**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Overview of Predictive Modelling in Education**

To analyze information, it can help to predict future outcomes. With predictive analytics, you can enhance the growing phase of universities by gaining meaningful insights data.

In today’s results-centric world, educational institutions compete with one another to achieve success every year and strive to maintain that success in the future. Predictive analytics plays a vital role in the education system and helps boost the growth of schools by providing the best learning experience for students and sustaining enrollment. The role of predictive analytics in education is not only to improve the growth of the institution. It is also used to identify areas of the institution that are lagging and set plans to enhance their quality, cultivate new opportunities, and detect current and future risks.

**2.2 What is Predictive Modeling?**

Predictive modeling is a statistical technique used to determine the likelihood of a student performing some desired enrollment behavior. In education, predictive modeling is used to predict future student behavior based on the behavior of previous students. The technique involves identifying variables that influenced the behavior of previous students and constructing a statistical model to predict future behavior. Predictive modeling is an important tool in contemporary marketing, recruitment, and retention for higher education institutions.

Predictive analytics is a set of techniques that includes data mining, modeling, machine learning, statistics, and artificial intelligence that helps to predict future outcomes. Using historical data, you can apply mining models to predict future events. For example, let’s say you are a grocery shop owner and you need to increase profits. You could use predictive analytics models to analyze the purchasing patterns of your shoppers, and then use that information to recommend additional products and services to the customers most likely to purchase them. Even with a minor rate of success, this simple strategy would boost the store’s profits. By feeding predictive analytics models with the right historical data, you can set yourself and your organization up for success.

The rise of analytics in recent year is sensible. Analytics is the process of using computational methods to discover influential pattern in data. The goal of analytics is to gain insight in decision making (Abbot, 2014). The idea of using the analytics is not a brand-new and being represented by different sector including data analysis, neural network, pattern recognition, knowledge discovery, data mining and data science [According to the definition provided by Abbott, (2014), predictive analytics is the process of discovering interesting and meaningful pattern in data. A further definition is given by Barneveld, Arnold and Campbell (2012), describes that predictive analytics is a process that serves all level such as higher education and deals with extracting information using diverse technologies to reveal patterns and relationship in data. Predictive analytics could disclose latent relationships that might not be clear with a descriptive model such as demographic and student completion rates (Daniel, 2014). Predictive analytics can provide institution with intuitive and better decision based on data. It can be used on monitoring early stage of student semester and make intervention to increase their performance. The predictive analytics furthermore can help instructor to forecast course completion including student final grade which are directly correlated to student performance success (Daniel, 2014).

In educational data mining, predictive modeling mainly used in predicting student academic performance (Shahiri et al, 2015). Predictive modeling is a process that involved running one or more algorithms on a dataset where prediction is going to be carried out. It is the process of creating, testing and validating the model to best predict the probability of the outcome (Brownlee, 2015). Predictive modeling is born whenever data is used to train predictive modeling technique (Guazzelli, 2012). In this research of student performance, there are many predictive modeling techniques available including Bayesian Network (BNs), Decision Tree (DTs), Artificial Neural Network (ANNs), Support Vector Machine (SVMs), clustering, association rules and others

**2.2.1 Definitions within Enrollment Analytics**

1. Logistic Regression – statistical method used to create a predictive model; gives a probabilistic result based on the value of the predictor variables
2. Outcome or Dependent Variable – variable that is being predicted. Typical outcome variables include becoming an applicant, an admitted student, an enrolled student, or a retained student
3. Predictive Modeling – creation of a statistical model of future behavior
4. Predictor or Independent Variables – variables that explain the outcome or desired enrollment behavior
5. Significant Predictor Variables – predictor variables that are important in determining the outcome/target.

