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A REVIEW ON STUDENT LEARNING ANALYTICS AND ROLE OF MACHINE LEARNING TECHNIQUES

[1]KORRA RAKESH, [2]M SWAMY DAS

[1]M Tech Scholar, Department of Computer Science and Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad, India.

[2]Professor, Department of Computer Science and Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad, India.

Abstract: In the age of rapid technological developments and advancement, conventional Learning Management Systems (LMS) often struggle to meet the ever-changing needs of learners. the emerging technologies of AI and Machine Learning and bigdata are able to provide various kind of analytics including descriptive, diagnostic, predictive, and prescriptive analytics, as well as recommender systems and adaptive learning techniques. These analytics are useful for understanding, interpreting, prediction, decision making and building recommended system. By harnessing machine learning techniques, the shortcomings of traditional Learning Management Systems (LMS) platforms can be addressed. By incorporating the prescriptive analytics, Learning Management Systems (LMS) can be tailored made with recommendations to students, faculty by facilitating proactive interventions that are based on historical data patterns. The prescriptive analytics not only empowers teachers with insights for resource optimization and instructional strategies but also fosters an adaptive educational ecosystem that evolves alongside the diverse needs of learners and educators. This paper provides the recent developments on Learning Management System (LMS) and the role of ML techniques to provide Learning analytics aiming to revolutionize the learning experience.

Keywords- Prescriptive Analytics, Learning Management System, Machine Learning, Personalized Recommendations, Educational Ecosystem.

I. INTRODUCTION

A Learning Management System (LMS) serves as a digital framework tailored to streamline various aspects of educational management, including course administration, documentation, progress tracking, reporting, and content delivery. Its importance lies in providing a centralized and organized environment for learning, enhancing accessibility to educational resources, enabling personalized learning experiences, streamlining communication between instructors and learners, and offering tools for assessing and monitoring progress. A Learning Management System (LMS) serves as a pivotal tool in enhancing the efficiency and efficacy of educational delivery, benefiting both educators and learners alike.

The concept of learning analytics has evolved significantly over time, transitioning from an emerging idea to an indispensable tool in education. Stemming from its roots in educational data mining, learning analytics now offers a data-driven approach to enhancing the learning process. By measuring, collecting, and analyzing data on learners and their environments, educators can gain valuable insights to tailor learning experiences to individual needs. This field not only optimizes current educational practices but also serves as a catalyst for innovation, informing policies and fostering personalized learning journeys. Integration with educational technologies, such as Learning Management Systems (LMS), while ensuring ethical data use and privacy, is crucial.

Real-world applications demonstrate the efficacy of learning analytics, from boosting learner engagement to guiding predictive interventions that inform educational strategies. Its introduction marks a pivotal moment in education, reshaping traditional teaching and learning paradigms. Real-world applications of learning analytics demonstrate its effectiveness, ranging from increased learner engagement to predictive interventions that inform educational strategies. The introduction of learning analytics marks a pivotal moment in education, challenging traditional teaching paradigms and paving the way for more adaptive and personalized learning experiences.

Learning analytics encompasses various analytical approaches, including descriptive, diagnostic, predictive, and prescriptive analytics, as well as recommender systems and adaptive learning techniques. These methodologies collectively contribute to a holistic understanding of learners and their contexts, enabling educators to optimize learning environments effectively.

1.2 Transformation of Education & Learning Management Systems

The basic purpose of education is to provide students with knowledge and skills and attitude. With the rapid developments of emerging technologies including internet, 5G, AI, ML, bigdata analytics with the pedagogy of Education is drastically transforming in the recent period.

