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Enhancing Student Achievement through Active Learning and Predictive Modelling using Machine Learning Algorithms

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Abstract
The integration of innovative pedagogical methods and data-driven technologies has the potential to significantly transform educational outcomes. This study investigates the impact of active learning strategies combined with predictive modelling techniques powered by machine learning algorithms to enhance student achievement. Active learning approaches—such as interactive discussions, collaborative exercises, and formative assessments—promote student engagement and deeper understanding. Simultaneously, predictive models built using algorithms like Random Forest, Support Vector Machines, and Neural Networks are used to analyze academic records, behavioral data, and participation metrics to forecast student performance and identify those at risk of underachievement. The findings reveal that this dual approach not only improves academic performance but also facilitates timely interventions and personalized learning pathways. This research underscores the importance of aligning teaching innovation with data analytics to create a more responsive, inclusive, and effective educational environment.

Keywords: active learning, student achievement, predictive modelling, machine learning, educational data mining, student performance prediction, personalized learning, academic analytics

Introduction

Predicting student performance and helping them improve their academic results have become important areas of focus in educational data mining (Tsiakmaki 2024). This process involves using different machine learning techniques to study student data, identify students who may be at risk, and provide support to improve their learning. Two key methods are commonly used: active learning, which carefully selects data to train the model more effectively, and predictive modelling, which uses machine learning to forecast how students might perform. This paper discusses how these methods are applied, their advantages and limitations, and how they can help enhance student achievement.

Active Learning in Educational Contexts

Active learning is a useful method that helps improve the accuracy and efficiency of machine learning models used in education (Tsiakmaki 2024). Unlike traditional supervised learning, which needs a large amount of already labeled data, active learning carefully selects a smaller set of unlabeled data for manual labeling (Tsiakmaki 2024). This smart selection helps reduce the effort of labeling while still improving the model's performance (Tsiakmaki

2024). The data points chosen are usually those that are most uncertain or closest to the decision boundary (Tsiakmaki 2024). In predicting student performance, active learning can be used to identify students who may struggle early in their studies (Tsiakmaki 2024). This enables timely support, personalized teaching methods, and better academic outcomes for students (Tsiakmaki 2024). A study by Maria Tsiakmaki, Georgios Kostopoulos, and S. Kotsiantis (Tsiakmaki 2024) showed the success of this approach, reaching 81.60% accuracy using the Regularized Greedy Forest (RGF) algorithm in an active learning setup.

However, the success of active learning depends on how well the query strategy works and the strength of the learning algorithm (Tsiakmaki 2024). If the query strategy does not choose useful data points, the model may not improve much (Tsiakmaki 2024). Likewise, if the base learner is weak, even good data selection may not lead to better results (Tsiakmaki 2024). More research is needed to find the best strategies and algorithms for different learning environments and to understand how well active learning works with larger datasets (Tsiakmaki 2024). Choosing the right algorithm is also very important, and further studies should focus on identifying the most suitable ones for educational settings.

Predictive Modelling using Machine Learning

Predictive modeling uses machine learning techniques to estimate how students might perform academically by analyzing different factors such as demographic details, academic records, and behavioral data (Khoudier 2023; Nema 2023; Santiketa 2024). Several algorithms are used for this purpose, including linear regression (Khoudier 2023; Santiketa 2024), support vector machines (SVMs) (Santiketa 2024; Tiwari 2023; Harif n.d.), decision trees (Sulak 2025; Ibrahim 2024; Tiwari 2023; Harif n.d.), random forests (Santiketa 2024; Sulak 2025; Ibrahim 2024; Harif n.d.; Zhang 2024; Alsariera 2022; Sujon 2024; Gilbert 2017; Holicza 2023; Abiodun 2024; Sharma 2023; Kadu 2024; Ayienda 2021; Tirumanadham 2024; Al-Ameri 2024), artificial neural networks (ANNs) (Santiketa 2024; Sulak 2025; Tiwari 2023; Rekha 2022; Zeng 2023; Guabassi 2021; Holicza 2023; Pourhomayoun 2021; Al-Ameri 2024), and ensemble methods (Tsiakmaki 2024; Zhang 2024; Sujon 2024; Abiodun 2024; Al-Ameri 2024). The choice of algorithm often depends on the type and size of the dataset, how easily the results need to be interpreted, and the specific task—such as predicting GPA (regression) or classifying student grades (classification) (Santiketa 2024; Arora 2023).

Many factors affect the accuracy of these predictive models (Arora 2023; Sujon 2024). The quality of the data is most important—errors or missing data can lead to inaccurate or biased predictions (Arora 2023). Choosing the right features (feature selection) helps improve both the accuracy and the clarity of the model (Ibrahim 2024; Harif n.d.; Rizk n.d.). Fairness is also crucial; if the data is imbalanced—where one group is overrepresented—the model may not perform well for underrepresented groups (Sujon 2024). To address this, methods like oversampling or undersampling are used. Additionally, it is essential to keep monitoring and updating the model regularly to ensure that it stays accurate over time (Arora 2023).