**2.2.2 The Most Common Types of Predictive Models in Education**

1. Search Model - search name to enroll
2. Inquiry Model - inquiry to enroll (aka lead scoring model when used in performance-based marketing)
3. Applicant Model - application to enroll
4. Yield Model - admit to enroll
5. Econometric Model - financial aid modeling, usually for admit to enroll
6. Retention Model - enroll to first-year retention

**2.2.3 Examples of Predictive Analytics**

Predictive modeling in education has evolved over the years, and today, institutions use business intelligence software to bolster predictive analytics’ accessibility. These tools help institutions by providing visualizations of the data, giving users a straightforward way to access and analyze often complex data. The technology removes the long, laborious tasks of building complex technical scripts and algorithms, meaning decision-makers can access this data and make highly informed choices themselves

Predictive analytics is often thought of as new technology, it isn’t. It has been used for years in many sectors. Most organizations collect data, whether it’s product logistics, customer transactions, or student performance. By highlighting trends in existing data, businesses can predict how similar customers may act.

For example, in healthcare, it can determine the likelihood that a patient will cancel or skip an appointment; or in insurance, it can help to support fraud prevention. Another example would be financial services, predicting whether a loan applicant is likely to repay the loan based on specific characteristics that the system will request at application. It uses ‘big data’, complex datasets that can be cumbersome to manage or interact with manually. For this reason, business intelligence software is utilized to bolster predictive analytics’ accessibility. These tools help institutions by providing visualizations of the data, giving users a straight-forward way to access and analyze often complex data. The technology removes the long, laborious tasks of building complex technical scripts and algorithms – meaning decision-makers can access this data and make highly informed choices themselves.

**2.2.4 The Evolution of Predictive Analytics in Education**

To many, the idea of big data analytics is often thought of in relation to the digital technology, marketing, finance or healthcare sectors. Increasingly, predictive analytics is being used to drive systematic improvements within the education sector, with institutions using existing student data to gain insights on current or future student performance.

Predicting student outcomes has always been important to the education sector; schools, colleges, and higher education learning providers have historically used data linked to examination results and attendance records to predict a student’s academic success. Records were traditionally collated and analyzed manually, and any discrepancies relied on human intervention. This meant that data was likely to be siloed within departments, and interventions may not always have been immediate.

As institutions and technology have both evolved, this data has become more complex. In our modern education environment, the rapid rise of digital learning and educational technology has led to an exponential increase in data collection. A huge array of useful insights can now be gleaned from data, providing the opportunity to improve and support student performance as well as inform sound operational and commercial decision making.

A student management system will hold a variety of academic and student data but beyond this, institutions will record engagement with elements of digital learning, library services, or extracurricular activities. Whether on-campus or through online portals, students experience numerous data touchpoints. Predictive analytics can use this ‘big data’ to highlight trends and take a holistic view of an institution’s performance.

**2.2.5 The Importance of Predictive Analytics in Education**

Predictive analytics can use big data to highlight trends and take a holistic view of an institution’s performance. A student management system will hold a variety of academic and student data, but beyond this, institutions will record engagement with elements of digital learning, library services, or extracurricular activities. Whether on-campus or through online portals, students experience numerous data touchpoints.

By gaining these insights through data modelling, colleges, universities and training providers can identify potential future issues and proactively deal with them to enhance the student experience whilst also focusing on the bottom line. But as the number of datasets increase, so does the complexity of analysis. The beauty of data is that it is ever-evolving. Once institutions have established and built out core analytics models for understanding outcomes, these will adjust, and update based on any new data that the organization receives.

For example, an educational institution that has a predictive analytics model in place to understand the likelihood of a student passing or failing a course, based on existing data, can drop a new student’s application into the existing model to see what the predicted outcome would be for this individual.

Predictive analytics play an important role in driving efficiency improvements to all areas of the institution. Data from different parts of the organization can be used to inform predictive models, contextualizing the student experience within the whole institution. This helps organizations address areas that have the most impact on student performance; in a world of tightened resources, predictive analytics can be used to improve attendance, performance and enrolment.