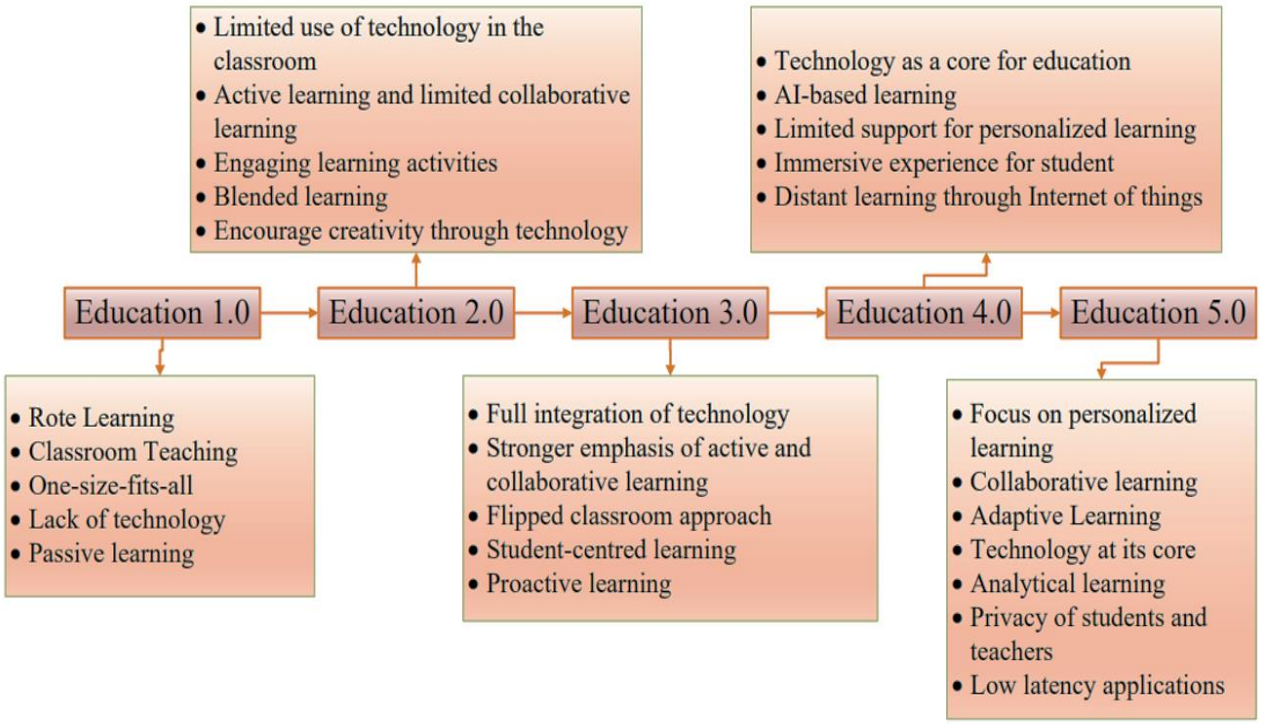

Figure 1:Transformation of education, learning methodologies

With this drastic transformation of education, the conventional pedagogy of education difficult and is a challenge to face the Millenium students who are digital natives the gap can be narrowed down by making use of Learning management system (LMS).

In contrast, Education 5.0 endeavors to foster a comprehensive and student-centric educational paradigm. It leverages technology to personalize learning, create immersive experiences, and provide students with the skills they need to succeed in the 21st century.

Here are some of the potential benefits of Education 5.0 for learners and teachers, as listed in the image:

- Gain skills and knowledge
- Personalized learning
- Immersive experience for students
- Collaborative learning

Of course, there are also challenges associated with Education 5.0. Some of these challenges include the need for robust infrastructure, ensuring privacy of students and teachers, and the cost of developing and implementing new technologies.

Education 5.0 holds the promise of transforming the landscape of learning and pedagogy. By harnessing the power of technology, we can create more engaging, effective, and personalized learning experiences for all students.

Machine learning algorithms play a crucial role in personalizing the learning experience within Education 5.0. These algorithms can analyze student data, such as test scores, homework assignments, and online interactions, to identify individual strengths and weaknesses. Utilizing this data enables the provision of personalized learning pathways, curated recommendations for learning resources, and dynamic adjustments to the complexity of instruction in the moment. For instance, an AI-driven tutoring system could detect a student's challenges with a particular mathematical concept, offering tailored solutions such as supplementary problem sets or customized video tutorials. This individualized strategy empowers students to advance at their preferred pace, ensuring mastery of concepts before advancing to new material.

