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Decision Tree-Based Approach for Predicting Mental Health Symptoms in University Students: A Case Study at IT Del

Rudy Chandra[1*], Bella Wahmilyana Asril[1], Erlangga Abel Napitupulu[1], Aqustin Angel D Tambunan[1], Felix Aldi I Simanjuntak[1], Mhd Adi Setiawan Aritonang[2]

[1] *Information Technology, Faculty of Vocational Studies, Institut Teknologi Del, Laguboti, 22381, Indonesia*

[2] *Computer Engineering, Faculty of Information Technology, Batam Institute of Technology, Batam, 29425, Indonesia*

*Corresponding Author: rudychandra@del.ac.id

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Abstract

Mental health significantly affects the well-being and academic productivity of university students. At Institut Teknologi Del, students face multiple stressors, such as heavy academic demands, strict dormitory rules, and social challenges, which often result in high levels of stress, depression, and anxiety. Early detection is therefore essential to support students' psychological resilience and prevent further mental health disorders. This study develops a web-based self-assessment system for mental health using the Decision Tree algorithm. This study analyzed 1,457 psychological screening records from IT Del students (2019–2024), consisting of 23 items on depression and anxiety, modeled using the CRISP-DM methodology. The system was implemented with Python (Flask) for the backend, Laravel for the frontend, and integrated via a REST API. The Decision Tree classifier demonstrated reliable performance. For depression detection, the model achieved accuracy, precision, recall, and F1-score of 0.931. For anxiety detection, performance was lower with accuracy 0.839, precision 0.921, recall 0.782, and F1-score 0.846. The proposed system offers a practical, accurate, and scalable tool for early detection of mental health conditions in university students. By enabling self-assessment and providing digital support for counseling services, this model contributes to strengthening institutional mental health programs.

1. Introduction

Mental health is a vital cornerstone of human well-being, profoundly influencing our social connections, emotional stability, daily activities, and overall productivity [1]. It embodies a state where individuals flourish both physically and psychologically. Specifically, mental health reflects a flourishing condition in which people recognize their strengths, adeptly handle stress, embrace change positively, work effectively, and make meaningful contributions to their communities [2].

In the realm of higher education, mental health is essential for maintaining student engagement and fostering academic success [3], [4]. Unfortunately, various psychological challenges such as stress, anxiety, and depression can significantly hinder students' motivation and learning outcomes [5], [6]. For many, anxiety can lead to distressing symptoms like restlessness, irritability, headaches, dizziness, insomnia, and clouded thinking. At the Institut Teknologi Del (IT Del), we've identified a unique set of stressors associated with dormitory life. The strict dormitory regulations combined with intense academic schedules often contribute to feelings of isolation and envy towards peers outside campus who seem to enjoy more freedom. Our surveys reveal that many IT Del students report high stress levels, difficulty concentrating, signs of depression, and a general sense of helplessness. According to our campus counselor, these challenges are largely attributable to academic pressures, a demanding learning environment, and hurdles in social interactions that collectively impact students' mental resilience.

The rising tide of mental health concerns among university students has spurred a search for focused solutions. Proven strategies like art therapy offer a fantastic avenue for emotional expression through creative activities such as drawing and painting, while character education enhances intellectual and moral development, equipping students with robust coping skills during both academic and life transitions [7], [8]. It's important to acknowledge the operational challenges faced by institutional counseling services, such as limited consultation time and high demand, which can restrict access to personalized mental health support.

Excitingly, emerging technologies, particularly Artificial Intelligence (AI), offer promising new ways to tackle these challenges. AI systems can take on tasks that typically require human intelligence [9], [10]. One notable method is the Decision Tree algorithm [11], which translates complex datasets into clear and understandable decision-making guidance through a tree-like structure [12]. Decision Trees are cherished for their capacity to handle complicated feature interactions, deliver reliable predictions, and provide easily interpretable results. Prior research has already shown their successful application in academic settings.

Anggreani, et al., in 2025 investigates the classification of students' mental health conditions based on academic and social factors using the Decision Tree method, aiming to facilitate early intervention. The dataset comprises 11 academic and social indicators, which underwent preprocessing before analysis. Results reveal that among 973 students without depression, all were accurately classified, and among 104 students with major depression, the model achieved complete classification accuracy. Overall, the method attained 76.71% accuracy, demonstrating strong agreement between predictions and actual conditions. These findings highlight the significant influence of academic and social variables on mental health and confirm the Decision Tree's reliability as a detection tool. The study emphasizes the necessity of targeted counseling services and proactive mental health interventions within academic and social settings [13].

