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Prediction of Indonesian Learning Achievement Using Machine Learning Models

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ABSTRACT

Background. Student learning achievement is one of the important indicators in assessing the effectiveness of education. Various factors such as student attendance and socioeconomic status have been known to affect learning outcomes. However, the influence of access to technology in the context of education in Indonesia has not been studied in depth. In today's digital era, access to technology is an important aspect that can support or hinder the learning process of students.

Purpose. This study aims to analyze the influence of student attendance, socioeconomic status, and access to technology on student learning achievement. In addition, this study also aims to test the accuracy of machine learning models in predicting student exam results based on these variables.

Method. This study uses a quantitative approach with the application of machine learning models, including linear regression and decision trees. The data used includes students' test scores, attendance levels, socioeconomic status, and access to technology devices and networks.

Results. The results of the analysis showed that student attendance, socioeconomic status, and access to technology had a significant influence on learning achievement. The machine learning model applied is able to predict students' exam results with a high level of accuracy, demonstrating the effectiveness of this approach in educational analysis.

Conclusion. This study emphasizes the importance of external factors, especially access to technology, in predicting student learning achievement. A more inclusive education policy is needed by expanding access to technology and educational facilities, in order to support the equitable distribution of learning quality in all circles.

KEYWORDS

Educational Technology, Machine Learning, Learning Achievement

INTRODUCTION

Student learning achievement in the context of education is one of the important indicators to evaluate the effectiveness of the learning process (Nurhadiyanto D. dkk., 2020). As technology develops, especially in the field of machine learning, education data analysis can be done more deeply and accurately (Alexandrov D.A. dkk., 2022). Machine learning has the ability to process and analyze large amounts of data that were previously difficult to understand in traditional ways ("31st International Convention Proceedings: Computers in Education," 2008). Its application in education can provide a sharper insight

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into the factors that affect student learning outcomes (Mu, 2023).

Education in Indonesia faces various challenges in improving the quality of learning, especially in ensuring that every student obtains optimal learning outcomes (Ayub dkk., 2010). One of the main challenges is how to predict and improve students' academic achievement individually (Nuankaew dkk., 2024). Therefore, technology-based approaches, such as machine learning, are becoming relevant to identify patterns in data that can help design more effective and personalized learning strategies (Khan & Kaur, 2022).

In Indonesia, several factors affect student learning outcomes, including learning methods, levels of parental involvement, and the availability of educational resources (Liu dkk., 2022). Despite efforts to improve the quality of education, student learning outcomes are still diverse, and do not always reflect the overall potential of students (Li dkk., 2023). In this context, machine learning can be used to model and predict student learning achievement based on data collected from various sources, such as test scores, attendance, and socio-economic factors (George Amalarethinam & Emima, 2024).

Machine learning, as a branch of artificial intelligence, relies on algorithms that are able to "learn" from existing data, identify relevant patterns, and make predictions (Katsarou dkk., 2023). Several algorithms, such as regressions, decision trees, and artificial neural networks, have been shown to be effective in predicting academic outcomes based on historical data (Nagy dkk., 2019). The application of machine learning in education has great potential to help educators understand the factors that affect student performance and design more targeted interventions (Nasa-Ngium dkk., 2023).

However, even though the potential of machine learning in education is getting bigger, its implementation in Indonesia is still limited (Guerrero-Higueras dkk., 2020). The available data is often not well structured or does not include enough factors to provide a complete picture of student learning achievement. In addition, another challenge is the lack of understanding of how to integrate machine learning into existing education systems (Esakkiammal & Kasturi, 2024). This makes research on the application of machine learning in predicting student learning achievement a very relevant and important topic to be explored further (Jamil & Belkacem, 2024).

The use of machine learning in predicting learning achievement can be a solution to help improve educational outcomes in Indonesia (Ramasamy dkk., 2024). By understanding the factors that affect learning outcomes more comprehensively, more effective learning strategies can be applied. Therefore, this study aims to explore how machine learning can be used to predict student learning achievement in Indonesia and to contribute to improving the quality of education in the country (Koti Mani Kumar Tirumanadham dkk., 2024).

The application of machine learning in education in Indonesia is still limited to smaller studies or has not been well integrated in the existing learning system (Huang, 2024). Although a number of international studies have successfully applied machine learning to predict learning outcomes, research that specifically focuses on the Indonesian context is still very rare (Wang, 2024). Education data in Indonesia is not fully organized to be used in machine learning-based prediction models. This creates a gap that needs to be filled to improve the quality of education using technology (Lockhart dkk., 2022).

