

Student Name	Study Program	Matching Percentage on Temu Bakat Test				
		PGSD	PGPAUD	PMM	RPL	TEKKOM
Alfia Usmi Latifah	PGSD	88,3	84,5	54,6	73	68,6
Ammar Wijaksono Saputra	TEKKOM	65,2	64,9	53,1	33,3	30,2
Ana Saputri	PMM	61,5	53,7	54,8	48	45,8
Annisa Octaviani	PGPAUD	50,8	38	47,9	74,9	70,9
Ariel Ilman Rosyada	PMM	66,5	60,6	51,5	41,2	30,3
Arij Fathi Bauzir	PGPAUD	72,5	65,9	59,2	42,8	41,3
Deswita Diandra	TEKKOM	62,1	55,6	48,8	74	79
Faishal Ramdani	TEKKOM	52,5	38	53,3	54,9	51,6
Farah Fauziah Luthfiatunnisa	PGSD	72,7	71,1	61	50,5	49,9
Fatra Al Khawarizmi	RPL	60,2	47,1	76,5	60,3	62,2
Frisian Nur Hanapiah	PGSD	71,9	61,2	69,8	48,8	51,8
Humairo Husnul Khotimah	PGSD	69,4	63,2	62,3	15,1	15,4
Maryam Silva Rahayu	RPL	60,8	50,4	67,5	62,3	63,7
Muhammad Aiman Zikri Zega	RPL	65,6	56,9	65,6	42	44,7
Muhammad Azzura Al Karazi	TEKKOM	62,5	47,5	79,2	61,5	64,8
M. Fadlan Akbarkusumah	TEKKOM	74,4	71,1	66,5	30,5	30,7
Nuhsandriya Hermawan	PGSD	70,1	60,1	59,6	18,4	19,4
Putra Indika Malik Hakim	TEKKOM	81	79,8	59,8	35,7	32,4
Riska Setiawati	PGSD	66,5	55,3	76,5	39,1	43,6
Riva Fadilah Cahyadiana	PGSD	48,5	40	55,2	29,2	29,9
Safitri Ayu Dwi Cahyani	PMM	46,5	43,4	52,3	27,5	28,6
Selvi Triwanvi	PGSD	81	78,3	68,1	63	60
Sinamo Kevin	RPL	61	40	52,9	77,6	75,1
Tania Indriani	PGSD	82,7	79,6	68,5	74,2	73,6

B. System Development and Evaluation

The system interface was created after planning in creating a recommendation system. Interface creation is carried out in the Design App feature provided in the MATLAB application. The system is designed in such a way that it can be used easily as shown in Figure 4. There are 7 input dropdowns that need to be filled in according to the results of the Temu Bakat test that was carried out previously. The user will fill in the input based on the 7 most dominant talents from the test results which are marked in red as in the example of the test results shown in Figure 3. If the results are red, only 6 talents are obtained, then 1 yellow talent can be selected based on the user's preferences.