**2.3 Roles of Predictive Modelling in University**

Predictive analytics can help identify trends that expand access and responsiveness in education, such as online classes on weekends or quick reviews during examination. Predictive models can be used to identify students who need more attention in their studies before problems arise and to empower the faculty to find solutions like tutoring or special sessions. Predictive analytics can help administrators and teachers improve the institution wherever they face difficulties, such as student dropout rates.

**2.3.2 How Predictive Analytics Can Help Transform Education**

In education, institutions can monitor the quality and success of their operations based on student data. This data can be used in analytics to predict future trends and results. The predictions provide details that can help guide and alter current strategies that maintain and improve the institution’s progress toward academic goals and toward providing a quality education to all students.

With the help of predictive analytics, the education system’s quality can be improved by monitoring student performance based on previous records like test results, assignment grades, and even personal feedback from students. This data helps the faculty enhance and improve training for difficult subjects, which in turn helps the students to excel in areas that were problematic for previous classes.

Predictive analytics can also be used to predict student attendance and keep students who are prone to absence informed, which can help ensure they maintain regular attendance. The analytics can be used by the faculty or institution to determine potential causes for a student’s attendance troubles, whether it’s their financial status, health conditions, or some other reason, and enable the school to aid. This will reduce student dropout rates for the institution, and in turn maintain student enrollment.

**2.3.3 Advantages of Predictive Analytics in Education**

* Predictive models can be used to identify students who need more attention in their studies before problems arise and to empower the faculty to find solutions like tutoring or special sessions.
* Predictive analytics can help administrators and teachers improve the institution wherever they face difficulties, such as:
  + - Uncovering reasons potential students decline enrollment.
    - Identifying departments with higher dropout rates and using prediction results to formulate strategies to maintain consistent enrollment.
    - Analyzing student feedback annually to find what works and what needs improvement to help keep the institution in a good position educationally and financially.
* Predictive analytics can be used to analyze students’ past achievements in sports and other physical activities and encourage them to continue their involvement in such activities. The same could be done for academic extracurricular activities as well.
* Predictive analytics can help identify trends that expand access and responsiveness in education, such as online classes on weekends or quick reviews during examination periods. After adopting an educational trend, its success can be monitored and improved to provide the best learning experience for all students.

**2.3.4 Bold BI’s solution for predictive analytics in education**

With Bold BI’s user-friendly and fully customizable dashboards, you can track and manage all metrics and key performance indicators of an educational institution.