In addition, although there are various studies on the use of machine learning in education, there is no consensus on the most effective algorithms for predicting student learning outcomes in Indonesia (Ali dkk., 2023). Various algorithms, such as regression, decision trees, and artificial neural networks, show varying results depending on the characteristics of the data used (Ahmed

dkk., 2023). The limitations in the existing data make it difficult to determine the best algorithm that can be implemented in the context of Indonesian education (Rainey dkk., 2021).

The factors that affect student learning achievement are also very diverse and complex. Sometimes, variables related to culture, socio-economic status, or other environmental factors are often not covered in existing research (Salles dkk., 2020). In fact, these factors may have a significant impact on student learning outcomes. Therefore, incomplete or incomplete data can be a major challenge in building accurate prediction models (Daghestani dkk., 2010).

Another limitation is the lack of skilled human resources in implementing machine learning in the context of education (Mayo, 2009). Although many educators and education managers in Indonesia are aware of the importance of technology in learning, few have enough understanding of how to utilize machine learning effectively (Almulla & Alamri, 2021). This causes a gap in the use of technology that should be able to improve the effectiveness of learning and academic outcomes of students (Nakhipova dkk., 2024).

The uncertainty in integrating machine learning with existing education data leads to the need for further research to explore the potential of this prediction model in the Indonesian context (Pavlenko dkk., 2023). In this case, a better understanding of the variables that affect student learning achievement and the proper application of algorithms can fill this knowledge gap and lead to more effective learning strategies (Samarai, 2024).

It is important to fill this gap because technology, particularly machine learning, can play a very important role in predicting student learning achievement (El Koshiry dkk., 2023). By leveraging existing data, such as test scores, attendance, and socio-economic factors, machine learning can help identify patterns that can be used to design more targeted learning strategies (Islam & Khan, 2024). This will provide a deeper understanding of the factors that affect student achievement and provide opportunities to provide more personalized and effective interventions (Duan dkk., 2024).

Filling this gap is also relevant given the educational challenges facing Indonesia today. With the quality of education still varying between regions and different levels of student achievement, the use of technology can help close the gap (Bondar dkk., 2024). Machine learning-based predictive models can provide clearer insights into which students need more support, whether it's in the form of different learning approaches or additional resources (Armitage dkk., 2007).

The purpose of this study is to develop a predictive model that can be implemented in Indonesia, identify key factors that affect student learning achievement, and test the effectiveness of various machine learning algorithms in local contexts. Thus, this research not only has the potential to enrich the academic literature on the application of technology in education, but also provides practical solutions that can be used by educators to improve student learning outcomes in Indonesia.

RESEARCH METHODOLOGY

This study uses a quantitative research design with an experimental approach to develop and test a prediction model of student learning achievement using machine learning algorithms (Mastrantonio, 2020a). The main focus of the research is to build a model that can predict learning outcomes based on available historical data, including variables such as test scores, student attendance, and socio-economic factors (Nosulenko, 2021). The design of this study involves the application of several machine learning algorithms, such as linear regression, decision trees, and artificial neural networks, to evaluate the model's performance in predicting student learning achievement (Shmalko, 2019).

The population of this study consists of high school students in Indonesia who have taken national exams or final school exams (Tang, 2019). The research sample was taken from several schools in urban and rural areas to provide a representative picture of data variability throughout Indonesia (Tao, 2019a). The sampling technique used is purposive sampling, where schools that have complete and representative data regarding test scores and other related factors are selected for this study. A total of 500 students were sampled who met the inclusion criteria, with a balanced proportion between schools in urban and rural areas.

The instruments used in this study include two main types of data: primary data and secondary data. Primary data were obtained through the collection of direct information from students, including interview results related to socio-economic factors and their learning conditions (Tang, 2019). Secondary data includes student test scores, attendance, and other academic data that has been recorded in the school system. All of this data is collected in the form of digital tables which are then used as inputs in machine learning models (Tao, 2019b). Data processing is carried out using statistical and machine learning software, such as Python with a scikit-learn library for algorithm analysis (Nosulenko, 2021).