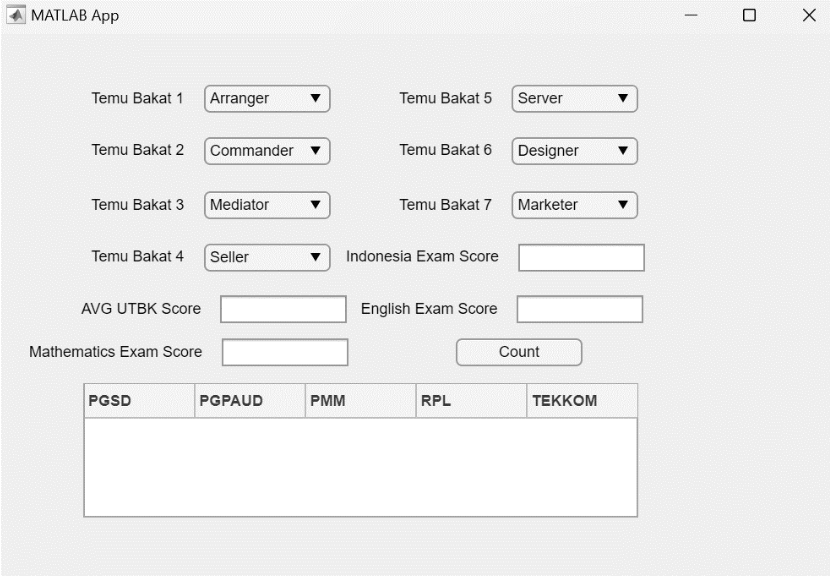

Figure 4. System Interface Design

The user then fills in several other inputs such as the average UTBK score and also test scores in several subjects, namely Mathematics, Indonesian and English. When the Count button is pressed, the system will carry out various calculations behind the application starting from calculating the percentage of talent in each study program, calculating the average score on school exams and calculating using the Mamdani fuzzy inference system which has been previously designed. The research was conducted on 24 students at the UPI Campus in Cibiru and the recommendation system that had been created was then tested using data obtained from the survey that had been conducted. The results of the recommendation system testing are shown in Table 8.

Tabel 8.
System Test Result

Student Name	**Study Program Recommendation Level**				
	PGSD	**PGPAUD**	**PMM**	**RPL**	**TEKKOM**
Alfia Usmi Latifah	HR	HR	R	R	R
Ammar Wijaksono Saputra	R	R	R	R	R
Ana Saputri	R	R	R	R	R
Annisa Octaviani	R	R	R	R	R
Ariel Ilman Rosyada	R	R	R	R	R
Arij Fathi Bauzir	R	R	R	R	R
Deswita Diandra	R	R	R	HR	HR
Faishal Ramdani	R	R	R	R	R
Farah Fauziah Luthfiatunnisa	R	R	R	R	R
Fatra Al Khawarizmi	R	R	HR	R	R
Frisian Nur Hanapiah	R	R	R	R	R
Humairo Husnul Khotimah	R	R	R	R	R
Maryam Silva Rahayu	R	R	R	R	R
Muhammad Aiman Zikri Zega	R	R	HR	R	R
Muhammad Azzura Al Karazi	R	R	HR	R	R
M. Fadlan Akbarkusumah	R	R	R	R	R
Nuhsandriya Hermawan	R	R	R	R	R
Putra Indika Malik Hakim	HR	HR	R	R	R

Riska Setiawati	R	R	R	R	R
Riva Fadilah Cahyadiana	R	R	R	R	R
Safitri Ayu Dwi Cahyani	R	R	R	R	R
Selvi Triwanvi	HR	HR	R	R	R
Sinamo Kevin	R	R	R	HR	HR
Tania Indriani	HR	HR	R	R	R

Table 7 shows that there are several students who are Highly Recommended (HR) to take certain study programs, the majority of other students get Recommended (R) status in various study programs and there are no students who are Not Recommended (NR) in the system testing results. This is because the degree of membership generated based on all input data held by each student tends to be middle to upper so that no student has a tendency to get a Not Recommended (NR) result.

IV. CONCLUSION

This study has successfully demonstrated the development and implementation of a study program selection recommendation system utilizing the Mamdani fuzzy inference system. By considering individual talents, academic achievements reflected in UTBK scores and school exam grades, the system offers personalized recommendations to assist prospective students in making informed decisions regarding their higher education pathways.

The testing conducted on students at UPI Campus in Cibiru showcased the system's effectiveness in providing suitable study program suggestions for each individual. This highlights the value of fuzzy logic in handling the complexity and uncertainty inherent in the decision-making process of choosing a study program.

While the system proves to be a valuable tool, it is essential to acknowledge its limitations. The reliance on self-reported talent data and the potential for bias in the weighting of factors are aspects that require further investigation and refinement.

Future research endeavors could focus on incorporating additional factors such as personality traits, career aspirations, and learning styles to enhance the personalization of recommendations. Furthermore, exploring the integration of machine learning techniques for dynamic adaptation of fuzzy rules and conducting longitudinal studies to evaluate the long-term impact of the system on student success and career satisfaction would be valuable extensions of this work.

Overall, this research contributes significantly to the field of decision support systems in education by providing a practical and effective solution to the challenge of study program selection. Through continuous improvement and evaluation, such recommendation systems hold the potential to empower students, improve academic outcomes, and contribute to a more fulfilling educational experience.

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