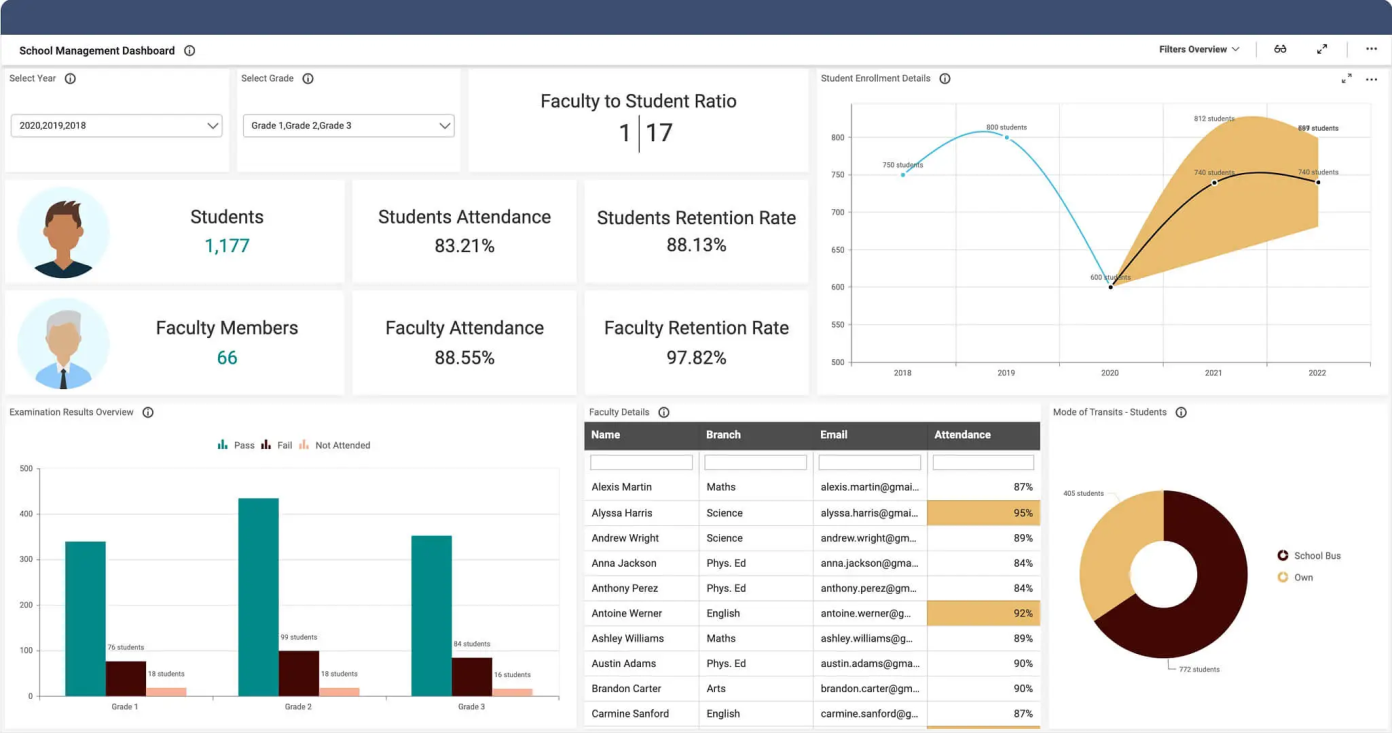


Fig. 1: BOLD BI’S School Performance Dashboard. (Source: Bold BI, 2023)

In Bold BI’s school performance dashboard, using student enrollment records from 2018 and 2019, predictive analytics models and predicted student enrollment for the current academic year and the next two (2020, 2021, and 2022) were used. This helped the administrators plan for future faculty positions to help improve student performance, and it identified opportunities where the quality of education could be improved. The effective decision-making enabled by this dashboard helps to maintain and grow student engagement for future academic years. You can also monitor other metrics related to the school’s performance. Predictive analytics is the best way for schools to provide quality education for their students by forecasting future results and maintaining the success of the institution.

**2.4 Academic Success Definition**

Student success is a crucial component of higher education institutions because it is considered as an essential criterion for assessing the quality of educational institutions (National Commission for Academic Accreditation &amp, 2015). There are several definitions of student success in the literature. In (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006), a definition of student success is synthesized from the literature as “Student success is defined as academic achievement, engagement in educationally purposeful activities, satisfaction, acquisition of desired knowledge, skills and competencies, persistence, attainment of educational outcomes, and post-college performance”. While this is a multi-dimensional definition, authors in (York, Gibson, & Rankin, 2015) gave an amended definition concentrating on the most important six components, that is to say “Academic achievement, satisfaction, acquisition of skills and competencies, persistence, attainment of learning objectives, and career success” (Fig. 3).

Despite reports calling for more detailed views of the term, the bulk of published researchers measure academic success narrowly as academic achievement. Academic achievement itself is mainly based on Grade Point Average (GPA), or Cumulative Grade Point Average (CGPA) (Parker, Summerfeldt, Hogan, & Majeski, 2004), which are grade systems used in universities to assign an assessment scales for students’ academic performance (Choi, 2005), or grades (Bunce & Hutchinson, 2009). Academic success has also been defined as related to students’ persistence, also called academic resilience (Finn & Rock, 1997), which in turn is also mainly measured through grades and GPA, measures of evaluations by far the most widely available in institutions.