Despite the increasing prevalence of mental health issues among university students, existing campus counseling services often face limitations in accessibility and resources, making early detection and intervention challenging. Therefore, there is a need for a practical, accurate, and scalable digital system that can assist students in understanding their psychological condition while also supporting institutional counseling programs. The problem addressed in this study is the lack of an accessible tool for early detection of depression and anxiety symptoms among students at Institut Teknologi Del. The objective of this research is to develop and evaluate a web-based self-assessment system using the Decision Tree algorithm, which enables students to monitor their mental health status and provides counselors with a reliable digital support system.

2. Related Work

2.1 Mental Health Symptoms

Mental health encompasses more than just the absence of mental disorders; it includes emotional balance, the ability to manage stress, and resilience in the face of life's challenges. A person with good mental health feels content with themselves, has a realistic self-assessment, and accepts their shortcomings and weaknesses. They can confront problems effectively, feel satisfied in their social life, and experience happiness in their overall life. Additionally, mental health can be described as a successful form of self-adjustment or the absence of psychopathology, where an individual exhibits no disorders in psychological, emotional, behavioral, or social aspects. In contrast to the concept of mental health, mental disorders refer to conditions in which individuals experience significant difficulties adapting to their surroundings. An inability to effectively solve problems can lead to excessive stress, rendering an individual's mental health more vulnerable [14]. Mental disorders, also referred to as mental illnesses or psychiatric disorders, are characterized by disturbances in a person's cognitive, emotional, or behavioral functioning, mood regulation, or a combination of these factors.

They occur when adaptive mental mechanisms fail to respond appropriately to external stimuli and psychological stressors, leading to impaired mental functioning [15]. The presence of depression and anxiety among students significantly undermines daily productivity and academic performance. This highlights the need for heightened awareness, both at the individual and community level, as an essential form of self-care and collective responsibility toward mental well-being.

2.2 Decision Tree

The Decision Tree algorithm is a model resembling a flowchart, organized in a hierarchical tree structure. Each internal node represents a test on a specific attribute, each branch indicates the outcome of that test, and each leaf node corresponds to a class label or a class distribution [14], [15]. A Decision Tree is comprised of nodes and edges (links), which can be categorized into three main types:

1. Root Node: This is the starting point of the classification process.
2. Internal or Branch Nodes: These nodes represent decision points based on attributes.
3. Leaf Nodes: These nodes indicate the final classification outcomes.

In classification tasks involving a finite number of classes, the Decision Tree offers a clear and interpretable decision-making framework. The root and internal nodes are labeled with attribute names, the edges are labeled with possible attribute values, and the leaf nodes carry distinct class categories. This structural clarity makes the Decision Tree an effective and transparent classification technique for various data analysis and machine learning applications [16].

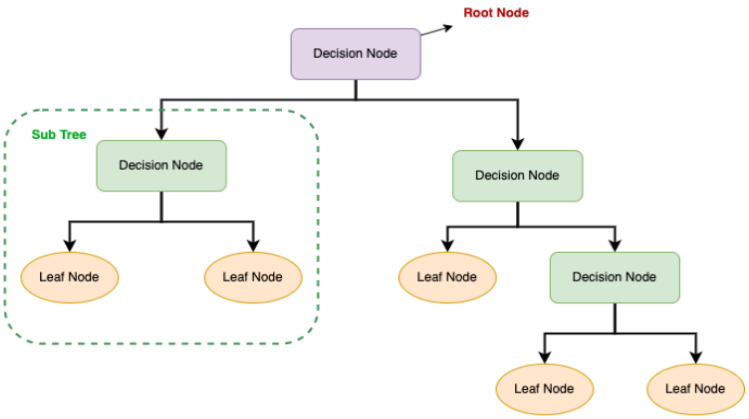


Fig 1. *Decision Tree hierarchical flowchart*

This hierarchical arrangement, as illustrated in Fig. 1, enables Decision Trees to model decision-making processes in a structured and interpretable way, making them widely applicable in classification and prediction tasks.

2.3 Confusion Matrix

Confusion Matrix is a concept for calculating actual data and predictive results from a classification/identification method used [17]. The Confusion Matrix table has 2 dimensions, including the dimensions of the actual data and the predicted results [18], [19], as shown in Table 1.

