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EARLY WARNING SYSTEM FOR-AT RISK STUDENT IDENTIFICATION IN EDUCATION

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Abstract:

The development of data analysis techniques and intelligent systems has significantly impacted education, leading to the rise of educational data mining (EDM). The Early Warning System (EWS) plays a crucial role in predicting at-risk students and analyzing learner performance by considering various socio-cultural, structural, and educational factors influencing dropout rates. Our project introduces a robust EWS model, built on an original database that ensures precision in selecting dropout indicators. Using the K-Nearest Neighbour (KNN) algorithm, our model achieved outstanding accuracy, exceeding 99.5% for the training set and 99.3% for the test set. Additionally, we explored alternative classification models to enhance prediction accuracy and improve intervention strategies. To make the results more accessible and actionable, we developed a Django-based application that visualizes predictive insights, enabling educators and policymakers to analyze student data efficiently, customize intervention approaches, and implement data-driven educational planning. This interactive system provides real-time analytics and an intuitive interface, helping institutions take proactive steps to reduce dropout rates, enhance student retention, and improve overall academic success. Furthermore, the system allows for continuous monitoring and evaluation of student performance, offering personalized recommendations based on historical data and trends. By integrating various data sources, including attendance records, academic performance, and socio-economic factors, the model ensures a comprehensive approach to early intervention. Future enhancements include incorporating deep learning techniques for even more accurate predictions and expanding the system's adaptability to different educational settings. With its ability to process large-scale educational data and generate insightful reports, our EWS has the potential to revolutionize student support systems, empowering educators with advanced tools to foster an inclusive and effective learning environment.

Keywords: Educational Data Mining (EDM), Early Warning System (EWS), at-risk students, dropout rates, K-Nearest Neighbour (KNN) algorithm, predictive insights, data-driven educational planning.

1. INTRODUCTION

The evolution of IT practices has been shaped by intelligent systems, especially predictive and recommendation systems. With the rise of Big Data, these systems have advanced, utilizing sophisticated computing methods and hardware. Early Warning Systems (EWS) are a key application, designed to analyze data, detect anomalies, and provide timely alerts. EWS follows stages like data collection, analysis, anomaly detection, alerting, risk assessment, and response. Educational Data Mining (EDM), a core part of Education integrating EDM, EWS improves predictive accuracy, helping institutions monitor student performance, detect at-risk students, and implement strategic interventions.

Educational planning ensures efficient use of resources to achieve societal educational goals. A well-planned system promotes equity, quality, and reduced dropout rates while improving overall academic performance. The integration of EWS with analytics helps in developing adaptive education plans that can respond to evolving challenges in the education sector. EDM also evaluates education systems by comparing outcomes with objectives, enabling data-driven decision-making for better policy formulation. By leveraging machine learning and statistical techniques, EWS can provide early insights into student performance, allowing timely interventions. Future research will enhance predictive accuracy using deep learning, improve real-time monitoring, and expand its applicability across various educational settings. Additionally, advancements in AI-driven analytics will help refine these systems, making them more effective in addressing student needs. Refining these systems will support better decision-making, improved student outcomes, and sustainable educational growth, ultimately contributing to a more inclusive and efficient education system.

2. LITERATURE SURVEY

A. N. de Vasconcelos, L. A. Freires, G. D. L. Loureto, G. Fortes, J. C. A. da Costa, L. F. F. Torres, I. I. Bittencourt, T. D. Cordeiro, and S. Isotani. [1] There is a global effort to address the school dropout phenomenon. The urgency to act on it comes from the harmful evidence that school dropout has on societal and individual levels. Early Warning Systems (EWS) for school dropout at-risk student identification have been developed to anticipate and help schools have a better chance of acting on it. However, several studies point to a doubt that Correct EWS may come too late because they use only publicly available and general student and school information. The urgency to act on it comes from the harmful evidence that school dropout has on societal and individual levels. Early Warning Systems (EWS) for school dropout at-risk student identification have been developed to anticipate and help schools have a better chance of acting on it. However, several studies point We hypothesize that having a tool to assess more subjective and inter- relational factors would help anticipate where and when to act to prevent school dropout. This study aimed to develop a multidimensional measure for assessing relational factors for predicting school dropout (SD) risk in the Brazilian context.