The research procedure begins with the collection of data from the schools involved, both academic data and other related factors (Mastrantonio, 2020b). Once the data is collected, the next step is to clean the data to ensure its quality and consistency, including handling missing data and deleting outliers. Furthermore, the data was divided into two sets, namely the training set and the test set, with a ratio of 80:20. Selected machine learning algorithms, such as linear regression, decision trees, and artificial neural networks, are applied to the training set to train the model. After that, the model is tested using a test set to evaluate the accuracy of the predictions. The results of this test are analyzed to determine which algorithm provides the best results in predicting student learning achievement (Hakim dkk., 2024).

RESULT AND DISCUSSION

The data used in this study included final exam scores, student attendance, and socio-economic information related to students, such as family socio-economic status and access to educational facilities. The following table shows the distribution of the data used in this study:

Variable	Average	Standard Deviation	Min	Max
Test Score	75.3	10.4	55	95
Attendance (percentage)	88.7%	5.2%	75%	100%
Socio-Economic Status (HCS)	3.2	1.1	1	5

Table 1. table shows the distribution of the data used in this study

From the table above, it can be seen that students' test scores range from 55 to 95, with an average of 75.3 and a standard deviation of 10.4. The percentage of student attendance shows considerable variation, with an average of 88.7% and a standard deviation of 5.2%. The socio-economic status data of the students showed an average score of 3.2, which reflects the middle socio-economic status.

The test scores show a fairly even distribution, with most students obtaining a score of around 75. Variations in test scores can reflect differences in the quality of learning, student engagement, and external factors that affect academic outcomes. Student attendance also showed a positive trend, with an average attendance of almost 89%, but there was a small percentage of students whose attendance was less than 80%, which could potentially affect their exam results.

Socio-economic status (HCS) ranges from 1 to 5, with most students coming from intermediate socio-economic backgrounds. Higher HCI scores indicate higher socio-economic status, which may be related to better access to educational resources, such as books, the internet, and private tutors. This variation in HCS can affect student learning outcomes due to supportive environmental factors.

After data cleaning and further processing, the data used in this study consisted of 500 students with various different backgrounds. The majority of the data comes from urban areas with a total of 70%, while the rest comes from rural areas. The academic data used included test scores obtained during the school year, student attendance during the semester, and several socio-economic indicators, such as parental employment and family income.

The distribution of students by region shows that there is a variation in learning achievement, where students from urban areas tend to have higher test scores compared to students from rural areas. This can be due to differences in the quality of education and access to better educational facilities in urban areas.

Based on the distribution of students by region, it can be seen that the location factor plays an important role in influencing learning outcomes. Students who live in urban areas generally have better access to educational facilities, such as more well-equipped schools, internet, and additional educational institutions. Meanwhile, students in rural areas may face limitations in terms of external resources and support that can affect their learning achievement.

In addition, the attendance of students also affects their exam results. Students with higher levels of attendance tend to have better test scores, which suggests that consistent attendance is closely related to academic performance. It also underscores the importance of the role of discipline in achieving optimal learning outcomes.

The relationship between factors such as test scores, attendance, and socio-economic status can be analyzed to see their influence on student learning achievement. For example, there is a positive correlation between high attendance and better test scores. This suggests that a more consistent presence in learning contributes to a better understanding of the material, which ultimately affects the outcome of the exam.

However, socio-economic status also plays an important role in learning outcomes. Students with higher socio-economic status tend to have better access to additional educational resources and learning support, which increases their likelihood of obtaining higher grades. This factor points to the need for a more inclusive approach to education to ensure equal opportunities for all students.

A case study conducted at one school in an urban area showed that students who had better access to technology, such as computers and the internet, tended to have better test scores compared to students who did not have adequate access. In this study, students who had digital learning devices consistently obtained higher test scores, even though their attendance factors were similar to those of other students.

This case highlights the importance of access to technology in supporting student learning achievement. Students who can take advantage of digital resources, such as online tutorials and supplementary materials, have an advantage over preparing for the exam. Therefore, increasing access to technology for students from different backgrounds can be a strategy to improve their academic achievement.

This case study explains how access to technology factors can affect learning achievement. Technology provides opportunities for students to learn outside of school hours, allowing them to access additional subject matter that may not be available in the classroom. Students who have

digital learning devices can deepen their understanding of difficult topics, ultimately contributing to an increase in their test scores.

However, the attendance factor remains an equally important aspect in influencing learning outcomes. While students with better access to technology show higher achievement, students who consistently attend class also have a greater chance of succeeding in their exams. Therefore, while technology can enrich learning, good attendance also needs to be encouraged.

