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Optimizing Education with Data Analytics: A Feature Comparison of LMS and SIS

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Abstract: In the realm of educational technology, Data Analytics (DA) is reshaping teaching and learning. This paper investigates the impact of DA on education, specifically comparing Student Information Systems (SIS) and Learning Management Systems (LMS). Data-driven insights from the SIS and LMS platforms enable educators to tailor instructional strategies to individual student needs effectively. While SIS manages student data for administrative tasks, LMS offers tools for content delivery and collaboration. Using the strengths of SIS and LMS, educators can optimise teaching and learning experiences, tracking student progress, and fostering collaboration. The comparison emphasises their distinct roles: SIS manages administrative tasks, while LMS focusses on content delivery and collaboration. Using both systems, educators improve the teaching and learning experience, using DA for continuous improvement. In summary, this paper underscores the transformative role of DA in education, framed within the context of comparing the SIS and LMS functionalities. By examining the intersection of data-driven decision making and educational technology, educators are equipped with the tools and knowledge to harness the power of data for meaningful and impactful teaching and learning.

Keywords: Adaptive learning, Data Analytics (DA), Education challenges, Learning Analytics, Learning Management Systems (LMS), Learning patterns, Personalised learning, Student performance, Student Engagement, Student Information Systems (SIS).

1. Introduction

Our society is deeply entrenched in the era of data. Each day, through the applications we use or the news we consume, individuals are inundated with a deluge of metrics and recommendations. We navigate this vast sea of information, constantly bombarded with data-driven insights and suggestions [1].

In this chapter, we will deal with the key concepts, identifying the power of the use of data, and, above all, we will apply it to the educational environment and the creation of learning analytics.

All the devices that surround us generate data: our mobile, our smartwatch, the IoT hubs in our house, the coffee maker and even the car. However, not only do tangible elements generate data [2], but also computer applications do so, since every time we go to check our email, a login is generated, every time we watch videos on YouTube, we choose over thousands of themes, or every time we use our browser, we are creating data. All the information that can be collected is called data [3]. However, a piece of data does not contribute anything, but a set of them has a characteristic: if a huge amount of them is brought together, it is possible to get patterns of behaviour, help us make decisions, and ultimately extract knowledge. If we think about the case of Netflix, thousands and millions of people, thanks to their consumption habits, and how they watch movies and series, allow this company to collect those data, process them, apply artificial intelligence to them, predict the next move or even be able to suggest a new content according to the affinity that the user has towards it [4]. In this case, to extract the information, a data analysis process has been followed. According to the study proposed by Van de Vijver [5], it is possible to define this analysis as the process of analysing raw

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information, which is untreated, to find trends and answer questions. Although this definition covers a wide scope, it includes many techniques with many different objectives. Data analysis has been the fruit of the intersection of information technology and statistics. This combination of fields is not only valid for helping companies and organisations to be successful, but is also being introduced, little by little, in other sectors such as education. The main goal is to increase efficiency and improve performance by discovering patterns in the data. Generally, data use is provided by an analysis process that begins with a descriptive study. This is the process of describing historical trends in data and is made up of different techniques and steps that are intended to help provide a global picture of the situation. Descriptive analysis has the mission of answering the question "What happened?" [6]. This often involves having indicators to measure. The indicators utilised will vary for each sector; however, descriptive analysis does not make predictions or directly inform decisions, as it focusses on summarising data in a meaningful and descriptive way [7]. If we move to the educational field, a classic indicator is the evolution of the average over time [8].

Another essential feature of data analysis is to perform a deeper analysis. This part is also part of data science and takes advantage of advanced tools and algorithms to make predictions and discover trends in the data. These approaches include classic statistics and ML that have already been introduced before. ML or DL technologies such as NNs, NLP, sentiment analysis, etc., allow for more advanced data analysis. The result of an in-depth analysis provides a new perspective from the data to answer the question "What would happen if...?" [9]. Similarly, it is possible to ask questions like, "What would happen if the next grade were notable, what if you could improve your final grade if we are in the first term?" [10]. The availability of these techniques along with massive data sets and computing power has enabled the use of these algorithms in many industries and is slowly finding its way into education. However, the collection of large data sets is critical to the use of these techniques and to obtain the correct results. This type of analysis allows significant conclusions to be drawn from complex, and varied data sources, which has been possible thanks to advances in data processing and CC.