B. M. Mcmahon and S. F. Sembiante, [2] Emphasis in school dropout literature has shifted from exploring wide-ranging causes of dropping out to soliciting a smaller number of predictive indicators to identify students at increased risk for dropping out. However, much of the past decade's Early Warning research excludes indicators that do not add to the predictive nature of the model even if they might inform intervention. Considering this shift and the relative infancy of Early Warning research, this paper presents a critical systematic review of the literature surrounding dropout and Early Warning System(s) (EWS). Through a focus and evaluation of student-level indicators, we present an argument of how an effective EWS can bridge the gap between the prediction of dropout events and underlying causes, while providing actionable information for schools to intervene. Finally, we present preliminary data that demonstrate the potential of elementary- level student-level indicators as an avenue for shifting the focus of EWS from student identification to meaningful prediction and intervention. The results show how the student-level indicators explored in this paper can effectively identify students at these grade levels who are on- and off-track to graduation. We discuss the implications of evidence warranting the position that dropping out of school can be predicted as early as the elementary grade levels and its potential to drive future research in this area.

Z. Alharbi, J. Cornford, L. Dolder, and B. De La Iglesia, [3] The achievement of good honours in Undergraduate degrees is important in the context of Higher Education (HE), both for students and for the institutions that host them. In this paper, we look at whether data mining can be used to highlight performance problems early on and propose remedial actions. Furthermore, some of the methods may also form the basis for recommender systems that may guide students towards their module choices to increase their chances of a good outcome. We use data collected through the admission process and through the students' degrees. In this paper, we predict good honours outcomes based on data at admission and on the first-year module results. To validate the proposed results, we evaluate data relating to students with different characteristics from different schools. The analysis is achieved by using historical data from the Data Warehouse of a specific University. The methods used, however, are fairly general and can be used in any HE institution. Our results highlight groups of students at considerable risk of obtaining poor outcomes. For example, using admissions and first year module performance data we can isolate groups for one of the studied schools in which only 24% of students achieve good honour degrees. Over 67% of all low achievers in the school can be identified within this group.

M. S. Ahmad, A. H. Asad, and A. Mohammed.[4] Astonishing progress in machine learning and data mining techniques has been achieved during the last two decades. Education should benefit from these improvements to discover about how people learn in different educational settings. The aim of the research is comparing artificial neural network (ANN) to random forest (RF) machine learning models for predicting performance of students based on their demographic and assessment information. After analyzing the Open University Learning Analytics Dataset (OULAD), we applied feature-engineering techniques, and then the two models were evaluated. Our results showed that the ANN model outperformed the RF model accuracy 91.08& to 81.35 &. ANN performs well on educational data and can be efficiently used for predicting student performance and in early warning systems.

Y.-H. Hu, C.-L. Lo, and S.-P. [5] Shih An early warning system can help to identify at-risk students, or predict student learning performance by analyzing learning portfolios recorded in a learning management system (LMS). Although previous studies have shown the applicability of determining learner behaviors from an LMS, most investigated datasets are not assembled from online learning courses or from whole learning activities undertaken on courses that can be analyzed to evaluate students' academic achievement. Previous studies generally focus on the construction of predictors for learner performance evaluation after a course has ended, and neglect the practical value of an "early warning" system to predict at-risk students while a course is in progress. We collected the complete learning activities of an online undergraduate course and applied data-mining techniques to develop an early warning system. Our results showed that, time-dependent variables extracted from LMS are critical factors for online learning. After students have used an LMS for a period of time, our early warning system effectively characterizes their current learning performance. Data-mining techniques are useful in the construction of early warning systems; based on our experimental results, classification and regression tree (CART), supplemented by AdaBoost is the best classifier for the evaluation of learning performance investigated by this study.

3. PROPOSED METHODOLOGY

The proposed system is a modern, machine learning-driven early warning system that provides an advanced and holistic approach to identifying at-risk students in real time. By leveraging data from multiple sources—such as academic records, socio-economic factors, and behavioral indicators—the system uses machine learning algorithms like K-Nearest Neighbors (KNN), Random Forest, and SVM to predict students' likelihood of dropping out. The system processes this data continuously and proactively generates insights, allowing educational planners and decision-makers to act swiftly and effectively. Additionally, the proposed system integrates a user- friendly web interface, making it accessible to both administrators and teachers, allowing for better collaboration and informed decision- making. One of the key strengths of this system is its ability to analyze complex patterns and correlations that may not be immediately evident to educators. By applying predictive analytics, the system can identify students who are at risk due to declining grades, irregular attendance, behavioral changes, or financial constraints. These insights enable schools to implement timely interventions, such as academic support programs, counseling servicees, or financial assistance, tailored to each student's specific needs Furthermore, the system employs a feedback mechanism that continuously improves its predictive accuracy over time. As more data is collected and analyzed, the machine learning models are fine-tuned, ensuring that the predictions remain reliable and adaptive to changing educational environments. This feature makes the system highly scalable and effective across different regions and educational institutions, whether in urban or rural settings.

