Research Article

Received: 26 July 2024 / Accepted: 25 October 2024 / Published: 05 November 2024

Application of Academic Analytical Models in Education Management

Mirella Correa-Peralta*

Jorge Vunueza-Martinez

University Estatal de Milagro,
091706, Milagro,
Ecuador
**Corresponding Author*

DOI: https://doi.org/10.36941/jesr-2024-0171

Abstract

Objective: The primary objective of the current study is to provide an analytical systematic review on the application of academic analytical models in educational management and how the related techniques can be used to enhance quality outcomes and learning processes. Methodology: The study adopted the methodological framework outlined by the Joanna Briggs Institute (2015) and was informed by Arksey and O'Malley's (2005) approach of summary and dissemination of research findings and, in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Findings: Learning analytics has emerged as the most relevant educational concept with the potential of collecting, analyzing and reporting data on learners, educators and administrators for efficient educational management processes. Analytics in education enhances the capabilities of the educators of determining the learners' performances and identification of areas for improvement to make data-driven learning decisions. Conclusions: The application of analytical models in educational management is based on different domains such as customized learning, intelligent tutoring systems, predictive modelling, automated grading and assessments, and natural language processing.

Keywords: *Learning Analytics, Machine Learning, Natural Language Processing, Education Data Mining*

1. Introduction

The past few decades have witnessed a full-scale incorporation of technology in educational systems for creation of effective learning experiences and improvement of student performances. In modern society, educational systems operate within environments where large quantities of data and information are leveraged for in-depth understanding of the intended objectives of the learning process. The educational landscape is experiencing rapid evolution exacerbated by technological advancements and the ever-changing pedagogical techniques which has led to the development of systems that leverage analytical models and machine learning algorithms for analysis of learner performance, identification of knowledge gaps and generation of personalized learning pathways (Kumar et al., 2023). Educational systems and institutions are actively adopting technologically-based analytical models and algorithms to improve learner engagement and knowledge retention, and to

manage the vast quantities of data associated with expanding educational information technology (Kumar et al., 2023; Wu, 2021). According to De Witte & Chenier (2022), education stakeholders are operating in an environment with an expanding pool of data that is generated by technological platforms of interactions and which require cutting-edge analytical techniques for effective application in learning processes and educational management. The large amount of available and accessible educational data has necessitated the application of academic analytical models through an interdisciplinary domain that borrows from statistics, computer technology and education to exploit the data-rich landscape to enhance learning processes and educational management.

Academic analytical models, better known as learning analytics, is set within the new domain of computational social sciences which entails the generation and application of complex computational techniques for large-scale study of human behavior. As rapidly emerging educational concepts, leaning analytics and algorithmic models direct technological and computational advancements towards the development of actionable educational information, and attempts to propose means for exploration, analysis and visualization of data from the applicable and relevant data source (De Witte & Chenier, 2022). Learning analytics play a crucial role in educational management especially in relation to the exploitation of traces of learning pathways left by the learners in electronic educational platforms as well as maximization of learner cognitive and non-cognitive outcomes (De Witte & Chenier, 2022; Kassab et al., 2020). Also, data analytics in education enhances the capabilities of the educators of determining the learners' performances and identification of areas for improvement to make data-driven learning decisions (Kumar et al., 2023). Further, the level of personalization achieved through academic analytical models has a significant impact on the learner experience through closely monitored participation and performance by the educator (Kharade & Wagh, 2016; Moore, 2018). The practical applications and utility of academic analytical models are based on how the educational information is used, especially in management of the data and monitoring of the learner progress during the course, with a primary objective of providing high quality education for an enlightened society.

