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Expert System For Diagnosis of Mental Health Disorders in Students Using Case-Based Reasoning Method With a Web-Based Positive Psychology Approach

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Abstract

Mental health issues among students have become a significant concern affecting their quality of life and academic performance. An effective expert system is needed to diagnose and provide appropriate interventions. This research develops a web-based expert system that utilizes the Case-Based Reasoning (CBR) method combined with a positive psychology approach to diagnose mental health disorders in students. The CBR method identifies similarities between new and previous cases, while the positive psychology approach focuses on individual strengths and potential for growth. The system integrates a database of student mental health cases and CBR algorithms to produce relevant diagnoses. This study investigates four types of mental health disorders: panic, anxiety, stress, and depression. The method used for data analysis is Case-Based Reasoning. The diagnosis results are based on calculations from symptom choices within the system, where each symptom has a weight. The highest similarity calculation obtained from past cases is used as a solution to address the problem. System testing, based on expert knowledge with 15 test data samples categorized by mental health disorders and 38 symptoms, achieved an accuracy rate of 85%.

Keywords: *Expert, Diagnosis, Mentally, Student, Knowledge-Based.*

1. Introduction

Mental health is a state in which a person does not experience symptoms of mental disorders. Individuals with good mental health can carry out their daily routines effectively and adapt to various life challenges by utilizing their ability to manage stress. Student mental health encompasses multiple aspects of individual physical and psychological development. It involves handling stress, adapting, interacting with others, and making decisions. Each individual has a unique mental health condition that evolves. People often encounter situations that require various solutions, and many individuals face mental health challenges throughout their lives [1]. Mental disorders are health conditions that affect a person's emotions, thoughts, behavior, or a combination of these. This condition is often associated with stress or social, work, or family issues (APA, 2022). In short, mental disorders have a significant impact on how a person feels, thinks, acts, and interacts with others. Mental disorders should not be considered shameful but are medical conditions comparable to heart disease or diabetes.

The problems faced by students often make them involved in actions that are contrary to religious teachings. For example, a Jambi student with the initials GR was found hanging in his accommodation room. It is estimated that he committed suicide due to depression caused by various problems, including completing his thesis, conflict with his girlfriend, and financial issues. A student at Jendral Soedirman University (Unsoed) attempted suicide by cutting the veins in his right hand using a cutter. The student admitted that she attempted suicide because she was depressed because of the bad treatment her friends had given her. The student with the initials IN was found dead in his room by his father, hanging himself because his final assignment had not been completed. Even though his father had never received a complaint before he died [2].

In a previous study by Septianda, Luqman, and Mamluatul (2023) on an Expert System for Diagnosing Lung Diseases using the Case-Based Reasoning Method, accuracy testing was conducted with five valid data points. The testing included 20 patient data samples and involved ten respondents, consisting of 1 expert and nine patients. The results indicated that the system facilitates patients, with an average questionnaire score of 86.8%. The Case-Based Reasoning method was also proven effective for diagnosing lung diseases, with an accuracy rate of 90% [3].

Based on the study Rahman (2020) conducted on an Expert System for Detecting Laptop Damage Using the Case-Based Reasoning Method, this research utilizes the expert system as an alternative consultation, replacing the need for an expert's physical presence. The method applied is case-based reasoning, which was implemented on laptop damage data at Luthfi Computer.
The findings of this study indicate that the system can detect damage more quickly and accurately, helping users find effective solutions to the problems they face.

2. Literature Review

2.1. Expert System

Expert systems are a branch of Artificial Intelligence (AI) that has been around for a long time, with their development beginning in the mid-1960s. Newell and Simon first introduced expert systems since then. Various expert systems have been developed, such as MYCIN for medical diagnosis, DENDRAL for molecular structure analysis of unknown mixtures, XCON and XSEL for configuring large computer systems, SOPHIE for electronic circuit analysis, Prospector for supporting managerial decisions related to inventory and investment, and DELTA for the maintenance of diesel-electric locomotives, among various other systems[4].
Durkin explains that an Expert System is software designed to replicate the expertise of a specialist in solving problems.