The web interface of the system is designed for ease of use, featuring intuitive dashboards, data visualization tools, and automated alerts. Administrators can view real-time reports on student performance trends, while teachers can receive individualized recommendations for students who may require additional support. Role-based access control ensures data security and privacy, allowing different stakeholders to access relevant information without compromising confidentiality.

Moreover, the proposed system fosters a data-driven culture within educational institutions, encouraging proactive decision-making and early intervention strategies. By providing real-time analytics and automated alerts, the system empowers educators to take preemptive measures before a student reaches a critical stage of disengagement. Additionally, the integration of AI-driven insights facilitates a more personalized approach to student support, ensuring that interventions are not only timely but also tailored to individual needs. This adaptability enhances student retention rates, improves academic outcomes, and strengthens the overall educational framework. With its scalable architecture and continuous learning capability, the system serves as a valuable asset in promoting inclusive and equitable education, bridging gaps in student support and fostering long-term.

The proposed methodology typically includes the following key components: Real-time Predictive Analysis

The Early Warning System leverages real-time predictive analytics to monitor students' academic progress, behavioral patterns, and socio- economic conditions. By continuously analyzing data as it Personalized Intervention Strategies

The system does not just identify at-risk students but also suggests tailored intervention strategies. Based on predictive insights, students can be provided with personalized learning plans, mentorship programs, or targeted counseling sessions. Schools can create customized academic recovery programs, assign tutors, or provide psychological support depending on the root causes of a student's declining performance. By ensuring that interventions are student-specific rather than generic, the system maximizes its effectiveness in preventing dropouts.

Adaptive Learning and Recommendation System

To further support struggling students, the system includes an adaptive learning module that recommends resources and study plans based on individual needs. If a student is weak in a particular subject, the system can suggest additional learning materials, video lectures, or practice exercises. AI-powered recommendation engines can help students navigate their academic challenges effectively by offering a personalized learning pathway, helping them stay engaged and motivated in

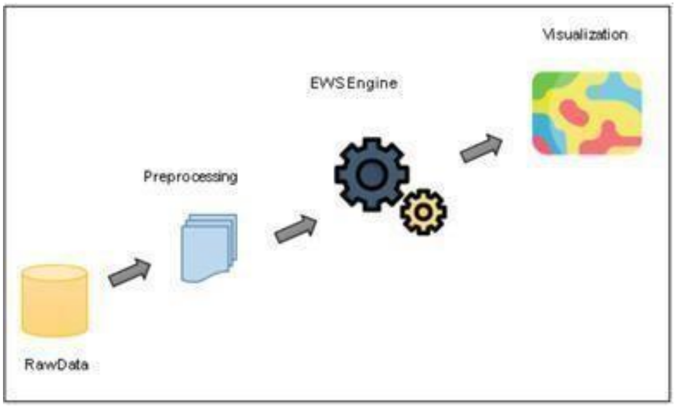

Figure 1: Proposed System

Parental and Community Engagement

Involving parents and local communities is essential in addressing student dropouts. The system incorporates mechanisms to notify parents about their child's academic progress, attendance, and behavioral trends through automated alerts and reports. Additionally, collaboration available, the system can identify at-risk students at an early stage. This community organizations can provide financial aid, tutoring services, or enables educators and administrators to implement timely interventions, extracurricular programs to support at-risk students. Strengthening this such as personalized academic support, counseling, or parental support network ensures that students receive assistance beyond theengagement, to prevent potential dropouts. Real-time alerts and reports classroom environment. provide a proactive approach, ensuring that no student falls behind

