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UiTM CAWANGAN NEGERI SEMBILAN



## Classification Symptoms of Mental Health Problems Among Students by using Fuzzy Inference System

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### Abstract

*The prevalence of mental health disorders among university students is a growing global concern, significantly impacting their well-being and academic performance. Many students struggle to recognize their mental health conditions and current assessment methods such as the Depression, Anxiety and Stress Scale-12 (DASS-21) utilized by the counselling unit at UiTM Seremban 3, often lack precision. This study addresses this limitation by aiming to identify the key symptoms affecting student's mental health and developing a more accurate classification model using the Fuzzy Inference System (FIS). The FIS model was constructed through a five-step process which are defining input and output variables, establishing membership functions, formulating a rule-base, conducting fuzzification and performing defuzzification. The results show that the developed FIS model is able to provide more precise value than the DASS-12, with a percentage error of less than 7% for all symptoms analysed. Furthermore, a comparative analysis of students from the three primary faculties at UiTM Seremban 3 reveals that students from Faculty of Sport Science and Recreation (FSR) experience the highest level health issues. This finding suggests that targeted mental health interventions and support programs are especially needed for students in the FSR faculty.*

**Keywords:** Mental health problem; Anxiety; Stress; Depression; Fuzzy Inference System

### Introduction

Mental health is broadly defined as an individual's overall psychological well-being [1]. It encompasses emotional, cognitive, and social aspects, along with the ability to cope with stress, manage adversity, and function effectively in daily life. Individuals with good mental health exhibit self-confidence, clear thinking, healthy interpersonal relationships, and active contributions to their communities. According to [1], mental health disorders arise from various factors, including genetic predisposition, biochemical imbalances, environmental conditions, and social influences.

Study done by [2] identifies the ten most prevalent mental health disorders, which include anxiety disorders, bipolar affective disorder, depression, dissociative disorders, eating disorders, paranoia, post-traumatic stress disorder (PTSD), psychosis, schizophrenia, and obsessive-compulsive disorder (OCD). However, detecting mental health issues in individuals remains challenging. One common assessment tool is the Depression, Anxiety, and Stress



Scale-21 (DASS-21), which is widely utilized across different countries. The original version of the scale, DASS, comprises 42 items, while its shorter counterpart, DASS-21, consists of 21 items categorized into three interrelated dimensions that measure symptoms of depression, anxiety, and stress [3].

Anxiety and depression are often comorbid, sharing similar symptoms such as sleep disturbances, fatigue, muscle tension, and irritability [4]. While anxiety is characterized by excessive and persistent feelings of fear and worry, depression is a mood disorder marked by a sustained period of sadness, loss of interest or pleasure and a significant disruption in daily life [4-5]. Key symptoms of depression, as defined by [5], include persistent low mood, changes in appetite or sleep patterns, feelings of worthlessness, and a lack of energy [5]. These conditions can severely impact a student's academic performance and overall well-being, often requiring treatment through counselling, medication or both [6].

The prevalence of mental health disorders among university students has increased significantly over the past decade. A recent meta-analysis estimated that 33.8% of university students worldwide experience anxiety, while 27.2% exhibit symptoms of depression [7]. These mental health challenges may have long-term consequences, potentially impacting students' professional lives after graduation. Consequently, developing a classification model for assessing student mental health is essential. However, personal factors also play a crucial role in shaping emotions and behaviour [8] and the selection of an appropriate classification model remains challenging due to the wide range of available methods. Several approaches have been explored, including linear regression [9], neuro-fuzzy models [10], convolutional neuro-fuzzy models [11], self-screening and referral systems [12], smartphone sensor-based methods [13] and fuzzy clustering algorithms [14].

Unlike other diagnostic processes, medical diagnosis is inherently complex due to the presence of vagueness, linguistic uncertainty, imprecise measurements, and natural variability [15]. Recent advancements in artificial intelligence (AI) and intelligent computing have facilitated the development of new methodologies that enhance medical decision-making, thereby reducing morbidity, mortality, and economic burdens on healthcare systems [10]. Research conducted by [10] demonstrates that the application of fuzzy systems can improve the assessment of depression severity based on patient case studies. Therefore, this study is motivated to use Fuzzy Inference System to identify symptom of mental health problem.

