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Improvement of Students' Academic Achievement Classification Model Through the Analytical Hierarchy Process Algorithm in Elementary School Burujul Kulon III

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Abstract

This study aims to improve the classification model of students' academic achievement at SD Negeri Burujul Kulon III using the Analytical Hierarchy Process (AHP) algorithm. This method is applied to analyze various student assessment criteria, including knowledge, skills, spiritual attitudes, and social attitudes, in order to create an objective and systematic evaluation system. The Knowledge Discovery in Databases (KDD) approach is used to ensure structured data management, including the stages of data collection, selection, transformation, analysis, and evaluation. The population of this study was all students of SD Negeri Burujul Kulon III with a sample size taken using the Stratified Random Sampling method, which ensures accurate representation of all grade levels. Data were collected through documentation studies, including exam result reports, skill assessments, and student behavior records observed by teachers. The analysis was carried out by applying the AHP algorithm to determine the priority weight of each assessment criterion through pairwise comparisons. The weights obtained are used to calculate the final grade which is the basis for classifying student achievement. The results of the study indicate that the AHP algorithm is able to produce a more accurate and relevant classification model to identify students with superior achievement, which is not only based on academic exam results but also includes student skills and attitudes. The resulting system provides significant benefits in academic decision-making, such as awarding outstanding students, identifying students who need special attention, and developing more effective learning strategies. This research also contributes to the development of data-based technology for educational evaluation, and can be an important reference for other educational institutions that want to improve the quality of evaluation, learning effectiveness, and student data management comprehensively, systematically, and sustainably in the future.

Keywords: *Analytical Hierarchy Process, Achievement Classification, Education.*

1. Introduction

Rapid developments in the field of Informatics have had a significant impact on various aspects of life, including technology, business, education, and the public sector. In this digital era, the transformation of information technology has not only changed the way we interact, but also affects the way we learn and teach. The education sector, as one of the key components in community development, faces the challenge of adopting technology to improve the quality of teaching and learning. Moreover, with the increasing amount of data available, the use of appropriate analysis methods becomes crucial in assessing and improving students' academic achievement. Therefore, it is important to develop an effective classification model, so that education can be optimized according to students' needs and potentials. However, despite the progress in the application of information technology, a number of challenges remain in the educational context, especially in terms of managing students' academic data. One of the main challenges is the inaccuracy in assessing student achievement, which can be caused by various factors, including less objective and inconsistent evaluation methods. In addition, many schools have not utilized modern data analysis techniques, making it difficult for them to identify students with high potential or those who need special attention. This gap indicates the need for a new approach to academic assessment that is not only accurate but also adaptive to the needs of different students. The availability of algorithms such as the Analytical Hierarchy Process (AHP) can be a solution to this problem, although its use in the educational context is still limited.

Previous studies have explored the use of the Analytical Hierarchy Process (AHP) Algorithm in various contexts, including improving students' academic achievement in schools. For example, research by [1] The AHP method is one of the methods in a decision support system that is unique compared to others. This is because in weighting the criteria, the weight of each criterion is not determined in advance but is determined using a formula from this method based on a priority scale (level of importance) sourced from the saatt table. In addition, research conducted by [2] The AHP method has advantages in weighting/rating factors and their classes as well as several disadvantages. The relative assessment of these factors largely depends on the knowledge of a person or professional. The relative preference given to a factor by a person or professional is often not recognized by others, which is a major weakness of any subjective decision-making system. However, pairwise comparisons provide a simple and acceptable decision rule. For example, a study by [3] AHP allows decision makers

to evaluate several alternative choices based on several existing criteria and then choose the optimal choice. The AHP model is in the form of a linear hierarchy so that the priority of attributes or criteria can be modeled. In addition, a study by [4] AHP can decide on quantitative and qualitative problems, the advantage of AHP is that it simplifies complex problems into a simple form in the form of a problem-solving hierarchy. Research conducted by [5] The AHP method can be used in decision making with complex situations. This method is considered to make it easier for researchers to make decisions compared to existing methods. The AHP method is used to determine the best alternative to a problem based on certain criteria. This method is considered very effective for comparing existing alternatives. In addition, research by [6] One of the most widely used methods is the Analytical Hierarchy Process (AHP) method. This method can solve very complex problems that can be easily simplified and can provide convenience in every decision making based on determining criteria, compiling hierarchies, providing comparative values against criteria to the ranking process. Study by [7] The concept of AHP is to change qualitative values into quantitative values.