In general, consist of several components

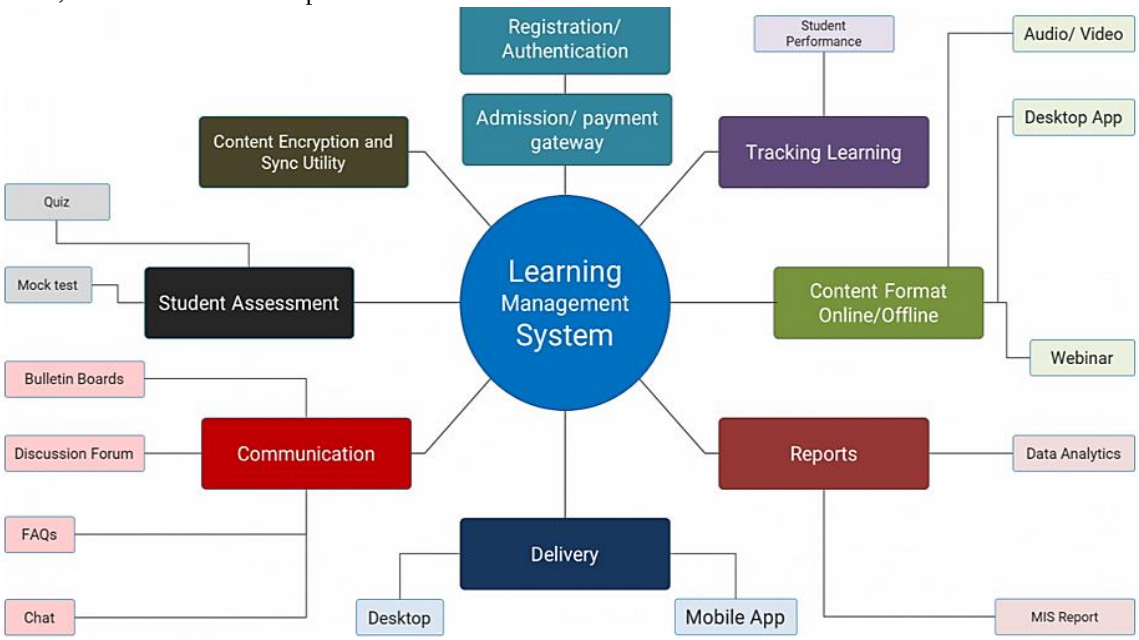

Figure 2: Block diagram of Typical Learning Management System

A Learning Management System (LMS) comprised of several modules that work together to facilitate online learning. Here's a few key modules:

- **Admission/Payment Gateway:** This module handles student registration, enrollment, and fee collection.
- **Content Format Online/Offline:** This module allows for the delivery of learning materials in various formats, including online and offline access for downloaded materials.
- **Communication:** This module provides communication tools like discussion forums, chat, and bulletin boards to enable interaction between students, instructors, and administrators.
- **Student Assessment:** This module offers tools for creating and administering quizzes, exams, and other forms of assessments to evaluate student learning.
- **Reports:** This module generates reports on student progress, course completion rates, and other learning data.
- **Tracking Learning:** This module tracks student activity within the LMS, including course progress, content access, and assessment results.
- **Content Encryption and Sync Utility:** This module ensures the security and accessibility of learning materials by encrypting content and providing tools for offline access.

The Tracking Learning module plays a pivotal role in understanding student performance within an LMS. By monitoring student activity, educators can gain valuable insights into:

- Tracking learning allows instructors to assess how students are progressing through the course material. This information can aid in pinpointing areas where students might encounter difficulties, enabling educators to offer tailored assistance and resources to address their needs effectively.
- Tracking can reveal how students are interacting with the course content. This information can help instructors determine whether the course is engaging and whether students are actively participating in learning activities.
- Tracking data can help instructors evaluate the effectiveness of course materials and identify areas for improvement.
- By understanding individual student needs and progress, instructors can tailor their teaching methods and provide more personalized learning experiences.

