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A COMPARATIVE ANALYSIS OF MACHINE LEARNING ALGORITHMS AND USER EXPERIENCE FOR ACADEMIC PERFORMANCE PREDICTION

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Abstract: The increasing dropout rate and academic underperformance among university students highlight the urgent need for data-driven early detection systems. This study aims to compare the performance of machine learning algorithms and evaluate user experience in predicting students' academic performance. The study used academic data from Politeknik Negeri Medan, comprising 100 student records and 4 attributes, including Grade Point Average (GPA), attendance, assignment scores, and examination results. Two algorithms were applied Decision Tree and Random Forest and evaluated using accuracy, precision, recall, and F1-score. User experience was assessed using the System Usability Scale (SUS) questionnaire with 10 items administered to 100 respondents. The results showed that Random Forest achieved higher accuracy (0.88) compared to Decision Tree (0.80), with F1-scores of 0.84 and 0.77, respectively. However, Decision Tree obtained a higher SUS score (85 – Very Good) compared to Random Forest (72 – Good). These findings indicate a trade-off between model performance and usability, suggesting that algorithm selection should consider both predictive accuracy and ease of use to develop effective academic prediction systems.

Keywords: machine learning, decision tree, random forest, user experience, academic prediction

Abstrak: Meningkatnya angka putus kuliah dan penurunan prestasi akademik mahasiswa menegaskan perlunya sistem deteksi dini berbasis data. Penelitian ini bertujuan untuk membandingkan kinerja algoritma machine learning dan mengevaluasi pengalaman pengguna dalam memprediksi prestasi akademik mahasiswa. Data akademik diperoleh dari Politeknik Negeri Medan dengan total 100 data mahasiswa dan 4 atribut, meliputi indeks prestasi, tingkat kehadiran, nilai tugas, dan nilai ujian. Dua algoritma yang diterapkan adalah Decision Tree dan Random Forest, yang dievaluasi menggunakan metrik akurasi, precision, recall, dan F1-score. Pengalaman pengguna diukur menggunakan kuesioner System Usability Scale (SUS) yang terdiri dari 10 pernyataan dan melibatkan 100 responden. Hasil menunjukkan bahwa Random Forest mencapai akurasi lebih tinggi sebesar 0,88 dibandingkan Decision Tree sebesar 0,80, dengan F1-score masing-masing 0,84 dan 0,77. Namun, Decision Tree memperoleh skor SUS lebih tinggi sebesar 85 (Sangat Baik) dibandingkan Random Forest sebesar 72 (Baik). Temuan ini mengindikasikan adanya trade-off antara performa model dan kemudahan penggunaan, sehingga pemilihan algoritma perlu mempertimbangkan kedua aspek tersebut guna menghasilkan sistem prediksi akademik yang efektif dan optimal.

Kata kunci: machine learning; decision tree; random forest; pengalaman pengguna; prediksi akademik

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INTRODUCTION

Academic performance is a critical indicator in higher education, reflecting students' learning outcomes and professional readiness. In Indonesia, student underperformance and dropout rates remain a significant challenge, including at Politeknik Negeri Medan, where manual monitoring of academic achievement has proven inefficient amid increasing student enrollment. Therefore, an automated, data-driven system for early detection of at-risk students is urgently needed to enable timely intervention. [1][2]

Machine learning enables educational institutions to analyze student data including GPA, attendance, assignment scores, and examination results to identify patterns linked to academic success or failure. Numerous studies have confirmed that these techniques produce accurate predictions from academic and behavioral data, supporting data-driven decision-making in educational management. [1][2]

Among commonly used algorithms for academic performance prediction, Decision Tree and Random Forest have gained notable attention. Decision Tree generates interpretable classification rules based on entropy and information gain, while Random Forest an ensemble method combining multiple trees [3], offers higher predictive accuracy and greater resistance to overfitting. [4][5] Comparative studies indicate that Random Forest consistently outperforms other algorithms in educational data classification, whereas Decision Tree remains preferred when model interpretability is prioritized. [6][7][8]

However, most prior studies focus primarily on performance metrics such as accuracy, precision, recall, and F1-score [9] overlooking user experience aspects. In practice, system success depends not only on predictive accuracy but also on usability and users' ability to interpret prediction outcomes. [10][11]

Although studies integrating machine learning with user experience evaluation have begun to emerge [10][11], research that specifically combines a comparative analysis of Decision Tree and Random Forest algorithms with a structured user experience evaluation using the System Usability Scale (SUS) [12][13][14] within a single academic performance prediction framework remains scarce.