Although DA is a broad field, there are several main types [11]: descriptive, diagnostic, predictive, and prescriptive analysis. Each type has a different goal and a different place in the data analysis process. Next, we will analyse the main applications of each one.

Descriptive analysis helps answer questions about what happened. These techniques summarise large data sets to describe the results to stakeholders. Developing KPIs, these strategies can help track successes or failures. However, specialised metrics such as measuring or tracking performance can be developed. Although it is possible to propose metrics to give them a result, when faced with open questions and to give confidence in the results, the collection of relevant data and their visualisation are required, since essential information on historical performance is provided [12].

Diagnostic analysis helps answer questions about the 'why' events happened. These techniques complement the more basic descriptive analyses in that they take the findings of the descriptive analysis and dig deeper to find the cause. Performance indicators are further investigated to find out why they improved or worsened. This usually occurs in several phases:

- Detecting data anomalies is crucial, as they represent unforeseen fluctuations in a specific metric or market [13].
- New indicators related to these anomalies are collected [14].
- ML or DL techniques are used to find relationships and trends that explain these anomalies [15].

Prescriptive analytics helps address inquiries regarding the actions that should be taken [16]. By using information from predictive analytics, data-driven decisions can be made. This allows informed decisions to be made in the face of uncertainty. Prescriptive analytics techniques are based on ML and DL strategies that can find patterns in large data sets [17]. By analysing past decisions and events, the probability of different outcomes can be estimated. Used in combination, they provide a complete understanding of the needs and opportunities of a given situation, achieving the mission of providing the information necessary to make effective and efficient decisions [18].

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2. Types of Analytics in Educational Tools

Once the data have been collected, the processing process begins. Since these isolated events do not provide much information on their own, it is necessary to perform a process known as feature engineering, which consists of processing the data to transform it into useful educational information. For example, each student's input and output can be logged, but this information will not be very useful until the total time the user has spent actively interacting with the learning platform is calculated. This process requires technical knowledge to manipulate the data, experience in the context, and creativity to know what features are useful. In addition, it is usually one of the most laborious stages in data analysis projects.

Descriptive analysis is a process that is used to analyse and understand large data sets. Its purpose is to provide an overview of the information and answer questions about what has happened. Descriptive analysis is based on the use of KPI [19] to measure the success or failure of a company or organisation. Additionally, specialised metrics can be developed to measure performance and track progress. Although this type of analysis is useful for summarising the data and providing a big picture, it does not provide information on the causes of the results. To address this issue, it is necessary to use diagnostic analysis techniques that seek to delve into the data and find the causes of the results. This process is done in several phases and requires the collection and visualisation of relevant data to make informed decisions.

Data analysis is the process of examining raw, raw information to find patterns and answer questions. This is achieved through the combination of information technology and statistics. In education, DA is used to increase efficiency and improve performance by detecting patterns in data. The descriptive analysis focusses on summarising data in a meaningful and descriptive way and answering the question "what happened?" [6]. Diagnostic analysis drills down on the findings of descriptive analysis to find the causes of changes in a metric or market. Predictive analytics uses historical data to identify trends and determine whether they are likely to repeat in the future. Finally, predictive analytics uses information to make data-driven decisions and estimate the probability of different outcomes [20].

The following are the types of analytics, usage scenarios, and questions that have been raised with them.

Table 1. Types of analytics. Source: [21].

Types of analytics	Usage Scenarios	Related questions
Descriptive	Reports, and descriptions	What went wrong? What went well?
Diagnostics	Interactions, and views	Why did this happen? What are the learning sequences explored?
Prescriptive	Alerts, notifications, and recommendations	What is happening now? What would be better to do?
Predictive	Future trends, and predictions	What do I expect in the future? How can I design learning paths?
Applied learning	Personalised teaching, and adaptive learning	How could you present these contents adapted to this student?