2. Literature Review

2.1. Related Research Results

Paper [1] entitled "Decision Support System for Study Program Selection Using the Analytical Hierarchy Process (AHP) Method" [8] discusses the application of the AHP method as a decision-making tool to help students choose study programs that suit their interests and needs. The main problem raised is the confusion experienced by students in determining the appropriate study program, considering the many choices and criteria that must be considered. The AHP method is used to break down the study program selection process into a hierarchical structure, where various criteria such as interests, academic ability, job prospects, and costs are the main considerations. Each criterion is then weighted and ranked, so that students can evaluate the study program that best suits their preferences based on the results of the hierarchical analysis.

Paper [2] entitled “Evaluation of E-learning Using Analytical Hierarchy Process (AHP)” [9] discusses the application of the AHP method in evaluating the effectiveness of e-learning in higher education. The background of this journal is the importance of evaluating e-learning which is still relatively new and has not completely replaced face-to-face learning methods. This evaluation aims to improve the quality of e-learning so that it is more optimal and effective in supporting the teaching and learning process. In this study, AHP is used to identify and weight various important criteria that affect the quality of e-learning, such as content quality, interaction between lecturers and students, ease of access, and availability of technical support. Each of these criteria is arranged in a hierarchical form, and AHP helps in determining priorities based on their level of importance.

Paper [4] entitled “K-Nearest Neighbor Algorithm to Predict Student Achievement Based on Educational and Economic Background” [10] discusses the application of the K-Nearest Neighbor (K-NN) algorithm in predicting student academic achievement. The purpose of this study is to assist universities in making predictions about student academic achievement based on background factors such as education and economic conditions. This is important because achievement prediction can be a useful tool in the decision-making process related to student guidance and support. In this paper, K-NN is used as the main method because this algorithm works by comparing existing student data with historical data of other students who have similar characteristics. The K-NN algorithm will determine the nearest "neighbor" based on similarities in educational and economic background, and then predict academic achievement based on patterns found in the data.

Paper [6] entitled "Employee Performance Decision Support System Bumi Mandiri Sukabumi Using AHP Method" [11] discusses the use of the Analytical Hierarchy Process (AHP) method as a solution to increase objectivity in employee performance assessment at Bumi Mandiri Sukabumi. Currently, performance assessments in the company are considered subjective and less transparent, due to the absence of specific evaluation criteria, so they are considered unfair and difficult for employees to understand. This study aims to build an AHP-based Decision Support System (DSS) that is able to compile structured assessment criteria and weights to assist in fairer and more accountable decision making in the performance assessment process.

Paper [7] entitled “Comparison of Data Mining Methods to Predict Student Academic Achievement” [12] discusses the use of data mining methods to predict student academic achievement. The focus of this study is to help educational institutions distribute scholarships more accurately to high-achieving students. In this context, errors often occur in scholarship allocation due to inaccuracy in predicting students who truly excel. To address this problem, this paper compares several data mining methods that can be used to predict student academic achievement, including algorithms such as Decision Tree, Naive Bayes, and K-Nearest Neighbors (K-NN).

3. Research Methods

The approach used is Knowledge Discovery in Databases (KDD), which is a systematic process for extracting knowledge from data in a database. The KDD stages are applied to ensure that the data analysis process runs in a structured manner, starting from data selection, data transformation, to pattern mining and evaluation of results as shown below.