Table 1 ***Confusion Matrix***

		True Values	
		True	*False*
Prediction	*True*	TP *Correct Result*	FP *Unexpected result*
	False	FN *Missing result*	TN *Correct absence of result*

The prediction performance calculation is described as follows[20]:

1. Accuracy

Accuracy is the percentage of the total correct number of each identification process which explains the accuracy of the model in identifying.

$$\boldsymbol{Accuracy} = \frac{\boldsymbol{TP+TN}}{\boldsymbol{n}} \quad (6)$$

2. Recall

Recall the percentage of positive data compared to the overall positive data

$$\boldsymbol{Recall} = \frac{\boldsymbol{TP}}{\boldsymbol{TP+FN}} \quad (7)$$

3. Precision

Precision percentage correct positive with overall positive predicted result

$$\boldsymbol{Precision} = \frac{\boldsymbol{TP}}{\boldsymbol{TP+FP}} \quad (8)$$

4. F1-Score

Comparison of the average precision and recall obtained

$$\textit{F1-score} = \frac{\boldsymbol{2 \times (All\ Precision \times All\ Recall)}}{\boldsymbol{All\ Precision + All\ Recall}} \quad (9)$$

3. Methodology

CRISP-DM stands for Cross-Industry Standard Process for Data Mining (CRISP-DM). The CRISP-DM method serves as a structured and documented framework with clear steps for conducting data mining analysis [21], as illustrated in Fig. 2.

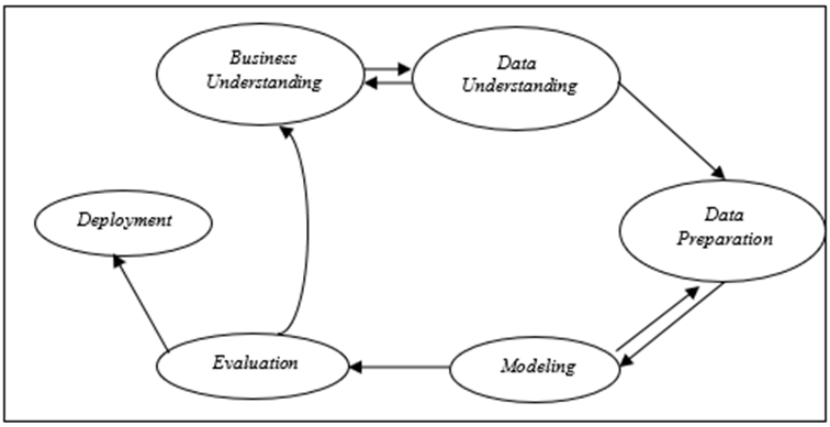


Fig. 2 ***Cross-Industry Standard Process for Data Mining***

3.1 Business Understanding

Mental health is a fundamental foundation for daily activities, as a stable psychological state and the ability to adapt to one's surroundings are crucial for maintaining and even enhancing individual productivity. This is especially relevant for university students, for whom stable and positive mental health is essential for achieving academic success.

On the other hand, mental health issues can lead to reduced motivation for learning, poor management of time and emotions, and strained social relationships. Recognizing these challenges, mental health becomes a critical factor in promoting productivity. This study addresses this issue by developing a simple web-based platform designed to help students assess and understand their mental health status. Specifically, the research implements a Decision Tree algorithm to predict the mental health conditions of IT Del students, using the web interface as a medium for delivering predictive outcomes.

3.2 Data Understanding

The dataset used in this study was gathered from questionnaire responses of Institut Teknologi Del students between 2019 and 2024. The questionnaire consisted of 23 items, with 15 items designed to assess depressive symptoms and 8 items to assess anxiety symptoms. The questions covered indicators such as sleep disturbances, loss of interest in activities, prolonged sadness, and suicidal thoughts. Each response was recorded on a four-point frequency scale: Never (1), Occasionally (2), Fairly Often (3), and Often (4), which was then converted into numerical features for analysis. In total, the dataset contained 1,457 records. Each record was labeled according to two categories: Tend to Be Depressed or Not Depressed, and Tend to Be Anxious or Not Anxious.

