

**University “St. Kliment Ohridski”
Bitola
Faculty of Information and
Communication Technology - Bitola
Republic of North Macedonia**

**PROCEEDINGS
15th International Conference on
APPLIED INTERNET AND INFORMATION
TECHNOLOGIES
AIIT 2025**



Bitola, November 7, 2025



University “St. Kliment Ohridski” Bitola
Faculty of Information and Communication Technology - Bitola
Republic of North Macedonia

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Introduction

As organizing partners of 15th International Conference on Applied Internet and Information Technologies AIIT 2025, we warmly welcome all participants, researchers, and colleagues joining us from various countries and universities, united by our shared commitment to advancing knowledge in the fields of computer science, applied Internet, and information technologies.

The AIIT conference has become a long-standing tradition of excellence and collaboration, co-organized by the Faculty of Information and Communication Technologies – Bitola, University “St. Kliment Ohridski,” and the Technical Faculty “Mihajlo Pupin” – Zrenjanin, University of Novi Sad, Serbia. Over the past fifteen years, this partnership has fostered not only strong academic cooperation but also genuine friendship among our institutions and scholars.

This year’s conference proudly continues that tradition, bringing together innovative research, diverse perspectives, and new insights into technologies that are shaping our digital future. The Scientific Program Committee once again faced the demanding task of selecting the highest-quality papers from more than sixty submissions spanning a wide range of topics—including Artificial Intelligence, Immersive Technologies, Mathematical Simulations, Data Science and Big Data Analytics, Knowledge and IT Management, Cybersecurity, Software Engineering, Data Mining, Digital Transformation, Behavioral Economics and Business, Social Engineering, Digital Humanities, Augmented Humanity, and Hybrid Intelligence. This ensures that the program reflects both scientific rigor and creative originality.

We would like to express our sincere gratitude to all reviewers for their dedicated work, as well as to the members of the Organizing Committee for their professionalism, commitment, and enthusiasm in preparing this event.

We are confident that these proceedings will provide an enriching and thought-provoking reading experience.

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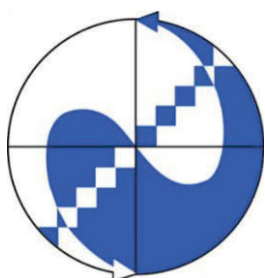


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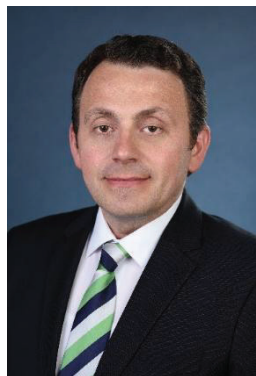


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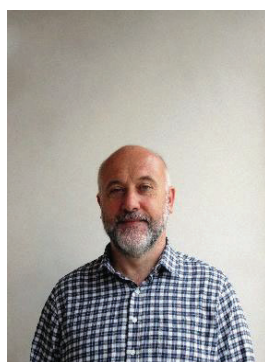
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Integrating XGBoost and Neural Networks for Accurate Student Performance Prediction in Higher Education

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Abstract:

This paper is dedicated to predict student performance as a persistent challenge in the academic world. One of the main reasons why institutions deal with these issues is to help students who are at risk of learning and lack successful results through personalized lessons. We have used and analyzed a hybrid approach consisting of XGBoost (eXtreme Gradient Boosting) and neural networks, which provide quite accurate predictions. This combination through XGBoost and deep learning, offers a higher reliability for building intelligent learning management systems (LMS), helping institutions make decisions in order to increase quality and positive results. We have also developed a platform that integrates both of these models and facilitates the practical usage of these cases. We have developed the platform through web technologies, with PHP used for the logical part of the platform and MySQL for data storage and structuring student data.