In essence, tracking learning and student performance is essential for ensuring that students are getting the most out of their online learning experience. It empowers instructors to identify learning gaps, provide targeted support, and ultimately improve student outcomes.

Learning Management Systems (LMS) suffer from a lack of personalized interventions tailored to meet the individual needs of students, primarily due to the absence of prescriptive analytics capabilities within traditional Learning Management System (LMS) platforms. This deficiency not only hampers educators' ability to intervene proactively but also contributes to ineffective resource allocation and instructional strategies. Additionally, the inability to adapt to the diverse learning preferences and requirements of students leads to suboptimal engagement and learning outcomes.

The adoption of Learning Management System has several motivations:

1. **Accessibility**: Provides learners with the ability to access learning materials at any time and from any location, enhancing the flexibility of education.
2. **Customization and Scalability**: Offers personalized learning experiences to meet the needs of individual learners and can easily scale to accommodate an increasing number of users.
3. **Tracking and Reporting**: Facilitates tracking of learner progress and assessment scores, allowing educators and trainers to identify areas for improvement.
4. **Cost-effectiveness**: Reduces the costs associated with physical classroom space and materials, making education and training more cost-effective.
5. **Consistency**: Ensures consistent delivery of content, which is particularly important for training purposes in corporate settings.

II. LITERATURE REVIEW

Several works are reported in literature related to LMS including the following:

Michael et al. (2022) proposed simulation-based data-driven models, marking a new era in decision-making and optimization through AI. This pioneering work underscores the synergy between varied analytical approaches to enhance accuracy and data security while emphasizing the importance of interpretability in complex decision-making landscapes. However, the integration of disparate technological frameworks remains resource-intensive, suggesting future research should focus on bridging these gaps to transform decision-making processes across industries [1].

Mochamad Yunus et al. (2023) examined the impact of the COVID-19 pandemic on student behavior in online learning environments through a survey methodology. Their research highlights the benefits of digital learning platforms, such as flexibility and reduced need for physical classrooms, while also revealing significant challenges like diminished lecturer oversight, technical difficulties, and decreased student engagement. These insights suggest a need for more robust, interactive platforms to balance the convenience of online learning with effective student engagement [2].

Katerina Lepenioti et al. (2021) explored the integration of human intuition with algorithmic precision in decision-making processes using reinforcement learning. This approach leverages sequential decision-making while respecting human feedback. Despite its potential, the reliance on human input and the risk of overfitting pose challenges, indicating the need for balanced integration of human and machine intelligence in future research [3].

Paola Mussida et al. (2022) introduced a predictive model to identify potential dropout scenarios among engineering students using Exploratory Data Analysis (EDA). While demonstrating the predictive power of data analytics in education, the study also raises ethical concerns regarding data privacy and the accuracy of predictions, underscoring the necessity for ethical considerations and ongoing refinement in predictive educational tools [4].

Mustapha Oudani et al. (2023) combined machine learning with optimization algorithms to address port logistics complexities. This research showcases the potential of ML in enhancing resource allocation and managing uncertainty but highlights the challenges of integrating sophisticated analytical tools into existing logistical frameworks, pointing to a promising area for future exploration in prescriptive analytics [5].

R. Kavitha et al. (2022) made significant strides in embedding AI and big data analytics within healthcare frameworks. Utilizing an enhanced K-NN algorithm, the study outlines methods to expedite and refine medical decision-making. However, the integration of advanced AI methodologies presents substantial hurdles, prompting discussions on the future role of AI in medical sciences [6].

A. Mohammed Faisal et al. (2022) delved into prescriptive analytics in the manufacturing sector, illustrating how simulation models can streamline practices for greater efficiency and cost-effectiveness. Despite the complexity of these models, this research suggests rich potential for further development and refinement in the field [7].

Karima Hamdane et al. (2022) critically examined learning analytics' potential to revolutionize education. The study highlights the promise of personalized education through advanced analytics while confronting ethical and logistical challenges, sparking crucial conversations about the balance between innovation and privacy in educational technologies [8].