3.3 Data Preparation

The instrument comprised 23 items divided into two categories: 15 items assessing depressive symptoms and 8 items assessing anxiety symptoms. Following collection, the dataset was partitioned for model development and evaluation using an 80:20 stratified split, preserving class distribution across training and testing sets. Approximately 1,165 records were allocated for training and 292 for testing. This approach aims to optimize model learning while ensuring that predictive performance generalizes effectively to unseen data.

3.4 Modelling

This study develops predictive models for psychological conditions, specifically anxiety and depression, using the Decision Tree Classifier algorithm. Decision Tree classification models—trained with varying parameters (max_depth = 3, 4, 5; min_samples_split = 5, 10; min_samples_leaf = 5, 10)—were evaluated using standard performance metrics for classification tasks. Two independent Decision Tree models were trained: (i) the Anxiety Model, which utilized anxiety-related features, and (ii) the Depression Model, which focused on depression-related features. Hyperparameters were tuned to control model complexity and improve generalization.

3.5 Evaluation

The Evaluation phase aims to assess the performance of models developed during the Modeling stage, ensuring alignment with the business objectives established in the Business Understanding phase. The evaluation utilized key metrics including accuracy, precision, recall, F1-score, and the confusion matrix. Both the anxiety detection model and the depression detection model were subjected to this assessment. Parameter tuning or further experimental iterations were planned to enhance predictive accuracy. Model performance was evaluated using accuracy on a held-out test set. The trained models were serialized in .pkl format using the Joblib library for deployment in a Flask API. This system accepts user responses, encodes them numerically, and classifies the individual's psychological condition using the trained Decision Tree models

3.6 Deployment

The Decision Tree models developed in this study were serialized in .pkl format using the *Joblib* library. For deployment, a prediction service was implemented via a Flask-based API, designed to receive input data from a Laravel application, perform predictions using the trained model, and return the results in JSON format.

The system employed a hybrid client–server architecture, with Laravel functioning as the main application and Flask as an independent prediction service. Its structural components included:

- Frontend (Laravel Blade Templates) – hosting the questionnaire interface.
- Laravel Controller – managing data input, API requests to Flask, and result display.
- Flask API – handling model inference and prediction logic.
- Decision Tree Model (.pkl) – stored on the Flask server and invoked during prediction.

This modular architecture offers high flexibility, enabling model updates within the Flask service without altering the primary Laravel system. Such a design facilitates efficient maintenance, scalability, and streamlined future development.

4. Results and Discussion

During the training process, the accuracy values of each model employed for classifying anxiety and depression conditions were systematically recorded. The performance evaluation results of these models are presented in tables that compare accuracy levels across various testing scenarios. This presentation aims to provide a comprehensive overview of each model's effectiveness in identifying the psychological conditions under investigation.

This evaluation was conducted on data representing students categorized as "Tending Towards Depression and Anxiety," thereby providing an assessment of the model's consistent performance within this specific population group. Table 2 and 3 presents the results of model evaluation performed using the *five-fold cross-validation* method. The reported values represent the mean accuracy obtained from each fold during the validation process.

Table 2 ***Depression Evaluation***

Model	Max_Depth	Min_Split	Min_Leaf	Accuracy	Recall	Precision	F1-Score
1	3	5	5	0.923	0.903	0.940	0.921
2	3	5	10	0.923	0.903	0.940	0.921
3	3	10	5	0.923	0.903	0.940	0.921
4	3	10	10	0.923	0.903	0.940	0.921
5	4	5	5	0.941	0.927	0.954	0.940
6	4	5	10	0.934	0.912	0.953	0.932
7	4	10	5	0.941	0.927	0.954	0.940
8	4	10	10	0.934	0.912	0.953	0.932
9	5	5	5	0.947	0.939	0.954	0.947
10	5	5	10	0.935	0.931	0.939	0.935
11	5	10	5	0.947	0.939	0.954	0.947
12	5	10	10	0.935	0.931	0.939	0.935

Table 3 ***Anxiety Evaluation***

Model	Max_Depth	Min_Split	Min_Leaf	Accuracy	Recall	Precision	F1-Score
1	3	5	5	0.826	0.973	0.742	0.921
2	3	5	10	0.826	0.973	0.742	0.921
3	3	10	5	0.826	0.973	0.742	0.921
4	3	10	10	0.826	0.973	0.742	0.921
5	4	5	5	0.834	0.869	0.801	0.940
6	4	5	10	0.834	0.878	0.796	0.932