Keywords:

Student performance prediction, XGBoost, neural networks, educational data mining, interpretability in AI

1. Introduction

One of the main challenges in higher education remains the prediction of student performance that involves the use of analytical techniques and artificial intelligence to forecast outcomes in future courses, track progress across semesters, and identify difficulties in specific topics. Universities often face the need to understand why some students show higher success and others show poor success. Therefore, through accurate predictions, these institutions help to intervene earlier, offering additional lessons to students who have poor success and improving the learning process. Therefore, the use of educational data and modern artificial intelligence techniques is constantly increasing its impact. Traditional methods, for example, linear statistical models, enable easy interpretation by teachers. They show that the average grade and class attendance predict high academic results. However, student behavior is inherently complex, and often there are no linear relationships, which these traditional models cannot predict. Therefore, in similar situations, new machine learning models such as XGBoost or neural networks are being used, which can reveal hidden patterns and provide more accurate results. We have proposed in our study a hybrid approach, where a weighted linear formula is used as an initial step to provide transparency and understanding of the main factors, but then the results are passed to more powerful models such as XGBoost and neural networks to improve the prediction accuracy. Through this hybrid model we aim to balance interpretability, in terms of providing clear insights into the factors that influence student outcomes, and performance, in terms of achieving high prediction accuracy, thereby offering a practical and reliable tool for universities. Through the obtained results we have seen that this approach achieves a higher level of prediction accuracy, enabling institutions to design personalized policies for students.

The rest of the paper is structured as follows. Section 2 provides a review of recent literature and related work. Section 3 outlines the research methodology and the approaches employed for the project implementation. Section 4 presents and analyzes the obtained results, along with a logical part of the code, while the remaining implementation details are made available on GitHub. Section 5 is dedicated to discussion, and Section 6 concludes the paper with key findings and directions for future work.

2. Related work

In recent times, student performance prediction has become one of the most important areas within learning analytics. Our research has focused mainly on deep learning (DL) models and careful feature engineering based on data from universities as well as publicly available datasets from open repositories. Studies show that DL has an advantage over traditional models, as these are able to capture non-linear dependencies and different dynamics over time [1] [2]. Usually, the process of building such a system goes through several steps: as a first step, the source of the data to be used is determined (such as grades, demographics, and LMS data), which are then cleaned and transformed into features that better represent student behavior and progress. After this process, predictive models are trained using different algorithms, including Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks, a transformer, or even combined. Finally, the results obtained are interpreted with the aim of supporting academic decision-making [3] [4]. One of the new trends in prediction is hybrid models. These approaches offer a combination of knowledge gained from domain expertise and the power of machine learning (ML) algorithms. A simple example is the use of a weighted formula to combine indicators such as grade point average, demographic factors, and subject difficulty, before subjecting this data to an advanced model such as XGBoost or an artificial neural network [5] [6]. Studies show that when integrating data from different sources such as demographic, academic, and LMS activity, hybrid models offer higher robustness than single DL or ML models [7] [8]. This is especially important in cases where data changes over time or when models need to be applied to other situations [9]. The inclusion of confidence intervals and reliability measures has been evaluated as a practice that increases certainty and transparency for decisions made based on model results [10] [11]. Building on recent developments, our approach starts with a formula that we have designed from the expertise of our research domain, and then we have used the XGBoost model and artificial neural network for more advanced processing, which is aligned with the new trends that we have identified in the literature. Our research suggests that this type of combination improves the accuracy of the prediction, offering good opportunities for real-time future interventions and for providing reliable results in the development of educational policies [12] [13].

3. Methodology

This study uses a hybrid approach to predict academic performance, aiming to improve accuracy and provide more practical insights for academic use. The formula integrates previous grade point averages (GPAs), progress trends, demographic factors, and subject difficulty coefficients, providing high interpretability based on domain expertise [13]. This formula serves as input to an Ensemble Learning model, which uses XGBoost to capture nonlinear relationships and efficiently process structured data [14], as well as a neural network to identify complex and hidden patterns [15]. The use of such hybrid approaches in educational data mining has demonstrated high accuracy and improved prediction reliability [16] [17], while the combination of interpretive and complex models ensures an optimal balance between transparency and performance [8]. In this study, we used this model since the same one in another scientific project was tested on a sample of 12 subjects, achieving a confidence interval of 97.5% and an average reliability of 97.8%, confirming the validity of the proposed approach [18]. To adapt it to our dataset of student records, the prediction was structured in two stages. By combining a hybrid model between XGBoost and neural networks.