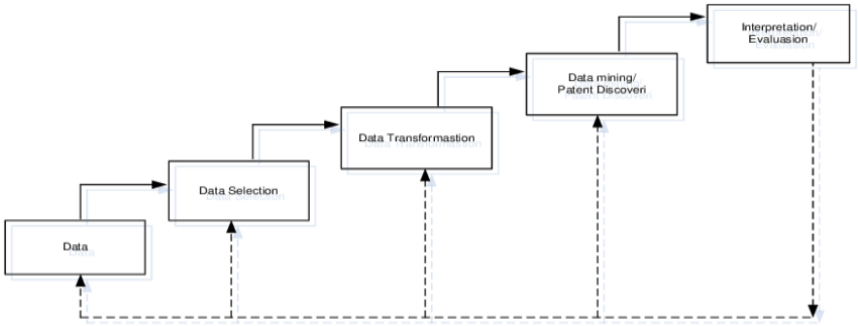

Figure 1: Research Stages of KDD Method

This research method aims to develop a classification model of student academic achievement at SD Negeri Burujul Kulon III using the Analytical Hierarchy Process (AHP) algorithm. The steps in this study are designed so that the results obtained can provide valid, accurate, and relevant information, which can be used as a basis for classifying student achievement. By combining the KDD approach and the AHP algorithm, this study is expected to contribute to data-based decision making in the field of education.

4. Result and Discussion

4.1. Data Selection

The results of the data after the selection show the values of the four main aspects used to measure students' academic achievement, namely Knowledge, Skills, Spiritual Attitude (KI-1), and Social Attitude (KI-2). From the table shown, it can be seen that the Knowledge and Skills values of the students vary, with the highest value recorded by Indira Pratiwi who has a Knowledge value of 791.0 and Skills of 770.0. The Spiritual Attitude (KI-1) and Social Attitude (KI-2) values mostly show relatively stable numbers, with an average Spiritual Attitude value of 93.75 and Social Attitude of 80.21 for almost all students. The following are the results of the data after selection.

Table 1: Data Results After Selection

Name	Knowledge	Skills	Spiritual Attitude (KI-1)	Social Attitude (KI-2)
Indira Pratiwi	791.0	770.0	93.75	80.208333
Aleesya Fitiya Endrina	779.0	779.0	93.75	80.208333
Faiq Alhaitami	773.0	785.0	93.75	80.208333
Anis Fitria	770.0	769.0	87.50	79.166667
Hafidz Ulwan Basyari	749.0	749.0	87.50	79.166667

4.2. Transformation Data

In the Data Transformation stage in the Knowledge Discovery in Databases (KDD) process, the selected data needs to be further processed to ensure that it is ready for use in machine learning analysis and models. This data transformation aims to change existing data into a more appropriate format and can improve the quality of analysis. In the context of this study, the transformation process includes data normalization, which is used to equalize the scale between attributes that have different units or value ranges. The following are the data results after normalization.

Table 2: Data Results After Normalization

Name	Knowledge	Skills	Spiritual Attitude (KI-1)	Social Attitude (KI-2)
Indira Pratiwi	1.000000	0.980892	1.000000	1.0
Aleesya Fitiya Endrina	0.984829	0.992357	1.000000	1.0
Faiq Alhaitami	0.977244	1.000000	1.000000	1.0
Anis Fitria	0.973451	0.979618	0.666667	0.8
Hafidz Ulwan Basyari	0.946903	0.954140	0.666667	0.8

4.3. Data Mining

In the Data Mining/Pattern Discovery stage, the main goal is to find hidden patterns or relationships that can provide deeper insights into the existing data. In the context of this study, this stage focuses on the use of algorithms to identify relationships between normalized values, such as Knowledge, Skills, Spiritual Attitudes (KI-1), and Social Attitudes (KI-2), with the results of students' Final Grades. Using a predetermined weighting technique, each student's criteria is calculated to produce a final score that reflects overall academic achievement. Below are the results of the final grades.

Table 3: Students with the Highest Final Grades

Name	Final score	Classification
Indira Pratiwi	0.994268	High
Aleesya Fitiya Endrina	0.991639	High
Faiq Alhaitami	0.990898	High
Arman Zaki Fadhulrrahman	0.945953	High
Ira Siti Nazhira	0.930463	High

Table 4: Students with the Lowest Final Grades

Name	Final score	Classification
Entang Nuraeni	0.616654	Medium
Alfandi Pramudiya S.	0.615542	Medium
Alfahrezi Anggara P.	0.611350	Medium
Djauhari Alfarisi	0.603606	Medium
(Go out) Hera Melani	0.000000	Low

4.4. Interpretation/Evaluation

The prediction results show that all students in the displayed data, namely Indira Pratiwi, Aleesya Fitiya Endrina, Faiq Alhaitami, Anis Fitria, and Hafidz Ulwan Basyari, are classified as Achieving based on their final grades and model predictions. In this case, the model predictions are fully consistent with the actual data, meaning that there are no misclassifications in the subset of data displayed. This reflects that the model has good accuracy at least on this sample, with prediction results that are consistent with the actual data. The prediction results are shown below.