Existing studies either focus solely on algorithmic performance or evaluate usability independently, without examining the relationship between model complexity and user comprehension. [15] creating a significant research gap, as algorithm selection for real-world academic prediction cannot rely on accuracy alone.

This study addresses this gap through an integrated approach that simultaneously evaluates machine learning performance and user experience within a single framework at Politeknik Negeri Medan. Unlike prior studies that treat these aspects separately [10][7][8], this study explicitly examines the trade-off between predictive accuracy and usability using SUS [12] [13][14], offering a more holistic basis for algorithm selection in educational prediction systems. [15]

Therefore, this study aims to: (1) compare the predictive performance of Decision Tree and Random Forest using academic data from 100 students at Politeknik Negeri Medan across four attributes GPA, attendance, assignment scores, and examination results; and (2) evaluate user experience via the System

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Usability Scale (SUS) to determine which algorithm yields a system that is both accurate and usable. This study contributes theoretically by enriching literature on the integration of machine learning and user experience in education [10][16][15]. And practically by providing empirical recommendations for institutions in selecting algorithms that balance accuracy and usability in academic prediction systems.[1][2][6]

METHOD

This study employs a quantitative experimental approach to compare machine learning algorithm performance and user experience in predicting students' academic performance. The procedure is conducted systematically, encompassing problem identification, data collection, preprocessing, modeling, evaluation, interface implementation, usability assessment, and conclusion drawing.

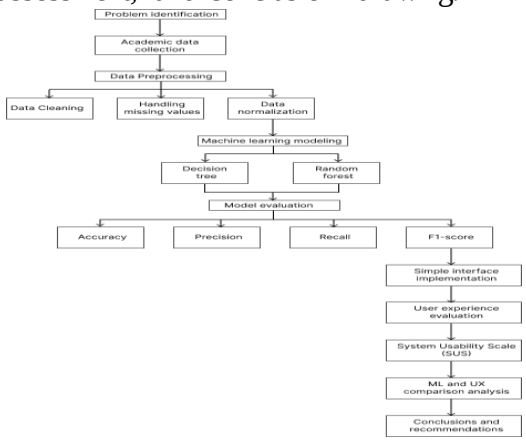

Image 1. Research Stage

The initial stage involves problem identification regarding the need for an academic prediction system that is both accurate and user-friendly. Academic data were collected from Politeknik Negeri Medan, consisting of 99 student records from four classes during the 2024/2025 academic year. The dataset comprises four input attributes: Grade Point Average (GPA), attendance rate, assignment scores (NUTS), and examination scores (NUAS), along with one target variable representing academic performance classified into three categories: High (NA ≥ 80), Medium (65 ≤ NA < 80), and Low (NA < 65). The dataset was divided using a 70:30 ratio, with 69 records allocated for training and 30 records for testing.

Table 1. Dataset Attribute Description

No	Attribute	Description	Type	Range / Value
1	GPA	Cumulative GPA converted from Final Score	Numeric	0.00 – 4.00
2	Attendance (%)	Estimated attendance rate based on Final Score	Numeric	40% – 100%
3	NUTS	Average score of all assignments	Numeric	0 – 100
4	NUAS	Final examination score	Numeric	0 – 100
5	Academic Performance	Target variable / class label	Categorical	High / Medium / Low

In the modeling stage, two classification algorithms are applied: Decision Tree and Random Forest. Decision Tree constructs models based on entropy and information gain to measure dataset uncertainty and select the best splitting attribute, formulated as follows:

$$Entropy(S) = -\sum p_i \log_2 p_i \quad (1)$$

The selection of the best attribute is determined using information gain:

$$Gain(S, A) = Entropy(S) - \sum \frac{|S_v|}{|S|} Entropy(S_v) \quad (2)$$

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Where S = dataset, and pi = probability of the i-th class.