1. Igzino states that an Expert System is a model and method related to a specific field with expertise comparable to a specialist's.
2. Giarratano and Riley describe an Expert System as a computer system that can replicate or match the skills of a specialist.

According to Halim (2011), expert systems have several characteristics, including:

1. Knowledge in expert systems is in the form of concepts, not numerical data. Computers process data numerically, while experts' knowledge comprises realities and regulations.
2. Information in expert systems is often incomplete, personal, and inconsistent. Additionally, information can change over time and be influenced by environmental conditions, making the decisions generated uncertain and not always clearly 'yes' or 'no,' but instead based on a certain degree of truth.
3. The solutions offered by expert systems for a problem can be highly varied and provide a range of acceptable answers. Since the factors considered cover a wide and uncertain range of issues, the system must be flexible to handle various possible solutions to existing problems.
4. Knowledge in expert systems can change or develop at any time, even continuously. Therefore, the system must be designed for easy modification to accommodate an ever-growing and increasingly diverse body of knowledge.
5. The opinions and perspectives of each expert do not guarantee that the solutions provided by the expert system are always correct. Each expert will make judgments based on subjective factors.

2.2. Mental Health

Understanding mental health cannot be separated from understanding physical health. Research shows that there is a close relationship between physical and mental health, where individuals with medical complaints often experience psychological issues that can develop into mental disorders. Conversely, individuals with mental disorders frequently experience disturbances in their physical functions as well [5]. Mental health is a state in which a person does not experience symptoms of mental disorders. Individuals with good mental health can function normally in their daily lives and can effectively adapt to various life challenges through their ability to manage stress [6].

2.3. Case-Based Reasoning

According to Aamot and Plaza (1994), Case-Based Reasoning (CBR) is a method for solving problems by referring to solutions from previous cases. CBR can diagnose and handle various cases and automatically provide information based on existing knowledge, which can be updated to accommodate the latest issues, allowing knowledge within CBR to evolve continually. New problem-solving in CBR is achieved by searching for similar past problems and providing the most appropriate solutions based on the existing case memory. Data about new problems used for solving is stored in case memory and can be revised to address future issues.
The design of this system adopts the Case-Based Reasoning (CBR) method. In CBR, various techniques, including the nearest neighbor algorithm, can be used. Nearest Neighbor measures the level of similarity (distance) between a case and a new case based on several characteristics defined with specific weights and then sums the similarity (distance) of all attributes [7]. The following equation defines the Nearest Neighbor:

$$\text{Similarity } (problem,case) = \frac{s_1 * w_1 + s_2 * w_2 + \cdots + s_n * w_n}{w_1 + w_2 + \cdots + w_n} \quad \ldots\ldots(1)$$

s = similarity (similarity value)
w = weight (assigned weight)
n = number of attributes in each case

Percentage Similarity
Similarity Result * 100……(2)

The similarity calculation helps obtain the highest similarity score or case similarity value. Information from other cases is used to find solutions to problems, also known as reuse. The reuse phase offers similar solutions. Since solutions containing similarities can be reused as problem-solving solutions, you may switch if the similarity score is below the threshold of 70%. The review process involves checking the proposed solutions or, if necessary, re-evaluating to see if new solutions have been found [8].

2.4. Confusion Matrix

This table illustrates the performance of a specific model or algorithm. Each row in the matrix represents the actual data class, while each column represents the predicted data class [9].

Table 1. Confusion Matrix

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

1. True Positive
   This refers to the number of data points that belong to the positive class and are also predicted as positive by the model.
2. True Negative
   This refers to the number of data points that belong to the negative class and are also predicted as unfavorable by the model.
3. False Positive
   This occurs when the model predicts many data points that belong to the negative class as positive.
4. False Negative
   This occurs when the model predicts that many data points belong to the positive class as unfavorable.

From these four data points, the accuracy level of the algorithm used can be calculated.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad \text{.....(3)}$$

2.5. Positive Psychology

Positive psychology is a scientific approach that focuses on making life 'more worthwhile.' Martin E. P. Seligman, in his inaugural speech, mentioned that before World War II, psychology had three main goals: addressing mental disorders, enhancing life happiness, and identifying and developing exceptional talents and intelligence. However, after World War II, two of these missions tended to be neglected. Therefore, positive psychology establishes three main focuses: research on positive emotions, studies on positive traits such as strengths and virtues, and research on institutions that promote good values.