**2.4.2 Academic Analytics (AA)**

To reflect the role of the predictive model at the institutional level, academic analytics is an essential component that encloses all activities in higher education (Tulasi, 2013). Academic analytics (AA) is an emerging data mining technique that is applied to monitor student performance by combining statistical analysis, institutional data and predictive modelling that can be used to change academic behaviour (Baepler & Murdoch, 2010). Analytics goes beyond traditional reporting systems by providing decision-support capabilities (Campbell et al, 2007), gathering and organizing information, as well as analyzing and manipulating the data (Daniel, 2014). There are a few of the applications of AA that have been used in student academic performance such as performance prediction, course recommendation, career path planning, behaviour detection and more (Sin & Muthu 2015). The implications of student performance prediction are useful in many contexts. Providing accurate prediction, it will have a significant influence on the faculty level to detect undesirable student results and improve the forecasting outcome (Kavipriya, 2016), whether students will survive to finish their studies or not (Christian & Ayub, 2014). It is clear that academic analytics is driven in gaining momentum and a great approach to predicting student performance, enabling the target of student intervention and improving student success (Mat et al, 2013).

**2.4.3 Performance Prediction**

In previous research on predicting student performance, a variety of methods have been employed, including Bayesian Network (Sharabiani et al., 2014), Decision Tree (Abdul Aziz et al., 2014), Support Vector Machine (Kavipriya, 2016), and regression (Khobragade and Mahadik, 2015). Some models have also utilized categorizations, such as "below satisfactory," "satisfactory," and "above satisfactory" (Ramaswami, 2012). Student performance prediction can be influenced by factors like student interactions with other students, instructors, or teachers (Sin and Muthu, 2015). By utilizing performance prediction models, it becomes feasible to identify underperforming students and provide them with appropriate academic guidance to enhance their study progress and ultimately academic achievement (Sin and Muthu, 2015).

These prediction models have been applied in various studies. Sharabiani et al. (2014) employed Bayesian Networks to predict student performance, while Abdul Aziz et al. (2014) used Decision Trees in their research. Kavipriya (2016) applied a Support Vector Machine approach for student performance prediction, and Khobragade and Mahadik (2015) conducted a study using regression analysis.

**2.5 Factors influencing students' academic performance**

Academic performance is a measure of a student's achievements across all their academic subjects, and it is influenced by various factors. Here are some of the factors that influence students' academic performance.

**2.5.1 Student factors**

Students have a significant role in their academic achievement. Time management, self-motivation, engagement, behaviour, and attitudes are the key factors governing their academic success. Other student factors that affect academic performance include learning skills, parental background, and peer influence. Below is a brief factor that affects student’s performance.

1. Time management: Time management is a crucial factor that affects academic performance. According to a study by Macan et al. (1990), students who manage their time effectively are more likely to perform better academically.
2. Self-motivation: Self-motivation is another critical factor that affects academic performance. According to a study by Pintrich and De Groot (1990), self-motivated students are more likely to be engaged in their studies and perform better academically.
3. Engagement: Engagement is a factor that affects academic performance. According to a study by Fredricks et al. (2004), students who are engaged in their studies are more likely to perform better academically.
4. Behavior: Behavior is another factor that affects academic performance. According to a study by Rimm-Kaufman and Pianta (2000), students who exhibit positive behavior, such as attending classes regularly, being punctual, and following school rules, are more likely to perform better academically.
5. Attitudes: Attitudes are another factor that affects academic performance. According to a study by Schunk and Pajares (2002), students who have a positive attitude towards learning are more likely to perform better academically.
6. Learning skills: Learning skills are another factor that affects academic performance. According to a study by Weinstein and Mayer (1986), students who have good learning skills, such as note-taking, critical thinking, and problem-solving, are more likely to perform better academically.
7. Parental background: Parental background is another factor that affects academic performance. According to a study by Sirin (2005), students from families with higher levels of education and income are more likely to perform better academically.
8. Peer influence: Peer influence is another factor that affects academic performance. According to a study by Ryan and Patrick (2001), students who associate with peers who are academically motivated and successful are more likely to perform better academically.