## Related Work

Study done by [10] applied a fuzzy-neural hybrid technique utilizing Mamdani's fuzzy logic controller to assess the severity of depression. Similarly, [9] developed a conceptual framework integrating fuzzy inference systems and linear regression to analyze the impact of various factors on patients' health-related quality of life (HRQL). Collectively, these studies demonstrate the diverse range of fuzzy-based approaches, including clustering algorithms [14] and fuzzy-neural hybrids [16], which have been applied to model complex health-related problems.

Fuzzy Logic Mamdani Method was used by [17] to investigate mental health disorders. The objective of this research was to develop a classification model for identifying characteristics of mental disorders using the Fuzzy Logic Mamdani Method. The proposed system demonstrated high classification accuracy, with an error margin of less than five percent. Additionally, [18] applied the Fuzzy Inference System (FIS) to predict depression risk levels.



Several studies have highlighted that depression is a significant public health concern with a high prevalence among the adult population [10]. Unlike other diagnostic processes, medical diagnosis is inherently complex due to vagueness, linguistic uncertainty, measurement imprecision, and natural variability (Taiwo, 2012). The FIS model has demonstrated an accuracy rate of 94%, with a correlation coefficient of 0.746 between FIS predictions and conventional depression severity scales, indicating its potential to assess depression severity and track its progression. Furthermore, the model effectively predicted 125 cases, exhibiting a strong correlation coefficient ( $r = 0.88$ ,  $p\text{-value} = 0.001$ ) between actual and predicted instances.

Accordingly, studies by [18] focused on forecasting depression risk levels, while [17] employed FIS to classify characteristics of mental disorders. In contrast, the present study explores the classification of students' mental health issues using FIS. The primary distinction between these studies is that while [17] and [18] concentrated solely on mental disorder characteristics, this research integrates their approaches to develop a model capable of determining the severity of symptoms associated with three major mental health conditions: anxiety, stress, and depression.

## Methodology

The Figure 1 shows a Fuzzy Inference System (FIS) used in this study. It operates in three main stages in which the first stage is fuzzification that convert a precise numerical input into a fuzzy value representing it as a degree of membership in different categories. Second stage is inferences that uses a knowledge base containing logical rules to process these fuzzy values and make a decision. The last stage is defuzzification in which converts the fuzzy decision back into a single, precise number as the final output of the system.

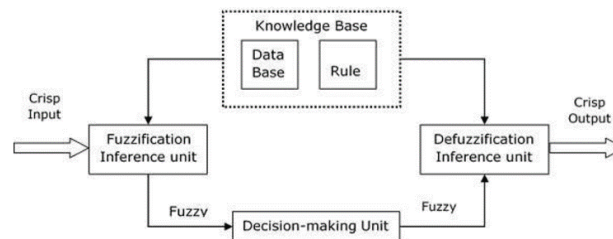


Figure 1. Process in Fuzzy Inference System (FIS)

Data were collected using an online questionnaire, which was distributed to students at UiTM Seremban 3. Although the DASS-21 consists of 21 input variables, this study considered only nine by combining similar questions. The decision to reduce the number of variables was made to limit the number of rules required for the FIS. For each mental health problem, the model was designed with only three input questions. This focused approach resulted in the development of 64 rules for each of the three mental health categories, as the number of rules is calculated by raising the number of linguistic terms to the power of the number of input variables, ensuring a manageable and effective rule base for the FIS. The selected nine variables and their corresponding combined questions from the DASS-21 are detailed in Table 1.



Table 1. Question combination

Mental	Symptoms	Question number in DASS-21
Depression	$x_1$ :worthless	10, 17, 21
	$x_2$ :not enthusiastic at all	5, 16
	$x_3$ :gloomy and sad	3, 13
Anxiety	$x_4$ :panic and act stupid	9, 15, 20
	$x_5$ :difficulty breathing	4, 19
	$x_6$ :mouth felt dry	2, 7
Stress	$x_7$ :overreact	1, 8, 11, 12
	$x_8$ :easily offended	6, 14
	$x_9$ :hard to relax	18

**Fuzzification**

Table 2 shows fuzzy numbers, scales and membership function for each input variables and output variables using Mamdani method.