unnoticed. Multi-Level Decision Support System The Early Warning System is designed to assist decision-makers at different levels, from teachers to school administrators and policymakers. To maximize the system's usability, a well-designed and intuitive Furthermore, the cloud infrastructure facilitates automatic updates,
interface is essential. The user interface provides educators and ensuring that the system remains up to date with the latest features and administrators with easy access to critical student data, visual analytics, security enhancements. It also supports integration with other educational and predictive insights. Features such as dashboards, alerts, and report tools and platforms, enabling a more cohesive digital learning generation simplify the monitoring process, allowing decision-makers to environment. With built-in data encryption and access controls, the take immediate action. A user-friendly design reduces the complexity of system ensures that sensitive student information remains secure and interacting with predictive analytics, ensuring that stakeholders can protected from unauthorized access focus on implementing necessary interventions rather than struggling with technical challenges To maximize the system's usability, a well-designed and intuitive Furthermore, the cloud infrastructure facilitates automatic updates, interface is essential. The user interface provides educators and ensuring that the system remains up to date with the latest features and administrators with easy access to critical student data, visual analytics, security enhancements. It also supports integration with other educational and predictive insights. Features such as dashboards, alerts, and report tools and platforms, enabling a more cohesive digital learning generation simplify the monitoring process, allowing decision-makers to environment. With built-in data encryption and access controls, the take immediate action. A user-friendly design reduces the complexity of system ensures that sensitive student information remains secure and interacting with predictive analytics, ensuring that stakeholders can protected from unauthorized access focus on implementing necessary interventions rather than struggling with technical challenges To maximize the system's usability, a well-designed and intuitive Furthermore, the cloud infrastructure facilitates automatic updates, interface is essential. The user interface provides educators and ensuring that the system remains up to date with the latest features and administrators with easy access to critical student data, visual analytics, security enhancements. It also supports integration with other educational and predictive insights. Features such as dashboards, alerts, and report tools and platforms, enabling a more cohesive digital learning generation simplify the monitoring process, allowing decision-makers to environment. With built-in data encryption and access controls, the take immediate action. A user-friendly design reduces the complexity of system ensures that sensitive student information remains secure and interacting with predictive analytics, ensuring that stakeholders can protected from unauthorized access focus on implementing necessary interventions rather than struggling with technical challenges A crucial aspect of the system is its ability to integrate data from multiple Teachers can use real-time student performance insights to adjust their sources, creating a well-rounded profile for each student. Academic teaching strategies, while school principals can allocate resources more performance data, such as grades and attendance records, are combined effectively to areas with higher dropout risks. Educational policymakers with socio-economic factors like family income, parental education, and can use aggregated data to shape

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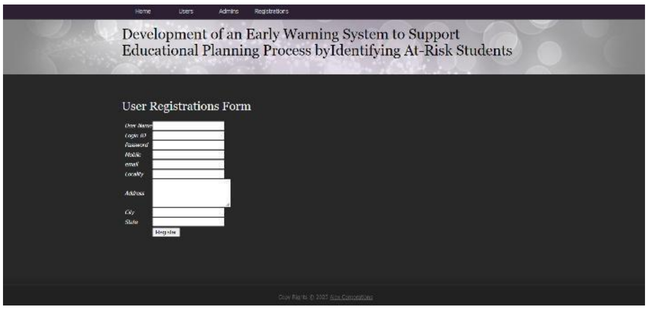
Applications

Applications of the Early Warning System (EWS) in Education



Student Dropout Prediction – Identifies students at risk of dropping out using academic, attendance, and behavioral data for early intervention.

Performance Monitoring – Tracks student progress and learning patterns to help educators refine teaching strategies.

Personalized Learning Support – Provides customized study plans and resources based on individual student needs and learning behaviors.

Behavioral Analysis – Analyzes student engagement and participation to detect disengagement and lack of motivation.

Data-Driven Decision Making – Assists institutions in making informed decisions by analyzing educational trends and student performance.

Automated Alerts and Notifications – Sends real-time alerts to teachers, parents, and administrators regarding students' academic struggles or attendance issues.

Resource Optimization – Helps schools allocate resources effectively by identifying areas requiring additional support.

Education Policy Development – Provides insights to policymakers for designing better strategies to improve student retention and outcomes.

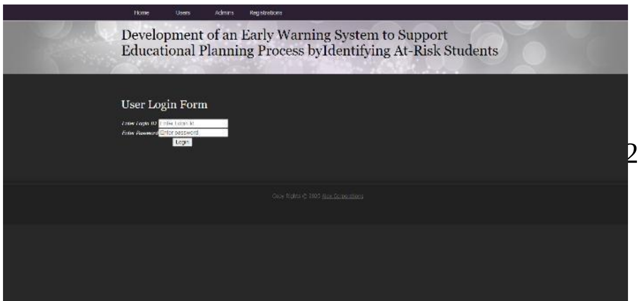
Advantages

Advantages of the Early Warning System (EWS) in Education

Early Identification of At-Risk Students – Detects students facing academic challenges or disengagement, enabling timely intervention.

Improved Student Retention – Reduces dropout rates by providing targeted support to struggling students.

Data-Driven Decision Making – Helps educators and policymakers make informed decisions based on real-time data analysis.



Enhanced Academic Performance – Provides personalized learning plans and resources to help students improve their studies.

Efficient Resource Allocation – Ensures optimal use of educational resources by identifying areas needing additional support.