3. Research Methods

3.1. Place and Time

This research was conducted at Malikussaleh University, specifically at the Reuleut Campus, to facilitate the collection of data and references needed for system development, ensuring that the research process can proceed smoothly. The research took place from February 2024 to May 2024.

3. 2. Research Steps

The steps of the research are as follows:

1. Literature Study
   In this stage, a literature study searches for references to strengthen the literature review. The sources used include books, journals, articles, and other relevant data sources. The results of this literature study will serve as the theoretical foundation and basis for calculations in the research.
2. Data Collection Methods
   In this stage, a questionnaire is distributed to students or direct interviews are conducted with students and experts. The aim is to gather information about the types of problems students face and the solutions that can be used to address these issues related to problem identification.
3. Needs Analysis
   In this stage, a needs analysis is conducted to design a system that includes software and hardware requirements. A laptop with an Intel Core i3 processor, 2 GB Nvidia GPU, and 6 GB of memory is needed for hardware. The required software includes Sublime Text version 3.2.2, XAMPP version 5.6.0, and a web browser.
4. System Design
   During the system design phase, the application to be developed is designed with the help of additional software, Mockup Balsamiq, which is used as a tool for creating the planned system.
5. Implementation
   In the implementation stage, application programming uses PHP and MySQL for database storage. Case-based reasoning and the Jaccard Similarity Coefficient methods are applied to address the identification problems faced by students.
6. System Success
   In the system success stage, the successfully developed system is displayed. If unsuccessful, the process returns to the needs analysis to identify any errors or issues.
7. Conclusion
   In this stage, conclusions are drawn based on the results of the entire process carried out in the research. This conclusion aims to address the research questions posed earlier.

4. Results and Discussion

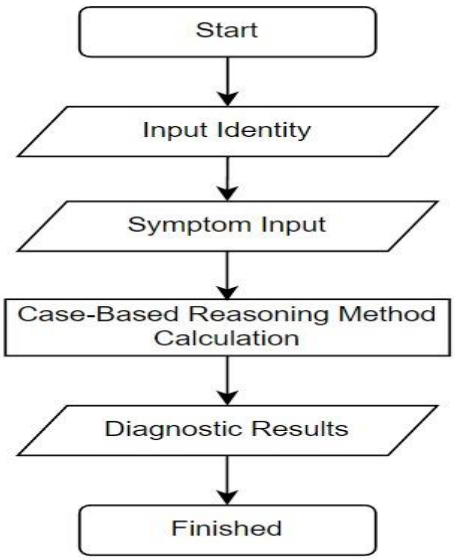

Fig 1. System Schematic

4.1. Research Results

The results of this research indicate that the methods used can be implemented in an application or expert system to determine the likelihood of students experiencing mental health disorders. By providing questions in the form of symptoms, the system displays a consultation page containing the inputted symptoms, from which the symptoms present in the student can be selected. The system then processes calculations using the case-based reasoning method and produces an output that diagnoses the student's mental health condition by consulting the system. Additionally, the similarity score of the diagnosed mental health condition is displayed, comparing it with historical case data in the system.

1. Data on Diagnosis Types and Symptoms

The table below contains symptoms associated with cases of each type categorized under mental disorders.

Table 2. Types of Diagnosis and Symptoms

Type of Diagnosis	Symptoms
Panic	Palpitations, racing heart, or increased heart rate Excessive sweating Trembling The sensation of shortness of breath or choking Feeling dizzy Chest pain or discomfort Nausea or gastrointestinal distress Loss of control, such as feeling crazy or feeling like there's a thought that's hard to let go Chills or sensations of heat Paresthesia (numbness or tingling) Derealization (feeling of unreality) or depersonalization (feeling detached from oneself) Fear of dying
Anxiety	Excessive and irrational feelings of anxiety, fear, and worry for a significant amount of time Easily fatigued Difficulty concentrating or a mind going blank Easily irritated Muscle tension, such as stiff jaw muscles, hand muscles, abdominal muscles, and others Sleep disturbances (insomnia)
Stress	Loss of interest in previously enjoyable activities Feeling tired or lacking energy despite sufficient sleep Becoming less open or communicative with those around Feelings of depression or helplessness Unexplained feelings of panic or panic attacks Avoiding social interactions or withdrawing from usual activities Pessimistic mindset about the future Inability to experience positive emotions, such as happiness, contentment, and feeling loved