Divakar R et al. (2022) explored the capabilities and challenges of big data through prescriptive and predictive analytics. The study emphasizes the transformative potential of data-driven decision-making but acknowledges the complexity and steep learning curve involved, indicating a need for greater understanding and application of these techniques [9].

Samina Amin et al. (2023) proposed an innovative e-learning framework using reinforcement learning to offer personalized learning pathways. This approach enhances learning outcomes by tailoring content to individual needs but also navigates the challenges of model accuracy and applicability across diverse learning environments, underscoring the promise and complexity of ML in education [10].

Divya Shree N et al. (2022) integrated predictive and prescriptive analytics into We-CDSS, facilitating personalized lifestyle recommendations for CAD management. The LWGMK-NN algorithm's accurate CAD risk prediction and the use of prescription rules to tailor lifestyle suggestions demonstrate the potential of predictive analytics in healthcare, though further refinement is necessary to address ethical and practical concerns [11].

Table 1: summary of works related to Learning Management System (LMS)

Author, year	Method/Approach	Feature/benefits	Limitations/ gaps
Michael, et al., 2022, IEEE	SPA- Decision making and optimization – AI methods	Accuracy, data security, and improved interpretability	Integration of technology integration, Resource intensive
Mochamad Yunus, et al., 2023	Servey- student behaviour in during the Covid-19 pandemic	Flexibility & reduces the need for physical presence	lack of direct observation and control by lecturers, technical issues, include lower student engagement
katerina lepenioti, et al., 2021	Sequential decision-making process	Non-intrusive support to humans	Reliance on Human Feedback. Risk of Overfitting:

Paola Mussida, et al., 2022	EDA	A predictive model using data analytics is developed to forecast potential dropouts.	data privacy concerns and model accuracy.
Mustapha Oudani, et al., 2023	ML-data prediction & a genetic algorithm for optimization.	Resource utilization and better handling of uncertainties	Integration and data analysis
R.Kavitha, et al., 2022	K-NN algorithm	Providing faster and more accurate medical decision-making.	AI and big data analytics in existing healthcare frameworks.
A.Mohammed Faisal, et al.,2022	Prescriptive analytics and simulation models	More efficient and cost-effective	Complexity of simulation models and analytics.
Karima Hamdane, et al., 2022	learning analytics techniques to enhance the e-learning process.	improved learning outcomes and personalized education.	Data privacy concerns and the complexity of analytics implementation.
Divakar R, et al., 2022	Prescriptive and predictive analysis	Improved data handling and decision-making	Complexity in implementation
Samina amin, et al., 2023	Reinforcement learning, Recommend personalized learning paths Markov decision process,	Improved learning performance, personalized and adaptive learning experiences	Model's accuracy over diverse learning contexts
Divya Shree N et al. (2022)	Integrated predictive and prescriptive analytics into We-CDSS using the LWGMK-NN algorithm.	Personalized lifestyle recommendations for CAD management.	Ethical and practical concerns need further refinement.

III. ROLE OF MACHINE LEARNING TECHNIQUES

Machine learning (ML) techniques are pivotal in the nuanced analysis and prediction of student performance, utilizing an array of features including assignment marks, practice test scores, and online engagement hours. By deploying sophisticated machine learning models such as the Random Forest Classifier, regression algorithm, Deep Learning techniques etc.,

- Random classifier: The Random Forest Classifier is an ensemble learning technique that creates numerous decision trees during training and aggregates their outputs for classification or regression tasks. It effectively manages the complexity and variability in educational data, offering precise predictions and tailored feedback to learners.
- Regression algorithm: Regression algorithms are statistical techniques employed to establish the connection between a dependent variable and one or more independent variables. Their purpose is to forecast continuous outcomes and discern the factors influencing the dependent variable. This capability aids educators in crafting precise intervention strategies aimed at enhancing student success.
- Deep Learning: Deep learning, particularly through neural networks, excels at analyzing complex datasets to uncover nuanced patterns, leading to precise predictions and tailored learning suggestions. This specialized form of machine learning employs multi-layered artificial neural networks to extract intricate data representations, enabling personalized educational approaches aligned with individual student needs.
- SHAP (SHapley Additive exPlanations): SHAP serves as an interpretative tool, offering detailed insights into the relative significance of different features. By elucidating model predictions, SHAP empowers educators to refine teaching strategies with a deeper understanding of how various factors influence student performance, enabling more informed decision-making in education.