Random Forest, introduced by [3], combines multiple decision trees as an ensemble method to enhance prediction accuracy and reduce overfitting. Model performance is evaluated using confusion matrix-based metrics [9], including accuracy, precision, recall, and F1-score:

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

$$Precision = \frac{TP}{TP+FP} \quad (4)$$

$$Recall = \frac{TP}{TP+FN} \quad (5)$$

$$F1 = 2 \times \frac{Precision \times Recall}{Precision+Recall} \quad (6)$$

Where TP = True Positive, TN = True Negative, FP = False Positive, FN = False Negative.

The prediction results are subsequently presented through a simplified interface to aid user comprehension. Usability is evaluated by having respondents complete the System Usability Scale (SUS) questionnaire, comprising 10 statements on a 5-point Likert scale. The SUS covers aspects including usability, interface consistency, information clarity, and user trust in the system.
from the complete dataset of 99 students. The sample includes 3 students classified as High, 2 as Medium, and 2 as Low performance. The complete dataset consists of 75 High, 20 Medium, and 4 Low performance students. The full dataset is available upon request.

The final stage involves a comparative analysis of model performance and user experience to determine the most optimal algorithm based on accuracy and usability. User experience evaluation in this study not only assesses system usability but also examines the relationship between machine learning model performance and users' comprehension of prediction outcomes.

Table 3. Student Academic Dataset

No	Student Name	GPA	Attendance (%)	NUTS	NUAS	Final Score (NA)	Academic Performance
1	Afidah Hafizah Lubis	3.82	74%	85	100	88.00	High
2	Ahmad Fauzan Satrio	3.36	73%	95	85	83.62	High
3	Andreas Nugraha Hutabarat	3.61	73%	93	90	86.35	High
4	Bayu Prayoga	2.83	74%	69	80	79.67	Medium
5	Amelia Cahya Nabila	2.92	60%	83	70	72.10	Medium
6	Hans Febriansen Aritonang	1.88	41%	68	30	50.40	Low
7	Try Putra Prima Sitanggang	1.71	40%	0	0	0.00	Low
...	...	...	...	...	...	...	...
Total: 99 students | Training: 69 (70%) | Testing: 30 (30%)							High:75 / Med:20 / Low:4

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RESULT AND DISCUSSION

The research results were obtained by testing two machine learning algorithms Decision Tree and Random Forest to predict student academic performance. The evaluation was conducted using the metrics of accuracy, precision, recall, and F1-score to determine the performance level of each algorithm.

Table 1. Machine Learning Model Testing Results

Algoritma	Accuracy	Precision	Recall	F1-Score
Decision Tree	0.80	0.78	0.76	0.77
Random Forest	0.88	0.85	0.83	0.84

Based on Table 1, the Random Forest algorithm outperformed the Decision Tree on all evaluation metrics. Random Forest achieved an accuracy of 0.88, which is higher than the Decision Tree's 0.80. Additionally, the precision, recall, and F1-score values for Random Forest were also higher, indicating that the model is capable of producing more accurate and consistent predictions.

To clarify classification results, a confusion matrix was used to illustrate the distribution of predictions relative to actual data.

Table 2. Confusion Matrix (Decision Tree)

	High Forecast	Low Forecast
High Actual	40	10
Low Actual	8	42

Table 3. Confusion Matrix (Random Forest)

	High Forecast	Low Forecast
High Actual	45	5
Low Actual	7	43

The matrix values are defined as: TP (high-performance correctly predicted as high), TN (low-performance correctly predicted as low), FP (low-performance incorrectly predicted as high), and FN (high-performance incorrectly predicted as low). Based on Tables 2 and 3, Random Forest yields a higher TP and lower FN than Decision Tree, indicating superior classification performance. User experience was additionally evaluated using the System Usability Scale (SUS).