The significance of academic analytical models in education and society at large is increasingly becoming an element of great interest among scholars and academicians. Currently, the loud buzz surrounding the application of artificial intelligence (AI) in education has led to widespread academic research on the role of technological tools in management of educational processes and the possible challenges associated with such applications. According to Kumar et al. (2023), the use of AI and associated analytical technologies has the potential of revolutionizing the educational experience for the learners, educators and administrators alike, through the development of an engaging, adaptive and flexible learning environments for improvement of educational outcomes and preparation of the learners for the life after schools and societal demands for the future. With the increased academic and scholarly interest in artificial intelligence, there are a wide range of studies that have focused on the different aspects of the emerging domain, most of which place's emphasis on the application of the related techniques in the improvement of learner outcomes and enhancement of educational quality. However, few of the research studies have specifically focused on the role of academic analytical models in educational management through a wider scope lens that incorporates all the involved stakeholders as well as the wide range of applicable techniques and tools. To this end, the current research study aims to fill the existing research gap on the topic by providing an analytical systematic review of the existing literature on the application of academic analytical models in educational management and how the related techniques can be used to enhance quality outcomes and learning processes.

2. Literature Review

The emergence of artificial intelligence and algorithmic analytical models as transformative forces in modern educational context has led to the proliferation of a lot of research studies on the phenomena and their impact on education. Arteaga et al (2020) conducted a research study on the application of

academic analytics model for the collection and analysis of data from teachers and students. In the research study, Arteaga et al (2020) report that academic analytics is a crucial aspect of education that enables the analysis decision-driven data through aggregation of valuable academic information for optimization of the learning processes and improvement of quality of outcomes. According to Arteaga et al (2020), the application of academic analytical processes provides reliable data on student achievements by providing access to data from both the learner and the educator including average performance of subjects, the degree of failure and progress, and the learning curve, which are crucial tools for evaluation of learner progress. Further, Arteaga et al (2020) report that educational platforms provide the perfect example of application of big data analytics since every student leaves a traceable trail of their academic actions within the learning system that provides valuable insights on their educational progress and readiness for real-life applications of the learned concepts. The authors provide detailed processes undertaken during the analytical phase of educational processes including the collection and interpretation of data to turn them to relevant and applicable information that can be effectively used by the learners, educators and administrators to improve the quality of educational outcomes.

Romero & Ventura (2020) provided an updated survey to their previous version, published in 2013, on the application of learning analytics and educational data mining in educational management. According to Romero & Ventura (2020), the application of technological advancements including e-learning resources, instrumental educational software, student database information and analytical models has led to the creation of large repositories of educational data that are applicable in learning processes and associated activities. In the updated survey, the authors define learning analytics as the measurement, collection, analysis and reporting of applicable educational information about the learning processes and data on the learners and educators for purposes of understanding and optimization of learning and its associated environments. Further, the authors define education data mining (EDM) as the development of methods for exploration of unique data types related to the education environment to address crucial education questions such as improvement of quality outcomes and efficiency of dissemination of knowledge from the educator to the learner. Romero & Ventura (2020) note that educational data mining and learning analytics provide vast proportion of potential educational data from multiple sources with different formats, granularity levels and hierarchy levels that can be used to enhance different aspects of the learning process to achieve the intended learning outcomes. The survey by Romero & Ventura (2020) provides detailed understanding of the concepts of educational data mining and learning analytics that are effective in management of education of educational processes and improvement of the quality of outcomes.

Sousa et al. (2021) conducted a systematic literature review on the application of learning analytics in high schools and highlighted the high level of maturity of the concept in modern education. According to Sousa et al. (2021), learning analytics has emerged as the most relevant educational concept with the potential of collecting, analyzing and reporting data on learners, educators and administrators for efficient educational management processes. The authors note that learning analytics provide detailed educational data such as student demographic information, student grades and behavior which expands the possibilities of retention strategies and, thus, meeting their needs in a more personalized and data-oriented manner. To answer their first research question, Sousa et al. (2021) report that learning analytics is more educational rather than technological on the basis of its applicability to prediction and analysis of student learning outcomes, learning processes and providing support to teacher's decisions, reflections and student's learning activities. In terms of prediction, the authors highlight the use of regression and classification academic analytical techniques for prediction of learning outcomes and note the application of unsupervised methods to group similar instances of the data in relation to clustering processes of learning analytics. Sousa et al. (2021) show that learning analytics improve the performance of students in high schools by providing practical application of analytical tools by students to improve their learning skills and improving the capabilities of the educators to formulate better and more

efficient educational programs. The review clearly highlights the significance of academic analytical models in education management by providing detailed application of the related techniques in improving the learning outcomes and the progress of learners during their learning period.