Stage I, involves a basic prediction with a neural map, where grades for future courses are estimated by calculating a weighted average of related course results using the correlation map.

Missing values are ignored rather than treated as zero, and if no prior records exist (e.g., first-year students), the prediction defaults to the current GPA.

Stage II, then combines this result with the GPA and adjusts it with demographic factors, making sure both interpretive and contextual variables are considered. This two-stage design allows the model to balance interpretability in the first stage with predictive power in the second stage. This combination can be regarded as a metamodel—similar to a second network layer or the regularization model of XGBoost.

4. Results

In this section, we present a practical implementation of the proposed hybrid model and the results obtained during testing. We have evaluated the model using real student data, and combining demographic and academic indicators to ensure a realistic prediction process. In addition, we describe the platform structure, the technology used, and the steps taken to integrate XGBoost with neural networks. The following subsections provide details on the data, system architecture, and analytical results of the prediction model.

4.1. Data and Platform

As for the dataset we used, it covers both the academic aspect of the students—namely their grades and overall academic performance—and the demographic aspect. A complete list of attributes is provided in the table below.

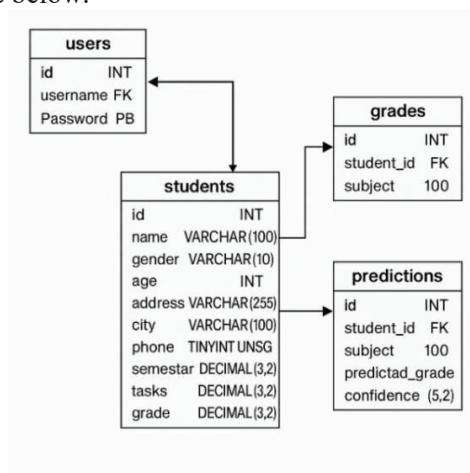


Figure 1. Entity-Relationship (ER) diagram of the database

At this stage, we have displayed another table which presents the name of the platform, the web languages used and their role in the development of our platform, as well as the database which served us to store data for students.

Table 1:

Student performance prediction platform

| Field | Specification |
|-----------|--|
| Platform | Integrating XGBoost & Neural Networks for Student Performance Prediction |
| Front-End | HTML, CSS, JavaScript |
| Back-End | PHP |
| Database | MySQL |

A. Block diagram of the platform

In this section, we present our project as a flowchart, illustrating the workflow of the proposed hybrid model for predicting student performance. The complete implementation,

including the full code, is available as open-source on the GitHub platform [19].