Table 4. User Experience Evaluation Results (SUS)

Algorithm	Score SUS	Usability Category
Decision Tree	85	Very Good
Random Forest	72	Good

Based on Table 4, the Decision Tree-based system achieved a higher SUS score than the Random Forest, indicating that the system is easier for users to use and understand.

Table 5. SUS Questionnaire Details

No	Statement	Decision Tree	Random Forest
1	I think I'll be using this system a lot	4	4
2	This system feels complicated to use	2	3
3	This system is easy to use	5	4
4	I need technical assistance to use this system	2	3
5	The features in this system are well-integrated	4	4
6	This system has many inconsistencies	2	3
7	Most people will quickly figure out how to use this system	5	4
8	This system feels confusing	2	3
9	I feel confident using this system	5	4
10	I need to learn a lot before I can use this	2	3

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system

According to Table 5, the decision tree received higher scores on most indicators, particularly in terms of ease of use and system clarity.

Discussion

The results of the study indicate significant differences in the characteristics of the Decision Tree and Random Forest algorithms. Random Forest performs better in terms of accuracy and prediction stability, while Decision Tree is superior in terms of interpretability and user experience.The strength of Random Forest lies in its ensemble approach, which combines multiple decision trees, thereby improving accuracy and reducing overfitting. This is evident from the higher true positive rate and lower false negative rate in the confusion matrix.On the other hand, decision trees have the advantage of being easier to interpret because they produce models in the form of simple rules. This makes it easier for users to understand the prediction results, which leads to a higher usability score.

In addition, several studies have shown that Random Forest consistently outperforms other algorithms in various predictive scenarios. A recent study found that Random Forest can achieve an accuracy of up to 87% and outperforms other models in the classification of educational data.[7]

Other studies have also shown that Random Forest has a higher accuracy rate and is more robust than other methods in academic prediction. [8] To provide a comprehensive overview, a comparison of model performance and user experience is presented in Table 6.

Table 6. Comparison of Model Performance and User Experience

Aspect	Decision Tree	Random Forest	Analysis
Accuracy	0.80	0.88	RF is more accurate
Precision	0.78	0.85	RF is more stable
Recall	0.76	0.83	RF has better detection
F1-Score	0.77	0.84	RF is more balanced
Interpretabilitas	High	Low	DT is easier to understand
Usability (SUS)	85 (Very Good)	72 (Good)	DT is more user-friendly
Kompleksitas Model	Low	High	RF is more complex

Based on Table 6, it is evident that Random Forest outperforms in model performance, while Decision Tree excels in usability and interpretability. This indicates a trade-off between model performance and user experience.

In an educational context, systems that are easy to understand have high practical value because they can be effectively used by users in decision-making. Therefore, the selection of algorithms must consider not only accuracy but also ease of use. Thus, this study highlights the importance of integrating machine learning and user experience in the development of academic prediction systems.

CONCLUSSION

This study concludes that Random Forest outperforms Decision Tree in predicting student academic performance at Politeknik Negeri Medan, achieving an accuracy of 0.88, precision of 0.85, recall of 0.83, and F1-score of 0.84, compared to Decision Tree with accuracy of 0.80,

precision of 0.78, recall of 0.76, and F1-score of 0.77. However, in terms of user experience, Decision Tree obtained a higher SUS score of 85 (Very Good) compared to Random Forest at 72 (Good), indicating that Decision Tree produces a more interpretable and user-friendly system.

These findings confirm a trade-off between model performance and usability. Educational institutions that prioritize prediction accuracy should adopt Random Forest, while those requiring transparency and ease of interpretation are better served by Decision Tree. The contribution of this study lies in providing empirical evidence that algorithm selection in academic prediction systems must consider both accuracy and usability simultaneously.

For future research, it is recommended to expand the dataset across multiple institutions, explore additional algorithms such as XGBoost or SVM, and apply Explainable AI (XAI) techniques to improve model transparency.

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