The analysis and modelling that are applied to the final features are crucial to understanding our data and gaining educational benefits from it. Many analytics studies focus on understanding how students interact with the learning environment in retrospect.

In summary, the learning analytics process consists of collecting and processing data on student learning, and behaviour, intending to obtain useful information and apply models, and algorithms that allow us to better understand the learning process and make decisions based on that information. These educational environments can be virtual or mixed, can include different types of sensors and other data sources, and can be applied at different educational levels and types of learning environment.

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3. The Origin of the Data as a Phase Before Its Management

Today, thanks to digitisation, educational institutions collect data from many sources, making it possible to distribute them in various groups according to their functionalities. On the one hand, there is the LMS and on the other the SIS.

Typically, an LMS provides a way to create and deliver content, monitor student engagement, and not only assess student performance, but also provide students with the ability to use interactive features such as discussion, video conferencing, or the use of internal forums to share opinions [22].

On the other hand, the SIS provide more generic capabilities, since they are more complete applications and with a broader spectrum of functionalities than the LMS. They are dedicated to addressing the higher-level aspects of the organisation. For example, they are used to register students for courses, keep track of grades, make transcripts, save student test scores or other assessment results, create schedules, track attendance, and management of many other data needs related to the actors in a school.

Both types are detailed below, and the different existing approaches and tools are discussed to generate data and leave the door open for its exploitation, and consumption by other systems, and tools.

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Table 2. Types of dimensions affected by data analytics (Part 1 of 2). Source: [23].

Dimension	Summary	Questions to be solved by using analytics
Information traceability	In education, algorithms are used to make decisions and assign learning resources based on information extracted from large data sets. There is an algorithmic responsibility in the process to assign when algorithmic decision-making is performed unsupervised by a teacher. Discriminatory and inequitable results may occur.	Are all stakeholders (teachers, staff, and students) interested in and informed about algorithmic decision-making? Is there a system of internal rules on transparent behaviour? Are teachers warned about taking responsibility when interacting with the system? Are there public measurement criteria for the performance of the system used?
Bias Management	When algorithms produce errors in their results, we refer to them as biased. Algorithmic biases can occur in many ways: by the social context in which an algorithm is developed, because of technical limitations, or by the way the algorithm is used in practice.	Is the system design focused on trust? Is there a decision review mechanism? Is there a bias tracking system? Is it possible to modify the system in case of bias?
The origin of the data	Data within algorithms is symbiotic with the algorithm itself. Therefore, data input in algorithms determine the characteristics of an analytics tool. When data sets are opaque, there is no way to accurately evaluate the results.	Is the data correctly labelled? Is the algorithm trained to discriminate cultural variants in the data? What data are used to feed the recommendations or suggestions? What data affect the creation of suggestions?
Explanation of the results, and conclusions	It must be ensured that both the algorithmic decisions and the data that drive the analytical tools can be explained, in technical terms, to teachers, families, and educational actors.	What part of the system can be explained to educational actors? How much data sources can be disclosed? How many of the decisions assumed by the algorithm can be explained?

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Table 3. Types of dimensions affected by data analytics (Part 2 of 2). Source: [23].

Dimension	Summary	Questions to be solved by using analytics
Equity	It must be guaranteed that algorithmic decisions do not generate discrimination or unfair treatment.	Is there a control of users who may be favoured or disadvantaged using analytics? Is there control of the potential damages or effects generated by the errors committed? Is there control over the context in which the analytics system operates? Are cultural norms considered?
Harmful content management	The design or use of an analytics-based tool should consider the type of content that users can add. It is harmful not to check and verify whether that content is harmful or not. Policies are required that define the possible damages caused to third parties in terms of containment and actions.	Is there control of false identities? Is there a check for suspicious profiles or fraudulent activity? Is there a control system? Is there a protocol against possible damages?
Pedagogical approach	Mainly, the design and use of the educational data analytics tool require a pedagogical approach to interpret the results. This means addressing at least essential educational aspects or issues such as knowledge of the learning behind the tool, attention to the context of the data, and the graphic utility to improve learning.	Is there a clear pedagogical approach to the use of the tool? What is the educational theory behind algorithmic decision making? Does it provide evidence based on data?
Privacy	If the data of the students that are used are considered private or intimate data, they have had to give their consent to be treated and analysed. So, the lack of privacy gradients can facilitate bad practices.	Have privacy gradients or roles defined? Have the spaces been delimited for the users? Are there mechanisms for student or even family consent?