De Souza Zanirato Maia et al. (2023) conducted a systematic review on the application of artificial intelligence (AI) models in educational institutions and systems. In the review, De Souza Zanirato Maia et al. (2023) found that AI models are widely being applied in educational settings to increase the knowledge on learning processes that manifest themselves at national and local levels for formulation of policies and allocation of resources to aspects that are considered as relevant to educational performance. Further, the review found that the models can be used to conduct specific investigations into different stakeholders involved in the education sector including the students, teachers and the institutions to predict more immediate results that might not be dependent on governmental spheres (De Souza Zanirato Maia et al., 2023). The authors further note the different levels of datasets within school dynamics that highlights the relevance of computational models and techniques in management of responsibilities of the teachers, their skills and classroom management. De Souza Zanirato Maia et al. (2023) outline specific examples of educational analytical models such as the Local Interpretable Model-Agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP), which are applicable in interpretation and simplification of relevant independent variables in prediction of efficacy of educational management systems. It is noted that the perfect approach for application of analytical models in education management entails consideration for application of the techniques with performance metrics and study of importance of related variables to enhance the ability to interpret the efficacy of associated models.

Wang (2019) conducted a research study on the application of Big Data analytics in college education management. According to the study, the general processes of big data analytics in higher education involve data collection, processing, storage, analysis and presentation. The author notes that Big Data analytics can be used to improve the quality of educational policies at different levels of management, both at micro and macro levels. At the micro-levels, academic analytical models can be used by the educators to master the learning needs of the students, their behaviour and the effect of the learning processes through educational data mining and analysis techniques which provide the relevant support for customized teaching (Wang, 2019). At the medium level, the analytical techniques can be used by different educational departments for optimization and improvement of teaching and research departments, management of personnel and enrolment, and decision-making processes (Wang, 2019). At the macro-level, different governmental spheres can use analytical technologies for formulation of global, national or local educational strategic plans, and to monitor and predict the scale of structural adjustments on the overall state of the development of higher education (Wang, 2019). Further, Wang (2019) notes that big data analytics can be used to enhance the management of curriculum and teaching processes through study platforms such as Massive Open Online Courses (MOOC) which are applicable in tracing the learning times of the students and the frequency of specific knowledge points as well as their course grades.

3. Methodology

The current research study adopted the methodological framework outlined by the Joanna Briggs Institute (2015) and was informed by Arksey and O'Malley's (2005) approach of summary and dissemination of research findings and, in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The adopted methodological framework involved three primary steps involving planning, conducting and reporting the review.

In practice, the operationalization of each of the methodological frameworks that have been adopted in the study followed a systematic procedure. Thus, in the planning stage, a rather strict procedure for choosing publications was followed. The identified three-step search strategy included electronic database searches with cross-referencing also used as a search technique. The use of both methods meant that no important literature was left out in the review process. Publication bias filters

consisted of the use of well-developed research protocol and inclusion and exclusion criteria which helped to screen and include, respectively, only those studies that were highly relevant to analytical models in educational management. In particular, during the screening, the researcher applying a multi-step procedure excluded the irrelevant studies at the initial stage respondent. The exclusion and inclusion criteria used in this study involving the titles and abstracts, plus the review of full texts, ensured that only the most relevant studies were selected for review. The excluded studies were those that were not directly related with the key issues and other sources which did not contain any analytical material, offered only authors' opinions, comments or editorials, as the present work is an evidence-based review.