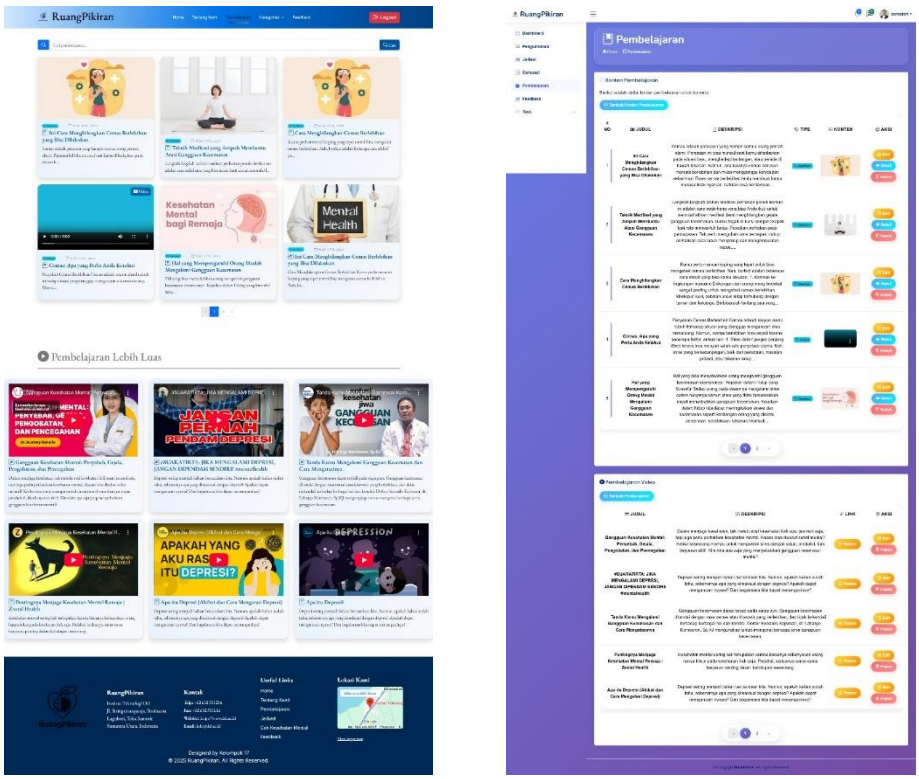
Model	Max_Depth	Min_Split	Min_Leaf	Accuracy	Recall	Precision	F1-Score
7	4	10	5	0.834	0.869	0.801	0.940
8	4	10	10	0.834	0.878	0.796	0.932
9	5	5	5	0.846	0.946	0.780	0.947
10	5	5	10	0.844	0.939	0.779	0.935
11	5	10	5	0.846	0.946	0.780	0.947
12	5	10	10	0.844	0.939	0.779	0.935

Among the twelve experiments conducted in Depression and Anxiety, the ninth model achieved the highest mean evaluation score, configured with a Max_Depth: 5, Min_Split: 5, and Min_Leaf: 5. This model was subsequently selected for further testing using the testing dataset to ensure its performance. The testing outcome is expected to yield an optimal model ready for deployment on the web platform. The testing results using the selected model are summarized in Table 4, which reports the evaluation of depression and anxiety detection on the held-out dataset.

Table 4 *Evaluation of Test Set Data of Depression and Anxiety*

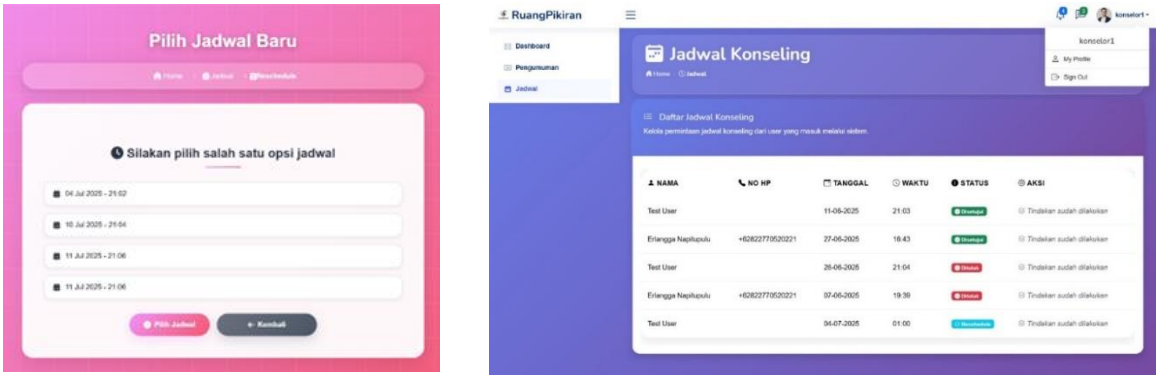
Class	Accuracy	Recall	Precision	F1-Score
Depression	0.931	0.931	0.931	0.931
Anxiety	0.839	0.921	0.782	0.846