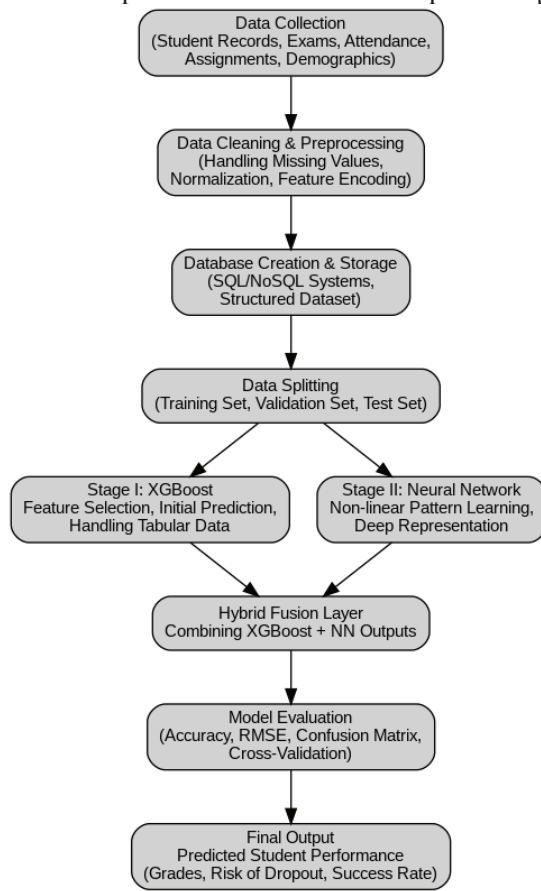


Figure 2. Block diagram of the proposed hybrid model

4.2. Results and Analysis

In this section, we present the results of the hybrid model consisting of XGBoost and neural networks. The results showed a high degree of accuracy in predicting performance by combining ML techniques, namely XGBoost and deep learning techniques. Feature analysis showed that GPA and attendance were the two determining factors in the prediction, followed by completion of assignments and other academic factors. Overall, our hybrid model demonstrated the ability to extract hidden patterns from the data and, at the same time to provide more reliable results, making the model quite suitable for its integration into intelligent systems in learning management.

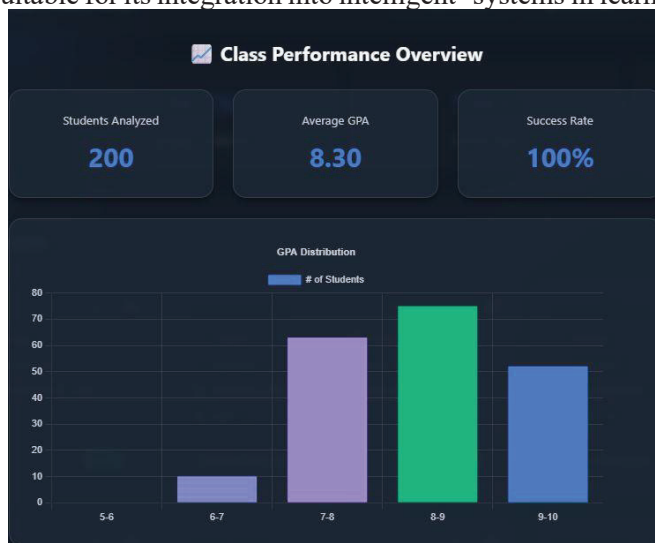


Figure 3. Student performance prediction platform statistics

In the two figures below we have presented the appearance of our platform, Figure 3, and we have presented the main page with the data of all students. Also the menus such as adding students, such as age, gender, residence, faculty, elected subjects, completed and incomplete exams, etc. Overview and Methodology are used for prediction. In Figure 4, we have made the general presentation of the statistics of a respective student after clicking on the View Full Analysis button.