Table 2. Fuzzy numbers, linguistic terms and membership functions

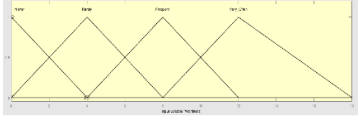
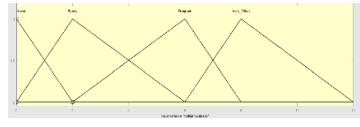
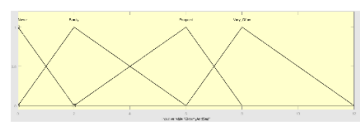
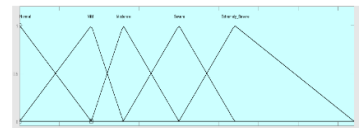
Mental Health Problem	Symptom	Linguistic Terms	Fuzzy numbers	Membership Function
Depression	$x_1$	Never	0, 0, 4	
		Rarely	0, 4, 8	
		Frequent	4, 8, 12	
		Very often	8, 12, 18	
	$x_2$	Never	0, 0, 2	
		Rarely	0, 2, 6	
		Frequent	2, 6, 8	
		Very often	6, 8, 12	
	$x_3$	Never	0, 0, 2	
		Rarely	0, 2, 6	
		Frequent	2, 6, 8	
		Very often	6, 8, 12	
	$y_1$	Normal	0, 0, 9	
		Mild	0, 9, 13	
		Moderate	9, 13, 20	
		Severe	13, 20, 27	
Extremely Severe		20, 27, 42		



Table 2 – continues from previous page

Mental Health Problem	Symptom	Linguistic Terms	Fuzzy numbers	Membership Function	
Anxiety	$x_4$	Never	0, 0, 4		
		Rarely	0, 4, 8		
		Frequent	4, 8, 12		
		Very often	8, 12, 18		
	$x_5$	Never	0, 0, 2		
		Rarely	0, 2, 6		
		Frequent	2, 6, 8		
		Very often	6, 8, 12		
	$x_6$	Never	0, 0, 2		
		Rarely	0, 2, 6		
		Frequent	2, 6, 8		
		Very often	6, 8, 12		
$y_2$	Normal	0, 0, 7			
	Mild	0, 7, 9			
	Moderate	7, 9, 14			
	Severe	9, 14, 19			
	Extremely Severe	14, 19, 42			
Stress	$x_7$	Never	0, 0, 6		
		Rarely	0, 6, 12		
		Frequent	6, 12, 18		
		Very often	12, 18, 24		
	$x_8$	Never	0, 0, 2		
		Rarely	0, 2, 6		
		Frequent	2, 6, 8		
		Very often	6, 8, 12		
	$x_9$	Never	0, 0, 1.5		
		Rarely	0, 1.5, 3		
		Frequent	1.5, 3, 4		
		Very often	3, 4, 6		
	$y_3$	Normal	0, 0, 14		
		Mild	0, 14, 18		
		Moderate	14, 18, 25		
Severe		18, 25, 33,			
Extremely Severe		25, 33, 42			



### ***Evaluate Fuzzy Inferences System***

The input and output variables of the membership functions were applied in the FIS for the evaluation process. The output was generated by using IF-THEN rule with condition “IF  $p$  is A THEN  $q$  is B” where  $p$  is the input variable, and  $q$  is the output variable and A and B is the linguistic terms. The inference engine uses a system of rules to make decision through the fuzzy “AND” operator and generates a single truth value determines the outcome of the rules. The following is part of the list of rules that was generated.

#### **Rules for Depression**

- IF  $x_1$  is never AND  $x_2$  is rarely AND  $x_3$  is never, THEN  $y_1$  is normal.  
IF  $x_1$  is never AND  $x_2$  is rarely AND  $x_3$  is rarely, THEN  $y_1$  is mild.  
IF  $x_1$  is never AND  $x_2$  is very often AND  $x_3$  is rarely, THEN  $y_1$  is moderate.

#### **Rules for Anxiety**

- IF  $x_4$  is never AND  $x_5$  is never AND  $x_6$  is frequent, THEN  $y_2$  is mild.  
IF  $x_4$  is never AND  $x_5$  is frequent AND  $x_6$  is rarely, THEN  $y_2$  is moderate.  
IF  $x_4$  is frequent AND  $x_5$  is very often AND  $x_6$  is never, THEN  $y_2$  is severe.

#### **Rules for Stress**

- IF  $x_7$  is rarely AND  $x_8$  is never AND  $x_9$  is rarely, THEN  $y_3$  is normal.  
IF  $x_7$  is frequent AND  $x_8$  is never AND  $x_9$  is never, THEN  $y_3$  is normal.  
IF  $x_7$  is very often AND  $x_8$  is very often AND  $x_9$  is frequent, THEN  $y_3$  is extremely severe.