The different types of options for the implementation of these existing approaches in the market are:

- **Based on CC**: They are hosted in the cloud and often follow a SaaS business model. Cloud-based providers oversee the maintenance of the system and perform any product feature updates or technical updates. For users, this fact is transparent, and they can access the system from anywhere, at any time, using a username and password.
- **Self-managed**: Self-managed systems require the educational institution to download and manage the necessary software, and equipment. Having the platform installed by opting for this modality provides greater control and customisation, but against this, centres must maintain the system themselves and often must pay for any updates that occur.
- **Desktop / Mobile App**: These desktop applications are installed on the end-user's device. However, the app can still be accessible on multiple devices. Mobile apps support mobile

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learning and are accessible anywhere, anytime via mobile devices. Although this approach is not as popular as previous ones, it is increasingly used as a standalone mode for the use of certain apps within the classroom or as a first attempt to bring digitisation software closer to the educational institution.

On the other hand, the various business plan models used include:

- **Freemium**: This pricing model allows access to the basic functions of some LMS or SIS platforms. Once businesses or educational institutions start to interact with the more advanced features of the system, a fee is added.
- **Subscription**: A recurring fee is paid at regular intervals, typically monthly, to access the LMS or SIS. Subscription may give an organisation full access to all features of such applications or may require the organization to pay for each user of the system.
- **Licensing**: This is either an annual fee that institutions must renew or an initial fee that gives users unlimited access.

4. Learning Management Systems

To perform learning analytics, learning environments need to generate and store data. One of the most common ways to do this is by recording all the clicks made by students in the educational environment, which is known as clickstream data. This approach is not only used in educational settings but is universal in many digital domains for modelling and understanding human behaviour. However, this has led to the creation of different data schemas in each system, making interoperability between different learning analytics models and solutions difficult. The two most widely proposed formats to achieve interoperability in online teaching environments are IMS Caliper [24] and xAPI[25].

In recent years, the use of sensors in education has also increased, both to capture audiovisual signals and biometric signals from students [26]. This area, which combines different data sources, is known as multimodal learning analytics and is especially promising for the assessment of complex tasks. In some cases, large amounts of data are captured and, to process them, Big Data architectures are needed that allow efficient storage, access, and processing. This represents a new challenge for educational institutions when adopting educational analytics environments [27].

Therefore, the first step in the learning analytics process occurs in the use of tools within the teaching environment and in the context in which the learning is taking place. Therefore, the participation of students in IT tools is a fundamental point in this first step. With the popularisation of online education, it has become easier to collect learning data. LMS [28] are tools commonly used in distance education, such as Moodle. With the advent of MOOCs, large amounts of data from students around the world have been collected, fuelling the development of numerous studies on the subject and establishing frameworks for learning analytics [29]. Learning analytics projects have also been carried out in less common environments, such as smart tutors, educational games, and sandboxes based on external services [30]. Each of these environments has its characteristics that can affect the implementation of the use of learning analytics. Furthermore, these analytics tools can be used both in full online education and in hybrid or inverted methodologies [31].

Although they are commonly used in higher education, studies have also been conducted in primary and secondary education settings [32]. In addition, the use of learning analytics in non-formal learning environments and professional work environments has also been investigated [33]. The latest trends also lead to the combination of learning analytics in physical and digital environments and the combination of data from multiple platforms at the same time [34].

LMSs are e-learning software and are orientated toward the transmission of nonface-to-face training information. LMSs are characterised by being software applications or web-based technologies and are used to plan, implement, and evaluate a specific learning process with two elements: a server that performs the basic functionality and a user interface that is operated by the educational institution staff, teachers, and, to a lesser extent, students and/or families [35]. Today, all these platforms allow

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the digital management of all the variables in a learning process. They not only allow the management of students, but also the distribution of content. [36].