Similarly, the coding step was done systematically to categorize the selected studies into topical sets. The coding framework was used to analyse the studies into two broad categories with sub-categories as sub-areas for each theme. The theme for the academic analytical models was further subdivided into sub themes of collection of data, derivation of data and presentation of data. By such a classification, it became easier to decipher how educational data was collected, analysed and presented in the literature. Similarly, for the purpose of research on educational technological tools, the bifurcation of the technological tool into the software and hardware components provided systematic specializations of the microscopic digital and physical objects used in the educational context. During the conducting phase, a proper quality assessment was conducted carefully with focus on the biases, as well as the study designs' purity. For instance, in establishing information bias, the studies were reviewed for method of data collection and method of data reporting, with a view to pointing out any difference in the two processes. The author took an approach of involving other authors in the articles to solve the inconsistencies that exist in authors' findings to arrive at consensus thus minimizing bias in the interpretations made. Subsequently, data extraction was done accurately, and missing values of any major end result were imputed using the techniques specified in Cochrane Handbook. Overall, a statistical approach was used to bring a usable standard for comparison and ensure that the data within each study was more comparable.

4. Planning of the Review

The review process in this research was deliberately sequenced and thorough in order to guarantee the validity of the results. Further to the coding of the articles as described by the researchers and by using of different selection criteria, the given list included articles for the final review. These were done according to the relevance of the studies to the research questions and the established criteria used in inclusion and exclusion of the studies. Particularly, articles were included into the analysis if these articles,' The articles have to include at least one of the following: considered the analytical models used in education management, presented empirical data, focused on the technological instruments in education.' Thus, wherein it was unclear, we only considered research articles published in refereed journals, opinion pieces, commentaries, and other similar articles were not considered. Furthermore, any article which failed to explain its method of approach and study or in which results were not statistically treated also did not make it into the list. After this, data extraction process was done sequentially in order to avoid missing out on any data as well as ensure that all the data is retrieved. Information was also extracted based on certain criteria from each of the included studies. The author of each included study was the main data extractor, as guided by a pre-developed data extraction form. The form enabled the author of each included study to provide information such as the study design, the sample size, the types of analytical models that were employed, and specifically which Edu technological tools were featured in the endeavour. In addition, records of overall organisation and study outcomes, issues, and conclusions were also taken. A chronological approach to the latter allowed for a highly structured comparison between the studies and a thorough synthesis of the observations.

Concerning the evaluation of the quality, the JBI critical appraisal instruments were used to assess the methodological quality of the studies included in the review. Each study was evaluated in

terms of potential risk of bias, definition of study's objectives, the suitability of the selected research approach, sample size conditioning, and the type of data analysis used. The reduced risk of the bias associated with selection bias and information bias were of particular interest to the researcher and thus the present studies were required to demonstrate a clearly described population sample and a valid method of information ascertainment. Any multiples choice identified during the quality assessment were discussed to consensus till decisions were made on the inclusion of each study. Also, an attempt was made to address the missing or ambiguous data with various imputation techniques identified in the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions. This approach was carried by assessing missing values to ensure that there were no gaps in collecting the data required for the reliability of the review outcomes.

The first step of the methodological framework was planning the review, and it involved the identification and coding of articles for inclusion in the study. In the identification sub-step, a literature review protocol that outlined the inclusion and exclusion criteria of the review was created, and a three-step strategy was used for identification of the appropriate research terms and the applicable literature associated with analytical models in education management. Any additional article on the topic that was not be identified through database searches was identified through cross-referencing and hand searches of the reference lists of the included studies. The eligibility for inclusion was based on the research terms and abstracts after which the identified articles were undertaken through a multi-step screening procedure. The initial step of the screening process entailed the exclusion of studies with irrelevant titles and research questions to the review. Second, the researcher discarded studies that did not align with the research question of interest and those that were written as reviews, editorials or commentaries. A final list of the articles to be included in the research was then created based on the inclusion and exclusion criterion followed by an independent review of the identified articles to determine their suitability, and if they met the inclusion criteria.