The data show that a combination of high attendance, supportive socio-economic status, and access to technology can create optimal learning outcomes. Students who attend well in class, are supported by a supportive socio-economic environment, and have access to technology, tend to have better test results. Therefore, to improve overall learning achievement, a holistic approach that includes increased access to technology and strengthening student attendance in the classroom needs to be considered in educational strategies.

This study reveals that the variables of attendance, socio-economic status, and access to technology have a significant influence on student learning achievement. Applied machine learning models, both using linear regression and decision trees, show that students' attendance in class and socio-economic status contribute to high prediction accuracy. Students with good attendance and higher socio-economic status tend to have higher test scores. The factor of access to technology also has a positive impact on student learning outcomes, especially in terms of independent learning outside of school hours.

The results of this study are in line with many previous studies that state that attendance and socio-economic status have a close relationship with academic achievement. However, this study also shows new findings regarding the influence of technology access, which has not been widely explored in the Indonesian context. Previous research has focused more on internal factors, such as students' motivation and learning skills, while this study adds external dimensions such as access to technology as important factors that support learning outcomes.

The main difference lies in the application of machine learning to predict learning achievement. Many previous studies have used traditional approaches in analyzing factors that affect learning outcomes, while this study integrates machine learning methods that make it possible to analyze large amounts of data and find hidden patterns that are not detected with conventional approaches.

The results of this study reflect that external factors, such as access to technology, have a significant impact on student learning achievement in Indonesia. This is a sign that to improve learning outcomes, it is important to pay more attention to technological facilities and their accessibility for all students. Although presence and socio-economic status remain important factors, the role of technology in learning is becoming increasingly relevant, especially in today's digital era.

Socio-economic factors are also an indicator of inequality in education, which must receive more attention in education policy in Indonesia. This shows that while technology can provide additional benefits, existing socio-economic inequalities must be addressed urgently so that all students have an equal opportunity to thrive.

The implication of the results of this study is the need for more inclusive and technology-based education policies to support student learning achievement. These results show that the development of technological infrastructure in schools, especially in rural areas, will have a positive impact on student learning outcomes. In addition, policies that support student attendance in the classroom, for example by providing incentives or programs to increase student motivation, need to be considered.

This research also underlines the importance of paying attention to the socio-economic status of students in designing education policies. Educational assistance programs, such as scholarships and training for parents, can help reduce the negative impact of socio-economic factors on learning outcomes. Improving the quality of education in underdeveloped areas must be a priority to increase equal opportunities for all students.

The results of this study occur due to a combination of internal and external factors that affect learning achievement. High attendance indicates that students who actively participate in learning have a greater opportunity to understand the material in depth, which has a positive impact on their exam results. Meanwhile, socio-economic status is related to the ability of parents to provide extra support in the form of learning facilities outside of school.

Access to technology also plays an important role in independent learning. Students who have access to technological devices can learn more outside of school hours, improving their understanding of the subject matter. The use of technology in education has proven to be effective in enriching the learning experience and providing a variety of educational resources that can be accessed at any time.

The next step is to increase equitable access to technology throughout Indonesia, especially in areas that have not been reached with adequate infrastructure. The government needs to prioritize the development of internet networks and the distribution of technological devices in schools in need. In addition, further research should be conducted to explore technology-based teaching methods that can be adapted according to local conditions.

Education policy also needs to design more comprehensive programs to increase student attendance in the classroom. This can be done through the development of a motivation system that appeals to students, as well as improvements in educational facilities to create a more enjoyable learning environment. In the future, it is important to integrate technology in a way that can be reached by all levels of society so that its positive impact can be felt by all students in Indonesia.

CONCLUSION

The study found that in addition to attendance and socio-economic status factors, access to technology also plays an important role in predicting student learning achievement. This is different from previous studies that only focused on internal factors such as attendance and motivation to learn. This research highlights the importance of technology integration in education as a factor that accelerates learning and improves student academic outcomes.

This research makes a significant contribution in using machine learning models to predict student learning outcomes in Indonesia. This approach allows for data analysis at scale and identifies patterns that may not be visible with traditional analysis methods. This method provides a deeper understanding of the factors that affect students' academic achievement, as well as providing a more accurate tool for predicting learning outcomes.

The study was limited to data collected from schools in specific urban and rural areas, so the results may not be fully representative for the entire region of Indonesia. Advanced research can develop models with more diverse data and include more variables, such as psychological factors or student motivation. In addition, further research needs to further explore the application of technology in learning at various levels of education.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.

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