In essence, ML augments the capacity to monitor academic progress, identify at-risk students proactively, and foster adaptive and collaborative learning environments. These ML methodologies are instrumental in discerning the key determinants of student success, thereby enabling targeted pedagogical interventions. Through the integration of these advanced techniques, educational institutions can better support personalized learning journeys, ensuring each student receives the guidance and resources needed to thrive academically.

In the context of Education 5.0, machine learning algorithms are integral to the personalization of the learning experience. These algorithms meticulously analyze comprehensive student data, encompassing test scores, homework submissions, and online interaction metrics, to pinpoint individual strengths and areas for improvement. Such data-driven insights facilitate the recommendation of tailored learning pathways, the selection of appropriate instructional materials, and the dynamic adjustment of instructional difficulty. For example, an ML-powered tutoring system can detect a student's difficulty with specific mathematical concepts and subsequently propose additional practice problems or video tutorials specifically designed to address those challenges. This precision-targeted approach enables students to progress at their own individualized pace, ensuring mastery of concepts before advancing to more complex topics.

IV. RECOMMENDATION

The implementation of prescriptive analytics within Learning Management Systems (LMS) represents a paradigm shift in educational technology, offering the potential to significantly enhance the learning experience for students and educators alike. One key aspect of this implementation is the choice of machine learning algorithms to analyze student behavior and performance data. Different algorithms may yield varying results, and careful consideration must be given to selecting the most appropriate ones for the task at hand.

- Integrating prescriptive analytics into existing LMS platforms presents both opportunities and challenges. While it enables hyper-personalized recommendations tailored to individual learners' needs and preferences, seamless integration requires meticulous planning and technical expertise. Among the myriad LMS options available, Moodle stands out as a popular open-source platform with customizable plugins. Integrating machine learning and interpretative tools like SHAP into Moodle can enhance student success by providing tailored interventions and recommendations.
- Additionally, the implementation of prescriptive analytics raises ethical considerations regarding student data privacy and transparency. Ensuring data security and building trust among stakeholders are essential for successful integration. Furthermore, the effectiveness of prescriptive analytics depends on the quality and relevance of input data. Maintaining data cleanliness and consistency is paramount to ensure reliable recommendations and improved learning outcomes.

In conclusion, while prescriptive analytics holds immense potential for personalized learning, careful consideration of algorithm selection, integration challenges, ethical implications, and data quality assurance is vital for successful implementation. By addressing these aspects thoughtfully, educators can harness the power of prescriptive analytics to unlock new possibilities for student success in the digital age.

V. CONCLUSION

In the foundational phase of this study, an insightful exploration of Learning Management Systems (LMS) and their potential to enhance educational outcomes was undertaken. Through an extensive review of scholarly literature and practical experimentation, valuable insights into the capabilities and challenges of LMS technologies were gained.

The study revealed the transformative power of LMS in shaping the future of education. While the focus was not limited to any specific platform like Moodle, the analysis highlighted the broad spectrum of functionalities offered by modern LMS solutions. From content management to student engagement tools, LMS platforms present a wealth of opportunities for educators to create dynamic and interactive learning environments. Furthermore, a hands-on approach, including the setup of LMS technologies on a local machine and the integration of server environments, provided practical insights into the implementation and customization of these systems. This experiential learning process deepened the understanding of the complexities involved in deploying LMS solutions in real-world educational settings.

The significance of these findings informs future developments in educational technology. This journey has laid a solid foundation for further exploration and innovation in the field of LMS, paving the way for more personalized, engaging, and effective learning experiences.

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