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Indira Pratiwi: Berprestasi -> Prediksi: Berprestasi
Aleesya Fitiya Endrina: Berprestasi -> Prediksi: Berprestasi
Faiq Alhaitami: Berprestasi -> Prediksi: Berprestasi
Anis Fitria: Berprestasi -> Prediksi: Berprestasi
Hafidz Ulwan Basyari: Berprestasi -> Prediksi: Berprestasi
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Figure 2: Prediction Data (after categorization)

The results show the visualization of actual and predicted data, it can be interpreted that the distribution of the number of students in two categories, namely Not Achieving and Achieving. In the actual data, there are 18 students in the Not Achieving category and 14 students in the Achieving category. In the predicted data, with a threshold of 0.65, there are 21 students as Not Achieving and 11 students as Achieving. By lowering the threshold to 0.65, the model produces predictions with lower accuracy compared to higher thresholds such as 0.70 and other higher thresholds. This shows that reducing the threshold makes the model more inclusive in classifying students into the Achieving category, so there is an increase in false positives and false negatives. The following are the results of the visualization of actual and predicted data.

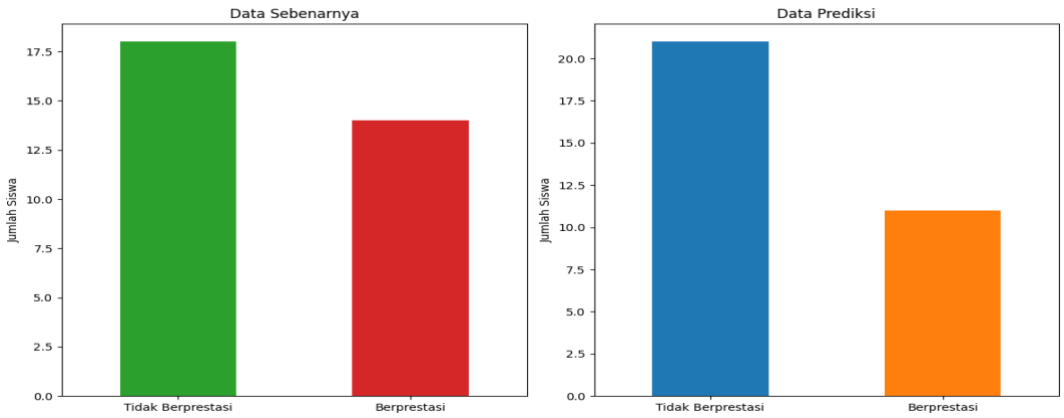

Figure 3: Actual Visualization and Prediction

4.4.1. Metrik Evaluasi

Based on the research results, namely Evaluation and Visualization of Student Achievement Classification Results in the Classification of Student Academic Achievement at SD Negeri Burujul Kulon III.

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Metrik Evaluasi:
Accuracy: 0.91
F1-Score: 0.88
Precision: 1.00
Recall: 0.79
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Figure 4: Accuracy Value Results

1. Accuracy

In testing the Analytical Hierarchy Process (AHP) model, accuracy is used as one of the main metrics to measure the performance of the model in classifying students' academic achievement at SD Negeri Burujul Kulon III. Accuracy is calculated based on the results of the confusion matrix, which is a comparison table between model predictions and actual values from the data being tested.

Accuracy= (TP+TN)/N = (50+41)/100 = 91/100 = 0.91

Accuracy calculation explanation:
TP (True Positives): 50, The number of positive data that are correctly classified as positive.
TN (True Negatives): 41, The number of negative data that are correctly classified as negative.
N (Total): 100, The total number.