**2.5.2 Lecturer Factor**

Teachers play a crucial role in shaping students' academic performance. The quality of instruction and delivery style, class size, and teacher-student relationships are some of the teacher factors that affect academic performance.

Vizeshfar and Torabi-zadeh (2018) showed that an effective teacher can dramatically alter students’ educational and thus economic outcomes. On the other hand, if the lecturer lacks the necessary training and teaching experience at the university level, as well as knowledge of effective teaching methods in higher education, the students will undoubtedly face numerous academic challenges.

In our day a modern teacher surpasses this definition as well. The teacher has gone beyond just teaching class, giving lectures, making exams and giving grades; the teacher also takes on the roles of organizing, managing, counselling, observing and evaluating. The teacher also has an important role in influencing society, creating a sound foundation towards the future of society and ensuring the continuation of such actions (Temel, 1988: 21).

After the family, school is the first basic socialization institution for the child. Apart from the parents, it’s the student’s teacher who is effectively in the front seat in regard to his/her personality development and both academic and social performance. The understanding of modern education in our day lays the duty and responsibility of being effective in not just the child’s intellectual development but also character development solely on the shoulders of the teacher. The fulfilment of this responsibility is only possible through the teacher’s being able to develop healthy personality values themselves as well as providing efficiency in their relationships with students so as to allow them to develop their personalities freely (Can, 2011; Inelmen, 2011).

The abilities and characteristics that are necessary in order to be a good teacher are also the same factors that define a good education. A good teacher has eight basic characteristics, which are; Knowledge of material; Decision-making; Critical thought and problem-solving ability; Self-understanding and self-correction; Reflecting; Recognizing students and knowing students' learning needs; Applying new findings in education; Teaching and communication ability. We can gather these properties under two headings (Ari, 2008: 5 - 6). The teacher who thinks critically and the self-governing teacher. A teacher who realizes that the nature of knowledge and abilities directly affects his/her students and surroundings takes responsibility for his/her own knowledge and abilities, creates positive relationships with his/her students and can relay these to students in the most efficient manner (Ari, 2008: 5 - 6).

In this whole process, the effect of the teacher in the personality development and success of students is a fact that cannot be overlooked. The teacher, through either positive or negative attitude in communication with students and in how he/she reflects this, directs the shape of their lives, has a positive or negative effect on the attitude shown toward themselves or the public in general, affecting development of the ability to communicate, research and be creative (Ataunal, 2003). The behavior and approach of the teacher is directly accepted and copied by students, which puts great responsibilities on the teachers. Studies performed in the current day clearly show the effect on students of mutual interaction in teacher-student relationships, teachers approach regarding students and especially the perception of this by students.

For a teacher, being able to interact with the student and display positive behavior such as asking questions, understanding their thoughts, showing interest and appreciation increases the students’ motivation and success. While working towards providing students at a certain development level information, experience and behaviour on a certain topic, teachers become role models for students by way of their own behaviour and attitude. Positive attitudes lead to success while negative attitudes lead to failure and as a result, success can lead to positive ego attitudes while failure leads to negative ego attitudes. For example, if the teacher engages in belittling comments towards a student due to his/her failure, the negative effects of this will be inevitable (Gecer, 2002).

In Frymier’s (1993) study concerning the effect of positive teacher behaviour on the student’s motivation level, the author has concentrated on certain behaviours for teachers such as giving feedback for student works, complimenting, wanting to listen to students and being interested. The results of the study show that teachers’ nonverbal actions such as smiling, having a relaxed stance, various gestures and facial expressions come first in improving the learning experience for students whereas the topic of the class itself comes in second.

The student’s performance is not completely the result of their work; performance is affected by many factors and the first one is the attitude of the teacher. A positive attitude from the teacher affects the student’s motivation, attitude towards school and school work, the student’s self-confidence and as a result personality development.

Teaching is much more than saying and explaining (Gundogdu, Silman, 2007: 264). One of the most basic principles of teaching abilities is the support of the student by the teacher and the teacher to put for their positive expectations in order to motivate the student to learn (Yavuzer, 2000). While the positive behaviour of the teacher allows him/her to create a positive relationship with students, it also allows for the teacher to delve into the positive behaviour of students as opposed to the negative, taking on a reinforcing role as well (Yavuzer, 2000).