	Insomnia, difficulty sleeping, or excessive sleeping
	Easily irritated or frustrated, even over small matters.
	Excessive vigilance
	Overreacting to surprises
Depression	Depressed mood nearly all day, almost every day
	Loss of interest in engaging in any activities
	Significant weight loss
	Lack of interest in forming relationships with others
	Having thoughts of suicide or self-harm several times
	Fatigue or loss of energy nearly every day
	Feelings of worthlessness or excessive or inappropriate guilt almost every day
	Decreased ability to think or concentrate

The following table contains features of cases of mental health disorders in students, with weights that support the calculation of the Case-Based Reasoning algorithm. The weighting of these features corresponds to the parameter weights; the higher the weight value, the more influential the symptom is.

Table 3. Parameter Weight

No	Description	Weight Value
1	Rarely	1
2	Often	2
3	Always	3

In this case example, one student presents with several symptoms as follows:
a. Palpitations, rapid heartbeat, or increased heart rate (Often)
b. Trembling (Often)
c. Feeling dizzy (Always)
d. Excessive and irrational feelings of anxiety, fear, and worry for most of the time (Often)
e. Easily fatigued (Always)
f. Easily irritated
g. Difficulty concentrating or having a blank mind (Often)
h. Sleep disturbances (insomnia) (Always)
i. Inability to experience positive emotions, such as happiness, satisfaction, and feeling loved (Often)
j. Easily angry or frustrated, even over small matters (Often)
k. Excessive vigilance (Often)
l. Depressed mood nearly all day, almost every day (Often)
m. Loss of interest in engaging in any activities (Often)
n. Lack of interest in forming relationships with others (Rarely)
o. Having thoughts of suicide or self-harm on several occasions (Rarely)

In calculating similarity, the Case-Based Reasoning method will look for similarities between the selected symptoms and the symptoms from the four (4) categories of mental disorders in students. From these calculations, the diagnosis type with the highest similarity value or percentage is the result of the diagnosis for that case.
1. Finding similarity of the new case with panic disorder.

Table 4. The Similarity of New Cases with Panic Disorder

symptom code	Symptom	X	*Similarity* (s)	Weight (w)
G01	Palpitations, rapid heartbeat, or increased heart rate	Yes	1	2
G02	Excessive sweating	Yes	0	3
G03	Trembling	Yes	1	2
G04	The sensation of shortness of breath or choking	No	0	3
G05	Feeling dizzy	No	1	3
G06	Chest pain or discomfort	No	0	3
G07	Nausea or abdominal distress	No	0	3
G08	Loss of control, such as feeling crazy or having a sense of a mental block that's hard to shake off	No	0	3
G09	Shivering or sensation of heat	No	0	3
G10	Paresthesia (numbness or tingling)	No	0	3
G11	Derealization (feeling of unreality) or depersonalization (feeling detached from oneself)	No	0	3
G12	Fear of dying	No	0	3
	Amount			**36**

$$Similarity = \frac{(S1*W1)+(S1*W2)+\cdots+(Sn*Wn)}{W1+W2+\cdots+W3}$$

$$= \frac{(1*2)+(0*3)+(1*2)+(0*3)+(1*3)+(0*3)+(0*3)+(0*3)+(0*3)+(0*3)+(0*3)}{3+3+3+3+3+3+3+3+3+3+3}$$

$$= \frac{7}{36}$$

= 0,194

The percentage of similarity for panic disorder is:

= 0,194 * 100

= 19,44

2. Finding similarity of the new case with anxiety disorder.

Table 5. Similarity of New Case with Anxiety Disorder

Symptom Code	Symptom	X	*Similarity* (s)	Weight (w)
G13	Excessive and irrational feelings of anxiety, fear, and worry for most of the time	Yes	1	2
G14	Easily fatigued	Yes	1	3
G15	Difficulty concentrating or having a blank mind	Yes	1	2
G16	Easily irritated	Yes	1	2
G17	Muscle tension, such as tightness in the jaw muscles, hand muscles, abdominal muscles, and others	No	0	3
G18	Sleep disturbances (insomnia)	Yes	1	3
	Amount			18

$$Similarity = \frac{(S1*W1)+(S1*W2)+\cdots+(Sn*Wn)}{W1+W2+\cdots+W3}$$

$$= \frac{(1*2)+(1*3)+(1*2)+(0*3)+(0*3)+(1*3)}{3+3+3+3+3+3}$$

$$= \frac{12}{18}$$

= 0,666

The percentage of similarity for anxiety disorder is;

= 0,666 * 100

= 66,66

3. Finding similarity of the new case with stress disorder.

Table 6. Similarity of New Case with Stress Disorder

Symptom code	Symptom	X	*Similarity* (s)	Bobot (w)
G19	Loss of interest in activities that are usually enjoyable	No	0	3
G20	Feeling tired or lacking energy even after getting enough sleep	No	0	3
G21	Becoming less open or communicative with those around you	No	0	3
G22	Feelings of depression or helplessness	No	0	3
G23	Unexplained feelings of panic or panic attacks	Ya	1	2
G24	Avoiding social interactions or withdrawing from usual activities	No	0	3
G25	Pessimistic mindset about the future	No	0	3
G27	Insomnia, difficulty sleeping, or sleeping excessively	Yes	1	2
G28	Easily angered or frustrated, even over small matters	Yes	1	2
G29	Excessive vigilance	No	0	3
G30	Exaggerated startle response	No	0	3
	Amount			36

$$Similarity = \frac{(S1*W1)+(S1*W2)+\cdots+(Sn*Wn)}{W1+W2+\cdots+W3}$$

$$= \frac{(0*3)+(0*3)+(0*3)+(0*3)+(1*2)+(0*3)+(0*3)+(1*3)+(1*2)+(1*2)+(0*3)+(0*3)}{3+3+3+3+3+3+3+3+3+3+3+3}$$

$$= \frac{9}{36}$$

= 0,25

The percentage of similarity for stress disorder is

= 0,25 * 100

= 25

4. Finding similarity of the new case with depression disorder.

Table 7. Finding Similarity of New Case with Depression Disord

Symptom code	Symptom	X	*Similarity* (s)	Weight (w)
G31	Depressed mood nearly all day, almost every day	Yes	1	2
G32	Loss of interest in engaging in any activities	Yes	1	2
G33	Significant weight loss	No	0	3
G34	Lack of interest in forming relationships with others	Yes	1	1
G35	Having thoughts of suicide or self-harm on several occasions	Yes	1	1
G36	Fatigue or loss of energy almost every day	No	0	3
G37	Feelings of worthlessness or excessive or inappropriate guilt nearly every day	No	0	3
G38	Decreased ability to think or concentrate	No	0	3
	Amount			**24**

$$Similarity = \frac{(S1*W1)+(S1*W2)+\cdots+(Sn*Wn)}{W1+W2+\cdots+W3}$$

$$= \frac{(1*2)+(1*2)+(0*3)+(1*1)+(1*1)+(0*3)+(0*3)+(0*3)}{3+3+3+3+3+3+3+3}$$

$$= \frac{6}{24}$$

= 0,25

The percentage of similarity for depression disorder is

= 0,25 * 100

= 25

From the process of calculating the search for similarity above, the similarity results or the similarity of the new case with the four categories of mental disorders are shown in the following Table 7

Table 8. Similarity Results of Case Examples

No	Diagnosis Types	Value Similarity
1	Panic	19,44%
2	Anxiety	66,66%
3	Stress	25%
4	Depression	25%

Based on Table 8 above, the trial results for the case example indicate that the case is diagnosed with anxiety disorder with a similarity value of 66.66

5. Accuracy Testing

The next step is to conduct testing on the system to ensure that the developed system functions properly.