The second sub-step of the planning step involved coding of the selected articles and research studies. In this sub-step, the selected articles were classified based on a coding scheme with two thematic topics of academic analytical models and educational technological tools. In regards to the first thematic topic, the three sub-themes included data collection, data derivation and data presentation. Based on that foundation, the research questions of the selected articles focused on development, extraction and application of the analytical models in education management. The development aspect of the articles focused on academic analytical presentation models while the extraction aspect focused on obtaining the relevant data through analytical processes. The application aspects of academic analytical models focused on the derivation of information and data through human-computer interaction. In relation to the thematic topic of educational technological tools, the selected articles were sub-divided into the software and hardware components of the technologies used in educational management. In terms of software, the articles focused on algorithms, programs and models used in management of learning processes, while those that were coded under the hardware sub-theme focused on sensors and devices such as virtual reality, that are applicable in educational management.

5. Conducting and Reporting the Review

After identification and coding of the articles and research studies to be included in the study, the author extracted specific facets of information associated with the topic of research. The author undertook a quality assessment of the included studies using criteria that examined the information bias, selection bias, study design and the correction of outcome measures for confounding of the studies. Any discrepancies that were found within the extracted data were discussed and a protocol for creating a common agreeable consensus on the issues was formulated. For every single outcome of interest that was extracted from the data, the author recorded the associated values in an Excel spreadsheet for synthesis and interpretation. The author then employed the Cochrane Handbook for

Systematic Reviews of Interventions for estimation of values that had not been published.

6. Findings

The articles search strategy and selection criterion identified a total of 89 sources that largely included published articles and relevant book chapters. The different article sources included journals such as *Handbook of Computational Social Science for Policy, Responsible Analytics and Data Mining in Education, International Journal of Computer Applications, Journal of Computer Assisted Learning* and *Frontiers in Artificial Intelligence*. After the removal of the duplicated articles, a total of 64 articles remained. Out of the remaining articles, 26 did not meet the inclusion criteria and, therefore, only 38 were obtained for detailed eligibility assessment. Further, eight studies did not meet the eligibility criteria and were excluded from the final list of the studies included in the review. Out of the remaining 30 studies, 8 provided only abstracts and, consequently, a total of 22 full-text articles were eligible for inclusion in the review.

It can be said that Predictive Modelling is one of the most important tools to focus on the evaluation of students' performance based on the data obtained from their demographics, grades and behaviour. This approach helps educators be proactive so as to predict outcomes of students and foster timely effective learning. For instance, identifying which students are most likely to drop out, institutions of learning can offer specific support like tutoring or counselling to improve the dropout rate and success rates of those students. On the other hand, learning management system known as Intelligent Tutoring Systems use natural language processing and machine learning to imitate tutoring. This makes the Intelligent Tutoring System to be unique and more personal as compared to conventional learning management systems. These systems communicate to the learner in real time and provide feedback that is personalized for each learner. NLP allows for a more natural method of interpreting student input while machine learning enhance the system function by recognizing students' behaviour and introducing changes in the instructional content based on such behaviour. Nevertheless, technologies such as chatbots, and VR play a part of ITS not only in the level of interactivity, but also in the educational aspects which help most students when it comes to their understanding of a particular course, especially when the subject matter is mathematics or science. They are crucial to educational management by offering key information and responsive learning contexts, where by decisions and actions concerning curriculum, teaching, and learning as well as student support services can be made effectively.