### ***Defuzzification***

Defuzzification is the final step in a FIS, converting the system’s fuzzy output into crisp values. This study utilizes the Mean of Maximum (MOM) method, a popular approach that calculates the final crisp output by averaging all output values that have the highest membership degree. In this context, the output is represented as  $Z$  which is determined by averaging the set of values  $x_j$  that share the maximum possibility degree  $M$ . The variable  $k$  denotes the total number of these output values with the highest degree of possibility [19].

$$Z = \sum_{j=1}^k \frac{x_j}{k} x_j \in M \quad (1)$$



## Results and Discussion

The result are categorized into three types of mental health problems which are depression, anxiety and stress.

### *Results for depression*

Table 4 shows the output for both DASS-21 and FIS method towards depression which was obtained from the MATLAB software.

Table 3. Result for Depression

Respondents	Faculties	DASS-21		FIS	
		Scoring	Level of Depression	Defuzzification values	Level of Depression
1	KPPIM	24	Severe	20	Severe
2	KPPIM	16	Moderate	14.2	Moderate
3	FSPPP	12	Mild	10.2	Mild
4	KPPIM	16	Moderate	13.8	Mild
5	FSPPP	26	Severe	20	Moderate
6	KPPIM	6	Normal	2.9	Normal
7	FSPPP	26	Severe	29.7	Extremely Severe
8	KPPIM	12	Mild	12.4	Mild
9	FSPPP	12	Mild	10.2	Mild
10	KPPIM	16	Moderate	13.8	Mild
11	FSR	16	Moderate	14	Moderate
12	FSPPP	16	Moderate	13.8	Mild
13	KPPIM	18	Moderate	20	Moderate
14	FSR	28	Extremely Severe	26.6	Extremely Severe
15	KPPIM	24	Severe	21	Severe
16	FSPPP	16	Moderate	13.8	Mild
17	FSR	16	Moderate	13.7	Mild
18	KPPIM	16	Moderate	13.7	Mild
19	FSPPP	24	Severe	26.6	Severe
20	FSR	20	Moderate	20	Moderate
21	KPPIM	12	Mild	9.1	Mild
22	FSPPP	22	Severe	20	Moderate
23	FSR	22	Severe	20	Moderate
24	FSPPP	8	Normal	2.9	Normal



Table 3 – continues from previous page

Respondents	Faculties	DASS-21		FIS	
		Scoring	Level of Depression	Defuzzification values	Level of Depression
25	FSR	28	Extremely Severe	29.7	Extremely Severe
26	FSPPP	26	Severe	26.6	Severe
27	FSR	28	Extremely Severe	26.6	Severe
28	FSR	24	Severe	26.6	Severe
29	FSR	20	Moderate	20	Moderate
30	FSR	12	Mild	12.4	Mild
TOTAL		562	-	524.3	-

Note: Kolej Pen Faculty of Administrative Science and Policy Studies (FSPPP)gajian Pengkomputeran Informatik dan Matematik (KPPIM), Faculty of Sports Science (FSR) and Faculty of Administrative Science and Policy Studies (FSPPP)

Table 3 presents a comparison of the depression classification results from the DASS-21 and the FIS. The results indicate that the FIS model’s classification was similar to the DASS-21 for 63% of the cases, demonstrating a high degree of agreement between the two methods. This further supported by the low percentage error of 6.7% for depression, which is well within an acceptable range for a predictive model and shows the FIS model’s strong accuracy.

$$\text{Percentage error} = \frac{|524.3 - 562|}{562} \times 100 = 6.7\%$$

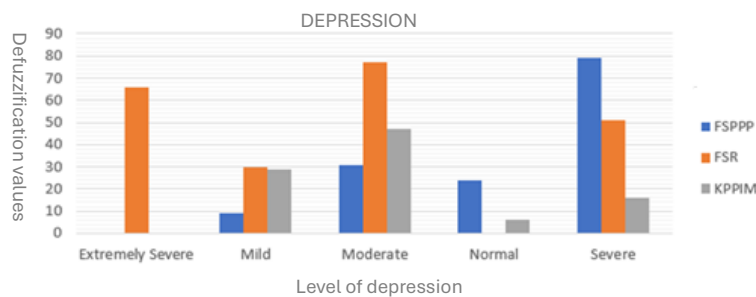


Figure 2. Result for depression between students in UiTM Seremban 3

Based on Figure 2, it shows that Faculty of Sports Science (FSR) has highest level of depression.