In the education system, a condition of being a good educator is knowing the communication process well. The teacher who tries to understand students’ emotions such as interest, fear, and worry, supports students’ social activities, appreciates, approves of and compliments them for activities he/she finds of value will make the students feel that they are being thought of, loved and aided and that the teacher is working for their good. Students of such a teacher will, taking the teacher as a role model, in turn, be considerate of others, running to the aid of others, maintaining good relations and positive attitudes (Basaran, 1994).

In this research, it is expected that students whose teachers displayed positive attitudes and behaviour will state that these in turn had a positive effect on their character development and success while negative attitudes and behaviour by teachers had a negative effect on their character development and success.

**2.5.3 Classroom Environment**

The classroom environment influences academic performance and productivity through three things: attendance, study time, and concentration. A conducive classroom environment can help students focus better and improve their academic performance.

In the realm of education, the classroom unfolds as a fascinating tapestry of human dynamics. Within its walls, you'll discover the key players: the teachers, the students, the ever-present books, the whimsical sense of creativity, and the intangible atmosphere. A symphony of sorts, where all these elements should ideally harmonize, creating an environment that fosters growth and development for each student.

Indeed, the classroom is not just a physical space; it's a crucible of academic transformation. It's here that a student's journey takes shape, and the way they navigate this space can be a telling reflection of their academic performance and productivity.

Consider for a moment the classroom's pivotal role. It's the primary arena where students engage with learning. If a student grapples with this environment, their struggles may cascade into other academic domains. The classroom exerts its influence through three potent channels: attendance, study time, and concentration.

Attendance, a silent testament to your commitment to learning. Showing up punctually, armed with eagerness, signals a readiness to engage with the academic journey. However, repeated tardiness can sow the seeds of disinterest, eventually manifesting as poor academic performance.

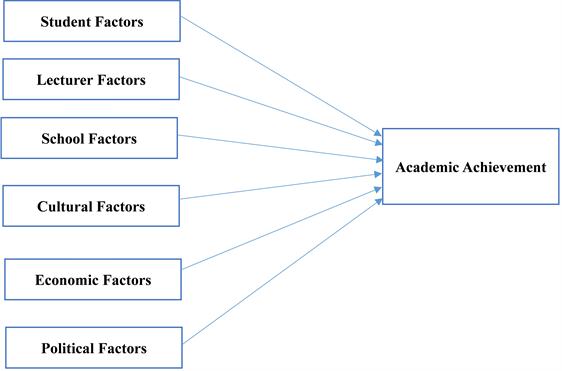
Then there's concentration, the magic elixir of the classroom. In this dynamic setting, every moment counts. Missing a vital piece of the puzzle can set you back. Concentration unlocks the door to comprehension and, by extension, eases the burden of assignments. Those who resist the allure of idle chatter, daydreaming, or unrelated activities in class tend to sow the seeds of academic success.

But what about the conductors of this intellectual orchestra – the teachers? They wield a profound influence. A teacher who fosters an atmosphere of curiosity, where questions are encouraged and seeking help is second nature, is more likely to nurture academic excellence. On the flip side, a classroom ruled by fear stifles inquiry, leaving students reluctant to voice their doubts or tackle academic challenges. Striking the delicate balance between discipline and a welcoming, inclusive environment is a teacher's enduring challenge, one that profoundly shapes academic productivity.

In this enigmatic dance of students, teachers, and the very essence of the classroom, a myriad of human emotions and complexities intermingle, creating an ever-evolving narrative of learning and growth.

**2.5.4 Family background**

A person's background, including their family's social and economic level, has an impact on their academic achievement. Family support and concern are also essential factors that distinguish students with low academic achievement from other students.