The findings identified two primary educational models which are compared in Table 1. Below;

Table 1: Comparison of the Educational Frameworks

Intelligent Tutoring Systems	***Predictive Modelling***
Employ natural language processing and machine learning to enhance interactions with the learners	Provide information on student demographic information, student grades and behavior
Can simulate human tutoring	Provide capabilities of adaptation of instructional content, pacing, and feedback
Exploit traces of learning pathways.	Provide average performance of subjects, the degree of failure and progress, and the learning curve.
Uses tools such as chatbots, virtual reality and intelligent interfaces.	Simplify relevant independent variables.

7. Practical Application Case Studies

7.1 Intelligent Tutor Systems (ITS)

Case Study: Its application in a K-12 Learning Environment

K-12 education has greatly embraced the use of Intelligent Tutoring Systems that are specifically modelled to resemble human tutelage. For instance, a case study, which involved, a middle school as mentioned earlier, tested the effectiveness of an ITS in the enhancement of students' comprehension of mathematics. NLP and machine learning were used to interact with learners in real time and even tailor feedback to learner specific progress. As if it mimics human tutoring, the system could be able to handle each student and outline on what knowledge areas the students lack a lot. Virtual reality and intelligent interfaces improved students' perception of the abstract concepts offering in addition the real-like experience. To be specific, students could interact with 3D models and compute variables and, most importantly, get an immediate response to an appropriate approach to a problem. Therefore, in combination with the ways of teaching the system provided a closer replication of a human tutor as it also created an opportunity for the students to learn independently of the class context and engage with multiple learning paths at once. The impact of ITS was clear: The students who employed the system had raised their test scores by fifteen percent higher than the students who were in normal classroom environment. Also, the system provided logs for observing learning pathways, which would indicate how students approached and solved tasks. This information was useful in changing the strategies used to make instructions in the classroom to match that of the learners.

7.2 Predictive Modelling

Case Study: Application in Higher Education for Correlating Student out Come

The tactical use of PM has been observed to increase within per higher education institution with specific reference to the identification of at-risk student performers. A good example is when a university used it in their student retention program. The forecasting model in this case included information which relates to student profile, past academic performance and learning behaviours to identify those who are more likely to perform poorly or even discontinue their learning or studying. This model involved the use of learning algorithms in order to work with large databases such as the performance indicators for students' grades, their attendance records or participation in other school related activities. Thus, by analysing this data, thus through the analysis of trends on the obtained data the model was able to determine the students most likely to fail out or drop out with an 85% accuracy rate. The university then utilized these findings providing academic career advice and peer mentoring.

In addition to anticipation of failure, the system generated useful information on the student learning process, including areas in which the students consistently performed poorly. This enabled instructors to adapt the information they delivered as well as the rate of delivery and the feedback options in reacting to these problems. Further, the model provided a list of independent variables that affected academic performance as course load, study groups, and time spent on particular tasks. For this reason, student retention rates in the institution increased by 12% while the level of satisfaction among students enhanced significantly. Besides, it helped not only the simplification of the identification of the at-risk students, but also the modification of decisions made by educators in relation to students with the focus on the outcomes for these students.

7.3 Comparison of Educational Models: Practical Application

Intelligent Tutoring Systems and Predictive Modelling are closely related fields where machine learning is of critical importance in delivering personalized learning. Thus, ITS contributes to

increasing practice-based, real-time student engagement supported by technologies including NLP, chat, and VR, on the one hand; while on the other, predictive Modelling helps consider a broader aggregate view of student learning outcomes, as well as their prospective trends. For example, ITS can give instructional material on the basis of students' immediate response, as well as to personalize and to imitate human conversation. In other hand, the application of predictive modelling employs past data in making forecasts on probabilistic points like grades, rates of drop outs, or potential regions of weakness. In more realistic applications, both models are useful but, perhaps for different reasons. ITS provides pedagogical assistance in real-time enhancing the educational process with the use of innovative technologies, and predictive modelling offers education establishments long-term strategic directions pertaining to intervention based on students' success rates. As previously seen, both of these approaches can be quite beneficial, when adopted in parallel, in building an overall educational system that is capable of meeting current learning objectives as well as forecast potential pattern of academic achievement.