**Result for Anxiety**

Table 4 shows the output for both DASS-21 and FIS method towards anxiety which was obtained from the MATLAB software.



Table 4. Result for Anxiety

Respondents	Faculties	DASS-21		FIS	
		Scoring	Level of Depression	Defuzzification values	Level of Depression
1	KPPIM	18	Severe	14	Moderate
2	KPPIM	14	Moderate	12.6	Moderate
3	FSPPP	20	Extremely Severe	23.5	Extremely Severe
4	KPPIM	18	Severe	23.5	Extremely Severe
5	FSPPP	20	Extremely Severe	25	Extremely Severe
6	KPPIM	14	Moderate	12.6	Moderate
7	FSPPP	12	Moderate	10.2	Moderate
8	KPPIM	12	Moderate	14	Moderate
9	FSPPP	20	Extremely Severe	23.5	Extremely Severe
10	KPPIM	8	Mild	10	Moderate
11	FSR	16	Severe	14	Moderate
12	FSPPP	24	Extremely Severe	23.5	Extremely Severe
13	KPPIM	24	Extremely Severe	26	Extremely Severe
14	FSR	12	Moderate	12.6	Moderate
15	KPPIM	16	Severe	14	Moderate
16	FSPPP	22	Extremely Severe	23.5	Extremely Severe
17	FSR	18	Severe	14	Moderate
18	KPPIM	20	Extremely Severe	23.5	Extremely Severe
19	FSPPP	18	Severe	14	Moderate
20	FSR	26	Extremely Severe	26	Extremely Severe
21	KPPIM	16	Severe	14	Moderate
22	FSPPP	16	Severe	12.6	Moderate
23	FSR	20	Extremely Severe	23.5	Extremely Severe
24	FSPPP	18	Severe	23.5	Extremely Severe



Table 4 – continues from previous page

Respondents	Faculties	DASS-21		FIS	
		Scoring	Level of Depression	Defuzzification values	Level of Depression
25	FSR	24	Extremely Severe	26	Extremely Severe
26	FSPPP	20	Extremely Severe	23.5	Extremely Severe
27	FSR	22	Extremely Severe	25	Extremely Severe
28	FSR	20	Extremely Severe	23.5	Extremely Severe
29	FSR	18	Severe	23.5	Extremely Severe
30	FSR	12	Moderate	12.6	Moderate
TOTAL		538	-	567.7	-

Note: Kolej Pen Faculty of Administrative Science and Policy Studies (FSPPP)gajian Pengkomputeran Informatik dan Matematik (KPPIM), Faculty of Sports Science (FSR) and Faculty of Administrative Science and Policy Studies (FSPPP)

Table 4 shows a 63% similarity rate between the classifications of the FIS and the DASS-21 for anxiety levels. The minimal 5.5% error margin indicates a close alignment between the two methods, confirming the FIS model’s strong performance.

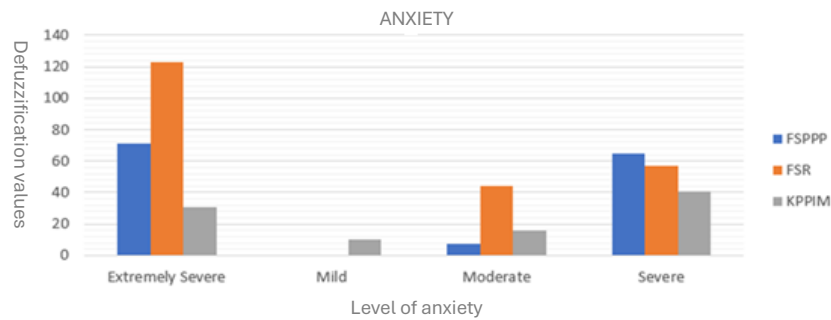


Figure 3. Result for anxiety between students in UiTM Seremban 3

Based on Figure 3, FSR students displayed the highest level of anxiety across the most severe categories, while students from KPPIM generally have the lowest.

**Result for Stress**

Table 5 shows the output for both DASS-21 and FIS method towards stress which was obtained from the MATLAB software.