Automated Alerts and Notifications – Notifies teachers, parents, and administrators about students' academic and behavioral issues.

Better Teacher Support – Assists educators in identifying students' strengths and weaknesses, allowing for customized teaching approaches.

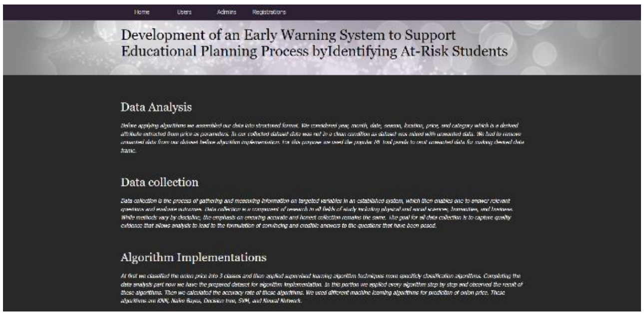
Predictive Analysis for Future Planning – Uses historical data to forecast trends and improve long-term educational strategies.

4. EXPERIMENTAL ANALYSIS

Figure 1 shows the web page of the Early Warning System (EWS) developed for educational planning. The interface allows users to input student-related data, which serves as the input for the predictive model. This page collects numerical values for various features, such as academic performance, attendance, and socio-economic factors, which are essential for the model to analyze and predict at-risk students.

Figure 2: Home page

Figure3 :Login page



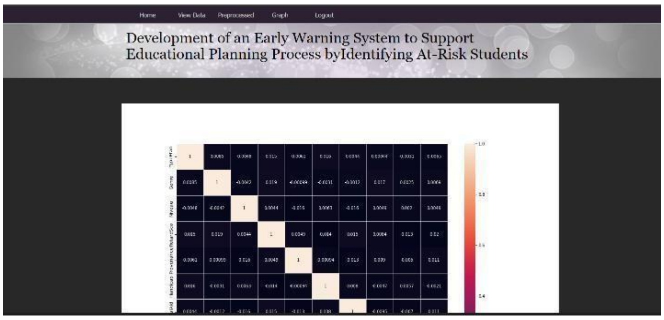
Development of an Early Warning System to Support Educational Planning Process byIdentifying At-Risk Students

Data Analysis

Data collection

Algorithm Implementations

Fifgure4.User Registration



Development of an Early Warning System to Support Educational Planning Process byIdentifying At-Risk Students

Figure5.Graph page

5. CONCLUSION

Education is a critical factor in national development, and school dropouts pose a significant challenge. Early school wastage, especially in primary education, results in a loss of financial resources and efforts, making it a high priority for educational authorities. Despite numerous initiatives to address this issue, it remains persistent, particularly in areas with limited resources. The Early Warning System (EWS) project provides an overview of the factors contributing to school dropout and offers insights into areas and individuals most affected. These insights can guide educational planners in formulating targeted policies and interventions.

By leveraging data-driven approaches, the EWS can help identify at-risk students early, allowing for timely intervention through counseling, financial aid, or tailored learning programs. Factors such as socio- economic background, family support, academic performance, and school infrastructure play a crucial role in determining dropout risks. Addressing these challenges requires a multi-stakeholder approach involving educators, policymakers, parents, and the community.

Moreover, technology-driven predictive models integrated into EWS can enhance its efficiency, ensuring that resources are allocated effectively to prevent dropouts. Schools and educational institutions can use real- time data analytics to monitor attendance patterns, behavioral changes, and academic progress, allowing them to act proactively. A well- implemented EWS can significantly reduce dropout rates, improve literacy levels, and contribute to a more educated and skilled workforce, ultimately fostering national growth and social development.

In addition to identifying high-risk students, the EWS can also help in designing personalized learning plans to keep students engaged in their education. Many dropouts occur due to a lack of interest or difficulty in coping with traditional teaching methods. By incorporating adaptive learning techniques, mentorship programs, and extracurricular engagement, schools can create a more inclusive and motivating learning environment. Government and non-governmental organizations (NGOs) play a vital role in the success of such initiatives. Investment in teacher training, infrastructure improvement, and community engagement programs can further strengthen the impact of EWS. Additionally, public awareness campaigns can help parents understand the importance of education and encourage them to support their children's schooling.

Ultimately, reducing dropout rates through an effective EWS not only benefits individual students but also contributes to long-term national development. A well-educated population leads to increased economic productivity, reduced poverty rates, and improved social stability. By integrating technology, policy reforms, and community participation, the education system can be transformed into a more resilient and inclusive framework, ensuring that every child has the opportunity to complete their education and build a better future.

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