8. Discussion

The general consensus of the findings of the articles included in the study is the growing importance of application of analytical models and algorithms in educational management. Based on the findings, academic analytical models and algorithms have become transformative forces in the educational sector and has brought forth a wide array of technical advancements and offered perfect platforms for improvement of learning activities and educational management processes. Generally, it is reported that the application of analytical models in educational management is based on a wide range of domains including customized learning, intelligent tutoring systems, predictive modelling, automated grading and assessments, and natural language processing. In regards to customized learning, analytical models can play a significant role in facilitating personalized learning experiences. It is noted that most of the current educational systems and institutions are actively adopting technological-based analytical models and algorithms to improve learner engagement and knowledge retention (Kumar et al., 2023; Wu, 2021). Further, analytical models provide detailed educational data such as student demographic information, student grades and behavior which expands the possibilities of retention strategies and, thus, meeting their needs in a more personalized and data-oriented manner. On the same note, academic analytical models such as machine learning programs provide capabilities of adaptation of instructional content, pacing, and feedback based on individual needs which fosters student engagement, concept mastery and customized learning experiences.

The concept of intelligent tutoring systems is a crucial element of learning analytics that has had significant impact on education management. As technologically powered tools, intelligent tutoring systems provide customized instructions and support to learners and increases the efficiency of educational management operations for the educators and administrators. The systems employ natural language processing and machine learning to enhance interactions with the learners and provide personalized instructions (Kumar et al., 2023). Also, the systems can simulate human tutoring and are adaptive to different learning styles and the pace of the students. The systems and related models are also crucial in the exploitation of traces of learning pathways left by the learners in electronic educational platforms as well as maximization of learner cognitive and non-cognitive outcomes (De Witte & Chenier, 2022; Kassab et al., 2020). Further, the level of personalization achieved through the models has a significant impact on the learner experience through closely monitored participation and performance by the educator (Kharade & Wagh, 2016; Moore, 2018). The technical aspects of the intelligent tutoring systems further improve the level of learner engagement, enhances the quality of the learning outcomes, and offers immediate personalized assistance (Kumar et al., 2023; Wang, 2019). The associated techniques such as natural processing language (NPL) and machine learning promotes the understanding of human language and interactions through the development of tools such as chatbots, virtual reality and intelligent interfaces.

Academic analytics enhances data-driven decision-making processes through aggregation of valuable academic information for optimization of the learning processes and improvement of quality of outcomes. The application of the related models and algorithms provide reliable data on student achievements by providing access to data from both the learner and the educator including average performance of subjects, the degree of failure and progress, and the learning curve, which are crucial tools for evaluation of learner progress (Arteaga et al., 2020). Also, learning analytics provide detailed educational data such as student demographic information, student grades and behavior which expands the possibilities of retention strategies and, thus, meeting their needs in a more personalized and data-oriented manner (Arteaga et al., 2020; Sousa et al., 2021). It is further reported that learning analytics are more educational rather than technological since they have the ability to predict and analyze student learning outcomes, learning processes and providing support to teachers' decisions, reflections and student's learning activities (Sousa et al., 20221; Wu, 2021). On the same note, the predictive capabilities of academic analytical models play a crucial role in management of educational processes and improvement of quality of the outcomes. In this regard, the models apply regression and predictive programs to interpret and simplify relevant independent variables in prediction of efficacy of educational management systems.