**Fig. 2: Factors affecting Students’ academic performance**

**2.6 Empirical Review**

In both EDM and LA, predictive modelling has become a core research practice. It provides foresight and vision for the future that can help enhance learning effectiveness and prompt remedial, timely, and appropriate actions. Practically, predictions are produced by analyzing historical data and projecting it on a model generated to forecast likely outcomes with a certain accuracy. To create a predictive model, Brooks and Thompson (2017) described the main steps to follow, beginning with (i) identifying the problem, (ii) collecting the data required for analysis, and defining the predicted outcome, (iii) selecting the predictor variables that perfectly correlate with the chosen output, and finally (vi) building the predictive model using one or more algorithms.

The existing reviews differed largely in terms of the scope and the perception of the subject. For instance, Nunn et al. (2016) described the methods, benefits, and challenges of LA to apply it more effectively to improve teaching and learning in higher education. Other reviews focused on both EDM and LA. For example, Baek and Doleck (2021) showed the similarities and differences in research across the two fields by examining data analysis tools, common keywords, theories, and definitions.

Aside from reviews that discussed LA and EDM generally, some reviews focused on specific learning issues. An example is mentioned by de Oliveira et al. (2021), the authors focused on retention and dropout of higher education students and how LA can be used to help prevent these cases. Meanwhile, Namoun and Alshanqiti (2021) explored the prediction of student academic performance and presented the intelligent techniques used in performance prediction. Since deploying the right interventions to help students at risk of underperformance or discontinuation is important, some reviews focused on the effectiveness of interventions based on predictive models to help institutions implement the right interventions (Larrabee Sønderlund et al., 2019).

Several algorithms are used to develop predictive models (Kumar et al., 2018), the most popular are Decision Trees, Bayesian Classifiers, Neural Networks, Support Vector Machines, K-nearest neighbour, and Logistic and Linear Regression. Algorithms are chosen based on the problem type, the nature of the outcome to be predicted, and the variables employed in the prediction. A common practice used by researchers is to test multiple algorithms and compare their performance to determine which one provides the most accurate prediction.

El Alfy et al. (2019) addressed the benefits that LA can provide, and the challenges regarding the use of it

**Limitations**

Offers a theoretical overview with no mention of methodologies

Missing paper filtration criteria

No focus on predictive modelling

Baek and Doleck (2021) compared the similarities and differences in research across the two fields of LA and EDM

**Limitations**

Only one database was used in the collection of studies (WoS)

Literature between 2015 and 2019 (not updated)

Does not focus on Machine Learning (ML) algorithms

de Oliveira et al. (2021) Analyzed how LA can be used to help prevent failure cases

**Limitations**- Limited to dropout management

Namoun and Alshanqiti (2021) presented a fundamental understanding of the intelligent techniques used for the prediction of student performance.

**Limitations** ‐Limited to predicting performance

Larrabee Sønderlund et al. (2019) Reviewed the evidence in terms of the efficacy of LA-based interventions targeting academic retention, underperformance, and dropout rates.

**Limitations**

Limited to LA interventions

Literature up to 2018(not updated)

Gasevic et al. (2019) proposed an approach that can be used in the adoption of LA in higher education.

**Limitations**

Systematic review guidelines were not followed

No focus on methods used in the prediction

Umer et al. (2021) presented a review of prior studies that have utilized ML techniques to predict student performances by using historical data.

**Limitations**

Focuses only on studies that predict student performance and dropout

Limited to blended learning

Liz-Domínguez et al. (2019) provided an overview of the current state of research activity regarding predictive analytics in higher education, highlighting the Early Warning Systems (EWS) that have been used in practice.

**Limitations**

Focuses on EWS

Literature up to March 2019 (not updated)

Chan et al. (2019) examined the use of e-LA data in healthcare studies with regard to how the analytics is reported.

**Limitations**

Limited to healthcare-related educational disciplines

No focus on predictive modelling

Rastrollo-Guerrero et al. (2020) analyzed the modern techniques widely applied for predicting students’ performance. Limited to predicting students’ performance

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