Table 5. Result for Stress

Respondents	Faculties	DASS-21		FIS	
		Scoring	Level of Depression	Defuzzification values	Level of Depression
1	KPPIM	10	Normal	5.34	Normal
2	KPPIM	14	Normal	13.1	Normal
3	FSPPP	22	Moderate	25.4	Moderate
4	KPPIM	18	Mild	18.1	Mild
5	FSPPP	12	Normal	13	Normal
6	KPPIM	12	Normal	4.53	Normal
7	FSPPP	24	Moderate	28.6	Severe
8	KPPIM	14	Normal	13.1	Normal
9	FSPPP	24	Moderate	28.6	Severe
10	KPPIM	12	Normal	9.59	Normal
11	FSR	16	Mild	14	Normal
12	FSPPP	14	Normal	14	Normal
13	KPPIM	12	Normal	7.68	Normal
14	FSR	24	Moderate	21	Moderate
15	KPPIM	18	Mild	17.5	Mild
16	FSPPP	14	Normal	8.41	Normal
17	FSR	18	Mild	17.5	Mild
18	KPPIM	14	Normal	14.4	Mild
19	FSPPP	26	Severe	25.4	Moderate
20	FSR	28	Severe	30.8	Severe
21	KPPIM	22	Moderate	18.1	Mild
22	FSPPP	28	Severe	21	Moderate
23	FSR	20	Moderate	18.7	Mild
24	FSPPP	20	Moderate	18.1	Mild
25	FSR	28	Severe	30.8	Severe
26	FSPPP	16	Mild	10.7	Normal
27	FSR	32	Severe	33.4	Severe
28	FSR	22	Moderate	29.1	Severe
29	FSR	26	Severe	28.6	Severe
30	FSR	6	Normal	4.94	Normal
TOTAL		566	-	543.49	-

Note: Kolej Pen Faculty of Administrative Science and Policy Studies (FSPPP)gajian Pengkomputeran Informatik dan Matematik (KPPIM), Faculty of Sports Science (FSR) and Faculty of Administrative Science and Policy Studies (FSPPP)

Table 5 presents the results towards stress, indicating a 63% similarity between the classifications of the FIS and the DASS-21 method. The results of the two methods show only



minor differences, with a low 4% percentage error. This low error rate suggests that FIS model's performance is accurate and acceptable for use.

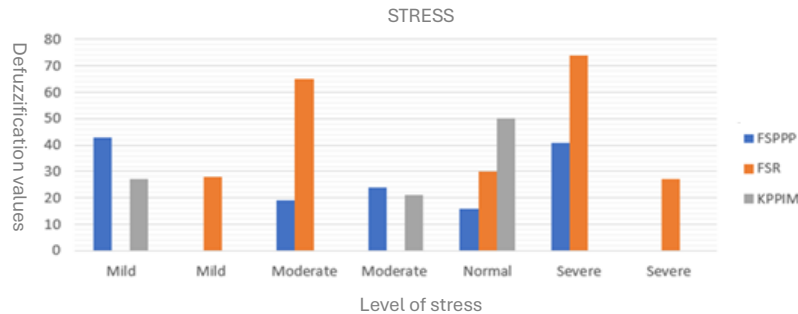


Figure 4. Result for stress between students in UiTM Seremban 3

Based on Figure 4, the results show that students from Kolej Pengajian Pengkomputeran Informatik dan Matematik (KPPIM) have the lowest level of stress compared to students in other faculties. The majority of KPPIM students fall within the normal range on the stress scale, indicating they are less stressed than their peers in FSR and the Faculty of Administrative Science and Policy Studies (FSPPP). The data also indicates that students from FSR experience the highest level of stress.

## Conclusion

This study successfully developed a Fuzzy Inference System (FIS) as a classification model for mental health issues, specifically addressing depression, anxiety and stress. The model's development followed a Iclear methodology, which included defining input and output variables, establishing membership functions and creating a rule base before undergoing the fuzzification and defuzzification processes.

The results confirm the model's accuracy and reliability, when compared to the DASS-21, the FIS model achieved a high level of similarity, with 63% similarity in classifications for all three mental health categories. Furthermore, the model demonstrated a low percentage error of 4% for depression, 5.5% for anxiety and 6.7% for stress indicating its high precision.

A comparative analysis of students from three faculties at UiTM Seremban 3 revealed significant differences. Students from the FSR consistently experienced the highest level of depression, anxiety and stress when compared to their peers in FSPPP and KPPIM.

In conclusion, the FIS model provides accurate tool for assessing student mental health. The findings not only validate its use but also highlight the need for targeted mental health support, particularly for students in the FSR faculty. Further research could explore incorporating all 21 questions from the DASS-21 to enhance the model's complexity and accuracy.

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