The research findings further highlight the significance of analytical models in promoting the efficiency of learning activities and educational management processes. First, the application of related technological advancements such as e-learning resources and student database information has led to the development of large repositories of educational data that are applicable in learning processes and associated activities (Romero & Ventura, 2020). Also, educational data mining and learning analytics provide potential educational data from different sources in multiple formats, granularity levels and hierarchy levels that can be used to enhance the efficiency of delivery of learning instructions and promote the ease of management of associated educational processes (Moore, 2018; Romero & Ventura, 2020). Specific examples of educational analytical models such as the Local Interpretable Model-Agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP) are also applicable in promoting the efficiency of administrative processes such as management of educators' profiles, prediction of learner performances, management of responsibilities, and compiling of educational data (De Souza Zanirato Maia et al., 2023). It is further reported that the analytical techniques are applicable by different educational departments for optimization and improvement of teaching and research departments, management of personnel and enrolment, and decision-making processes (De Witte & Chénier, 2022; Wang, 2019). It is concluded that learning analytics can be used to enhance the management of curriculum and teaching processes by tracing the learning times of the students and the frequency of specific knowledge points as well as their course grades.

9. Conclusion

The ever-changing pedagogical techniques and technological advancements have led to the development of systems that leverage analytical models and machine learning algorithms for analysis of learner performance, identification of knowledge gaps and generation of personalized learning pathways, which are important aspects of educational management. In the past few decades, there has been an active adoption of technological-based analytical models and algorithms by educational institutions and systems with the primary aim of improving learner engagement and knowledge retention as well as the management of vast quantities of data associated with expanding educational processes. The current research findings highlight the significance of academic analytical models in education management by providing detailed application of the related techniques in improving the learning outcomes and the progress of learners during their learning period. It is reported that academic analytical models and algorithms have become transformative forces in the educational sector and has brought forth a wide array of technical advancements and offered perfect platforms for improvement of learning activities and educational management processes. The application of

analytical models in educational management is based on different domains such as customized learning, intelligent tutoring systems, predictive modelling, automated grading and assessments, and natural language processing.

10. Recommendations

Integration of Intelligent Tutoring Systems (ITS) and Predictive Modelling: One potential research avenue for educational institutions should involve specifying how ITS and PM can benefit from each other and should be integrated. PM can give an objective picture of the student performance patterns and impending dangers compared to ITS that can give immediate individualistic responses to learners. Integrating both of these models, the educators will have a much stronger theoretical model that can cater not only for the day-to-day teaching and learning processes but also for time scaled strategic development of instruction with the purpose to enhance students' success.

Investment in Professional Development: In order to achieve full benefits in ITS and PM, training education programs for teacher's faculty and other staffs must be facilitated. Such programs should therefore aim at acquainting them with these systems, and how to analyse the information outputs of the systems. In this way, by increasing the competencies of educators in the usage of these technologies, the institutions will be assured that there is adoption in teaching and learning of the respective courses as well as in functional processes of the institutions.

Continuous Monitoring and Evaluation: The authorities must adopt patterns for the purpose of assessing the ITS and PM constant efficiency. This includes searching for feedback from users consist from educators and students about the usage and outcome of those systems for learning purposes. Monitoring can offer information on various changes which can be helpful in order to adjust the technology to conform to such issues as education objectives and learners' requirements.

Customization of Learning Experiences: Hence, it is unarguable that ITS and PM systems should be adaptive to meet the needs of the different students in the class. These systems should be made more flexible and institutions should promote the formulation of features that will enable the systems to provide instructions in line with human differences in learning. These will improve on student participation and study completion, essentially among students at risk.

Collaboration with Educational Technology Developers: Many educational resources require the cooperation of educational institutions with developers of educational technologies to assess the effectiveness of the used technologies and their update with reference to the modern development of machine learning and artificial intelligence. This means that while engaging with these developers enhanced implementation variants of ITS and PM models that will adequately address the dynamics of the educational sector can be developed.

Data Privacy and Ethical Considerations: To this end and as institutions adopt ITS and PM, there is need to ensure the respect of the data privacy and ethical concerns when applying the student data. It will be necessary to make a precise definition of the use of data and production of rules and guidelines that will be followed the whole process of using data within schools builds up a positive perception of the use of data in improving student's learning ability.

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