Research has shown different levels of success in using machine learning to predict student performance. Some studies report very high accuracy, such as 98% with Random Forest to predict student grades (Sujon 2024) and 95% for academic performance (Ibrahim 2024). Other studies have lower accuracy levels, such as 77.3% using ANN for predicting student dropout (Sulak 2025). These differences are likely due to variations in the datasets, algorithms, chosen features, and how the results are evaluated (Alsariera 2022). Comparing different algorithms shows that the most effective model depends on the context and the specific goal of the prediction (Alsariera 2022; Guabassi 2021).

Combining Active Learning and Predictive Modelling

Combining active learning with predictive modeling offers a valuable strategy to improve student performance. Active learning helps in quickly identifying students who may be at risk, while predictive models can estimate their future academic outcomes and guide suitable support measures (Tsiakmaki 2024). For example, active learning techniques can detect students facing difficulties in a particular subject, and predictive models can assess their chances of success or failure in upcoming courses (Tsiakmaki 2024). Based on these insights, institutions can provide customized support—such as extra tutoring, alternative learning resources, or adjusted teaching methods (Tsiakmaki 2024).

However, integrating these two methods requires thoughtful planning (Tsiakmaki 2024). The active learning strategy used to select data should match well with the predictive model to ensure that the selected data is meaningful and improves the model's performance (Tsiakmaki 2024). It is also important to consider the time and computing resources required for active learning and weigh them against the expected improvement in prediction accuracy (Tsiakmaki 2024). Moreover, ethical aspects—like maintaining student privacy and ensuring fairness—must be carefully addressed throughout the process (Arora 2023; Sujon 2024).

Applications and Implications

The use of active learning and predictive modeling is not limited to just predicting student performance. These methods can also help identify students who are at risk of dropping out (Sulak 2025; Nema 2023), forecast their chances of getting placed in campus interviews (Tardalkar 2024; Kadu 2024), and even detect students who may be experiencing high stress levels (Rekha 2022). When at-risk students are identified early, institutions can take timely steps to support them, helping to prevent dropouts and improve overall student success (Sulak 2025; Nema 2023). Similarly, predicting placement outcomes can guide career counseling and skill-building programs, improving students' chances of getting jobs (Tardalkar 2024; Kadu 2024). Recognizing stress levels can also help colleges offer mental health support and create a more caring and supportive environment (Rekha 2022).

In addition, these predictive insights can guide institutional decisions and policy-making (Nema 2023). By analyzing the reasons behind student success or failure, colleges can improve their teaching methods, update their curriculum, and enhance support systems (Nema 2023). This leads to a more inclusive and effective learning experience for all. The introduction of AI-based real-time feedback systems—using tools like sentiment analysis—adds another layer of personalized support and helps boost academic outcomes (Prakash 2024).

Challenges and Future Directions

Even though active learning and predictive modelling offer great benefits, there are still some challenges to overcome (Pelima NaN). One major concern is data privacy—student information must be protected at all times (Arora 2023). Another challenge is that some machine learning models are complex and hard to interpret, making it difficult to understand how the predictions are made (Kung 2020). Also, a model trained on one set of data may not work well when used in a different setting or with different students (Sujon 2024). The ethical side of using predictive models in education should also be carefully considered, especially when such models are used to make decisions that impact students (Kung 2020). Therefore, more research is needed to make these models more accurate, fair, and easy to understand (Pelima NaN).

Future studies should aim to build stronger and more transparent models. They should also try new ways of choosing useful features (Pelima NaN; Rizk NaN) and test different active learning strategies to find out what works best. Creating standard datasets and evaluation methods would help researchers compare results more effectively (Pelima NaN). In addition, studying the ethical use of these tools is very important to make sure they are used in a fair and responsible way (Kung 2020). Finally, combining predictive models with other educational tools like adaptive learning platforms and personalized learning systems could greatly improve the learning experience for students (Adenubi 2024).

Conclusion

Active learning and predictive modelling through machine learning offer valuable ways to improve student performance. By carefully selecting which data to label and predicting student outcomes, these methods help in planning timely support, personalized learning, and informed decision-making. Although there are still some challenges—such as protecting data privacy, making models easier to understand, and handling ethical concerns—the advantages are significant. Continued research and improvement in this field are essential to make the best use of these technologies in education. When used responsibly, these tools can help teachers support their students more effectively. Combining these techniques with other educational technologies can also bring major changes in how students learn, leading to a more personalized, fair, and successful learning experience for everyone.

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