2. Precision

In testing the Analytical Hierarchy Process (AHP) model, precision is used as one of the metrics to measure how accurate the prediction of the "Achieving" category produced by the model is. Precision is calculated based on the results of the confusion matrix, which is a comparison table between model predictions and actual values from the test data.

Precision = TP/(TP+FP) = 50/(50+0) = 1.00

Precision calculation explanation:
TP (True Positives): 50, the number of positive data that are correctly classified as positive.
FP (False Positives): 0, the number of negative data that are incorrectly classified as positive.

3. Recall

In testing the Analytical Hierarchy Process (AHP) model, recall is used to measure how well the model identifies all data in the "Achieving" category. Recall is calculated based on the results of the confusion matrix, which is a comparison table between model predictions and actual values from the test data.

Recall = TP/(TP+FN) = 50/(50+13) = 50/63 = 0.79

Recall calculation explanation:
TP (True Positives): 50, the number of positive data that were correctly classified as positive.
FN (False Negatives): 13, the number of positive data that were incorrectly classified as negative.

4. F1-Score

In testing the Analytical Hierarchy Process (AHP) model, F1-score is used as a combined metric to assess the balance between Precision and Recall. F1-score is calculated based on the results of the confusion matrix and is the harmonic mean of Precision and Recall.

F1-Score = 2 x (Precision x Recall)/(Precision+ Recall) = 2 x (1.00 x 0.79)/(1.00+ 0.79) = 0.88

4.4.2 Confusion Matrix

The results of the Confusion Matrix obtained are True Positive (TP) 11, the model correctly predicted 11 high-achieving students. True Negative (TN) 18, 18 students who did not achieve were correctly predicted as not achieving. False Positive (FP): 3, There were 3 students who did not actually achieve but were predicted as achieving. This indicates a false positive, where the model misclassifies students. False Negative (FN): 0, No high-achieving students were misclassified as not achieving. This is a very good result because there are no false negatives. Here are the results of the Confusion Matrix

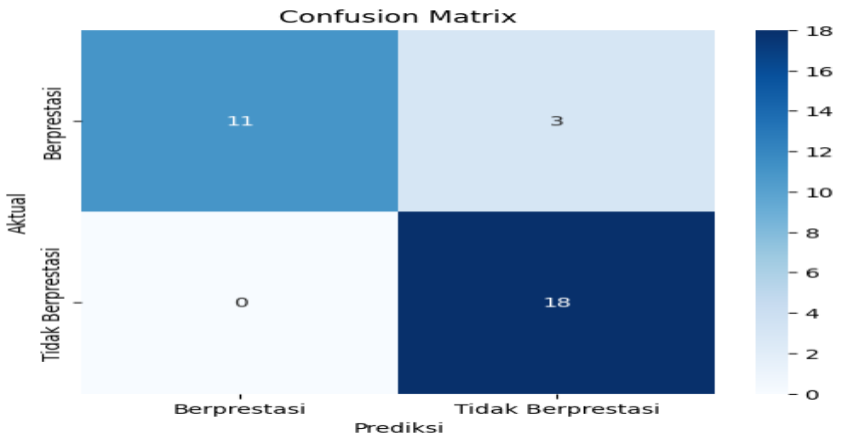

Figure 5: Confusion Matrix

5. Conclusion

This study successfully implemented the Analytical Hierarchy Process (AHP) algorithm to improve the classification model of students' academic achievement at SD Negeri Burujul Kulon III. The AHP algorithm is able to produce:

1. a more accurate classification model by integrating various criteria, namely academic values, skills, spiritual attitudes, and social attitudes. The process of determining the weight of the criteria using the paired comparison method provides systematic and objective results in assessing student achievement.
2. The evaluation results show that the classification model developed is able to identify high-achieving students more comprehensively, not only from an academic perspective but also from a non-academic perspective. This provides significant benefits for schools in decision making, such as awarding high-achieving students and identifying students who need special attention.
3. From the perspective of algorithm effectiveness, AHP has proven to be a reliable method for simplifying complex decision-making processes with results that can be interpreted easily and transparently. Thus, this study makes a real contribution to the development of data-based technology in basic education evaluation.

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