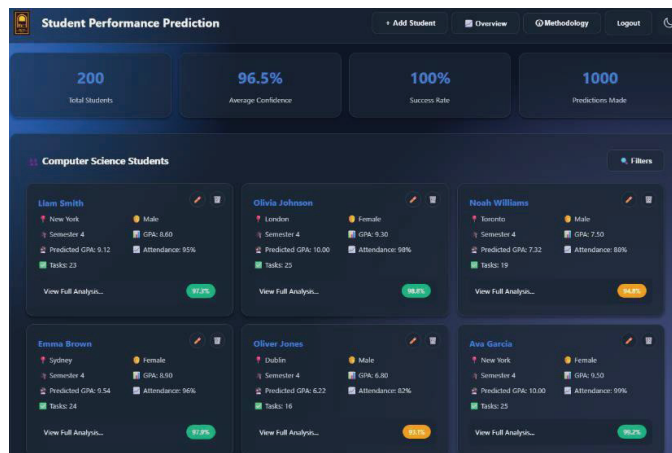


Figure 4. Platform Homepage

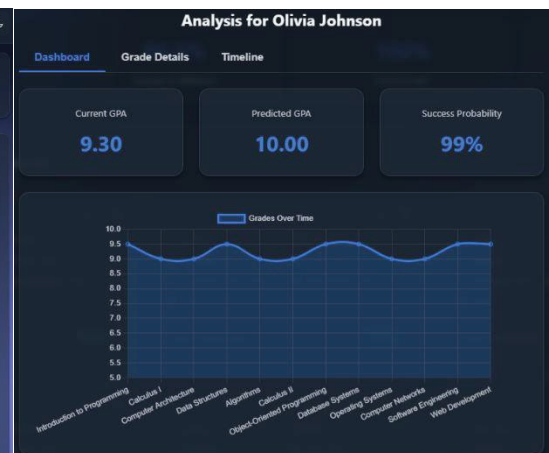


Figure 5. Dashboard general analysis for student

In the two figures below, we have presented all the subjects and grades. On the left side, we have listed the completed subjects, while on the right side, we have shown the predicted results for the subjects. The completed semesters, while below are the predicted semesters that remain to be completed are shown. Are shown in the Figures 5 and 6.



Figure 6. Grade details prediction

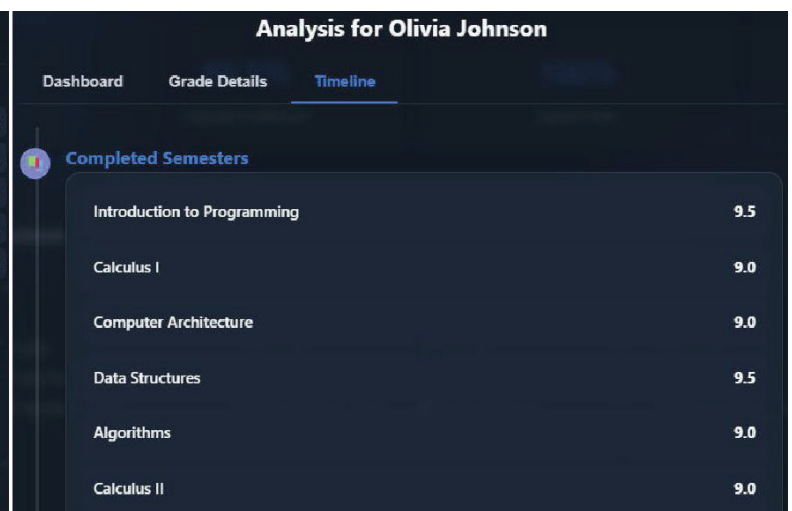


Figure 7. Semester prediction

These visualizations not only show academic progress, but also highlight how the system adjusts predictions based on student performance patterns. By identifying subjects where a student may be struggling, the platform can serve as a supportive tool for academic advising. This makes the prediction model useful not only for analysis, but also for proactive guidance and improvement of learning outcomes.

5. Discussion

The hybrid (ensemble) approach proposed in this paper combines the best of both models: we leverage XGBoost to incorporate global aspects of student performance and demographic

factors, while using an integrated neural network (in the form of a weight map between subjects) to capture connections between different subjects. The key idea is that a student's performance in certain core subjects (e.g., mathematics, algorithms, programming) influences his or her future performance in more advanced subjects (e.g., artificial intelligence, machine learning, computer graphics). This model has the potential for early warning systems by identifying students with deficiencies in specific subjects. However, this approach can be a bit challenging in terms of data, which we believe may be difficult to generalize across universities. We believe that expanding the data set to include socio-economic aspects could have a positive impact, especially in those universities where such data is available.

6. Conclusion

This study shows the importance of using hybrid approaches in predicting students' academic performance, through the combination of two models XGBoost and neural networks. In our case, the results have shown that the integration of a powerful algorithm such as XGBoost, for handling structured data, by adding the ability of neural networks to capture complex and nonlinear patterns, provides a significant increase in accuracy compared to traditional models. This model can help universities predict high-risk students by presenting their shortcomings and enabling institutions to offer personalized lessons. The hybrid approach, in addition to improving the prediction performance, creates a balance between computational efficiency and analytical flexibility. Based on the performance of our SPP platform, and the tests we have done, we assess that it has achieved our expectations by being the first project based on world research in recent years. This study analyzed the key requirements, challenges, and future perspectives of academic performance prediction. For future work, we could extend the hybrid model with broader data sources and advanced feature engineering, and test it across universities to assess its robustness and scalability.

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