Table 9. Test Data Table of the System

No	Name	Symptom	Expert Diagnosis	System Diagnostics
1	AAP (Man)	G13,G14,G15, G16, G17,G18	Anxiety	72,22% (Anxiety)
2	NYA (Man)	G13,G14,G15, G16, G17,G18	Anxiety	55,55% (Anxiety)
3	DAS (Woman)	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12	Panic	54,17% (Depression)

4	YMS (Man)	G13,G14,G15, G17,G15	Anxiety	50% (Anxiety)
5	SA (Woman)	G13,G14,G15, G16,G15	Anxiety	50% (Anxiety)
6	DAS (Woman)	G01, G02, G03, G04, G05, G06, G07, G08, G09, G10, G11, G12	Panic	54,17% (Anxiety)
7	RF (Man)	G13,G14,G15, G16, G17,G18	Anxiety	55,56% (Anxiety)
8	L (Woman)	G13,G14,G15, G18	Anxiety	50% (Anxiety)
9	SAL (Man)	G13,G14,G15, G16, G17,G18	Anxiety	55,56% (Anxiety)
10	UB (Woman)	G13,G14, G16, G17,G18	Anxiety	50% (Anxiety)
11	AAZ (Man)	G13,G14,G15, G16, G17,G18	Anxiety	50% (Anxiety)
12	RM (Woman)	G20, G21, G22, G23, G24, G25, G27, G28, G29, G30	Stress	55,56% (Stress)
13	TIF (Man)	G31, G32, G34, G35, G36, G37, G38	Depressed	62,50% (Depression)
14	APS (Man)	G01, G02, G03, G04, G05, G06, G07, G10, G11, G12	Panic	52,78% (Panic)
15	ZU (Woman)	G20, G21, G22, G23, G24, G25, G26, G27, G28, G29, G30	Stress	52,78% (Stress)
16	PRP ((Woman)	G19, G20, G21, G22, G23, G24, G25, G27, G28, G29, G30	Stress	52,78% (Depression)
17	HPL (Man)	G19, G20, G21, G22, G23, G24, G25, G27, G28	Stress	55,56 (Stress)
18	AM (Man)	G01, G02, G03, G04, G05, G06, G07, G09, G10, G12	Panic	52,78% (Panic)
19	NI (Woman)	G01, G02, G03, G05, G06, G07, G09, G10,G12	Panic	52,78% (Panic)
20	ATA (Man)	G31, G32, G34, G35, G36, G37, G38	Depressed	54,17% (Depression)

Table 4.13 shows that out of 20 test data, 3 test data do not match. After conducting the tests, the final confusion matrix obtained results in 17 correct data points and three incorrect data points according to the system. Thus, the accuracy calculation is as follows:

$$\text{Akurasi} = \frac{TP+TN}{TP+TN+FP+FN}$$

$$= \frac{17+0}{17+0+0+0+3}$$

$$= \frac{17}{20}$$

$$= 0{,}85 * 100\ \%$$

$$= 85\%$$

Based on the confusion matrix calculations, the accuracy level of the expert system utilizing the CBR method is 85%.

5. Conclusion

Based on the research results, the conclusions can be outlined as follows:

1. The Case-Based Reasoning method works by finding similarities between new and old cases stored in the knowledge base. Solutions to problems are derived from the oldest cases with the highest similarity. The similarity calculations are based on the weights of symptoms related to mental disorders, such as panic, anxiety, stress, and depression, which have been stored in the knowledge base.
2. The implementation of the Case-Based Reasoning method has proven effective in the expert system for determining the likelihood of mental health disorders among students based on the symptom data selected in the system. This is evidenced by system testing using 20 test data points with four categories of disorders and 38 symptoms, resulting in an accuracy level of 85%.
3. Integrating a positive psychology approach within the expert system adds value to the diagnosis. By focusing on individual strengths and potential for growth, the system not only diagnoses disorders but also provides suggestions that support students' well-being and personal development.
4. Implementing a web-based system allows students easy and comprehensive access, facilitating their search for help and information on mental health practically and efficiently. This platform simplifies interaction and use by various users without additional hardware.

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