The two developed models will be integrated into the constructed web platform. Upon completion of the embedding process, users will be able to access and utilize various available features, including an educational page containing learning materials on mental health, a scheduling system for counseling sessions with counselors, and a mental health assessment test. This integration aims to provide a comprehensive and easily accessible service to support the monitoring and improvement of users' psychological well-being.



(a) (b)

Fig. 3 *Figure of Educational (a) user page; (b) admin page*



(a) (b)

Fig. 4 ***Figure (a) Set counseling schedule (b) counseling schedule***

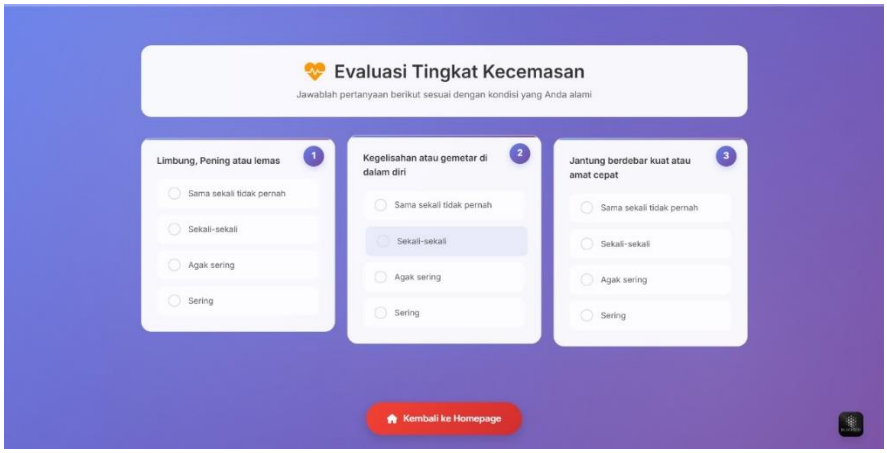


Fig. 5 ***Mental health assessment test page***

The developed platform provides both an educational page for students and an admin interface for counselors, as illustrated in Fig. 3. In addition, the system allows users to set and manage counseling sessions with counselors, as shown in Fig. 4. Finally, the platform integrates a mental health self-assessment test that students can complete online, as presented in Fig. 5. These results demonstrate that the proposed platform not only achieves reliable predictive performance but also provides practical tools that can support student mental health services in a digital and accessible manner.

5. Conclusion

The model's simple yet effective structure ensures computational efficiency and facilitates seamless integration into web-based systems. Despite testing with various parameter combinations, the model's accuracy remained stable. The Decision Tree model used in this study effectively classified students' mental health conditions into four categories: Tending Towards Depression, Not Depressed, Tending Towards Anxiety, and Not Anxious. The testing results showed that the model demonstrated high accuracy and stability, which Depression category achieved an accuracy of 0.931; precision: 0.931; recall: 0.931; F1-score: 0.931. The Tend to Be Anxiety category, performance reached accuracy 0.839; Precision 0.921; Recall 0.782; F1-score 0.846, making it a reliable tool for the early identification of students' psychological conditions. These strengths make the Decision Tree approach an effective method for supporting technology-based early detection systems in the field of mental health. This system is expected to support counseling services and serve as an efficient, sustainable solution within the Institut Teknologi Del environment.

While this study focuses exclusively on the Decision Tree algorithm, future research could incorporate baseline comparisons with other classifiers such as Logistic Regression, Random Forest, or Support Vector

Machines to provide a more comprehensive evaluation. Furthermore, addressing potential data imbalance through resampling or weighting techniques could improve model fairness across categories. In addition, exploring ensemble learning approaches or deep learning models offers promising opportunities to enhance predictive performance, particularly in detecting complex conditions such as anxiety.

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