LMSs are not only used by educational institutions, but also by companies of all sizes, governments, or educational institutions based on online learning because they are tools that can help improve traditional educational methods while saving time and money allowing teachers and IT administrators to efficiently control elements such as user registration, content, calendars, user access, communication, certifications, and notifications [37]. In summary, the main use of an LMS is for KM. KM refers to the collection, organisation, exchange, and analysis of knowledge and data from an organisation, regardless of whether it is an educational institution or a company, in terms of the resources, documents, and skills of the people who work in it [38].

However, the specific role of the LMS will vary depending on the strategy and objectives of the organisation or institution. The management, preparation, and training of personnel is one of the most common use cases for an LMS in a corporate or business environment. In this case, these types of tools are used to help train new employees, as they help to access educational materials regardless of the device, facilitating training. Thus, new employees can start their training, achieving results as soon as possible and being able to participate by expanding their knowledge. It should be noted that all use of these applications will generate statistics and data that will help companies understand how effective the courses are and identify areas where new employees need more help. Companies can also use these tools to provide training to external customers, partners, and members. For example, this type of training is common in technology companies, where users must learn how a system works before they can use the new product. Providing ongoing customer training will help improve the experience and increase loyalty to the company. Another common use of LMS in business environments is for staff development and retention. The LMS can be used to assign the necessary courses to employees to ensure that they develop effective job skills, stay informed, and maintain all relevant knowledge through preparation.

An LMS can be thought of as a Big Data repository that allows companies and institutions to create, store, and track information in one place. Any user, with a username, and password, can access the system to view, and control your learning resources through a web browser. However, if the system is self-managed, the software must be installed in the company or institution's facilities to access it through its server or equipment [39].

4.0.1. Features and Benefits

In the dynamic landscape of educational technology, a LMS plays a pivotal role in the design of modern learning experiences. The following key features highlight the essential aspects that contribute to the effectiveness and adaptability of an LMS. From ensuring an adaptive design that seamlessly integrates with various devices to robust reporting and data analysis capabilities, each element is carefully crafted to enhance the overall learning journey. The aspects of support services, social learning, and gamification underscore the importance of fostering a collaborative and engaging educational environment. Automation of administrative tasks streamlines operational efficiency, while multilingual support and the integration of AI and ML signify the system's commitment to providing a personalised and globally accessible learning ecosystem. Let us delve into each of these integral features that collectively define a robust and user-centric LMS.

- **Have an adaptive design**: Users must be able to access the LMS from any type of device they choose, be it a computer, tablet, or mobile device. The LMS should automatically display the most suitable interface version for the device chosen by the user. Additionally, the LMS should also allow users to download content to make it accessible offline. The UI must allow users, teachers, and students to easily navigate the platform, and must be aligned with the skills and objectives of both the user and the organisation. An unintuitive user interface can be confusing or distracting and will render the LMS ineffective.

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- **Reporting, and data analysis**: This includes having available learning assessment tools and the ability to generate reports to synthesise the vast amount of information created by the multiple points that these systems have. Administrators and faculty need to be able to see and track their training initiatives to determine whether they are effective or need adjustment. This can be applied both to groups of students and to scenarios where individual monitoring is carried out. Their content facilitates the creation and management of content catalogues and courses to provide a more targeted learning experience. They must help identify the competencies of each didactic material to associate it with an evaluation or a set of them. Faculty and administrators need to be able to assess an individual's skill set and identify any performance gaps quickly, and factually, using LMS records during an audit.
- **Support services**: The tool must have the support of a company that responds not only to doubts but also to possible infrastructure problems or technical incidents that may occur. Right now, on the market, it is possible to find LMS providers that offer different levels of support to cover all the needs that a company or educational institution may have. Many provide discussion forums where users can connect and help each other. However, additional support services are usually offered for an additional monthly or annual cost. Social learning and gamification capabilities: Some LMSs have begun to include tools for connecting and sharing content on social networks within their platform. This allows users to interact with their peers, collaborate, and share their learning experiences. Other LMSs include built-in game mechanics or gamification features that allow teachers and administrators to create courses that will receive more motivation and participation from students. This can help students who need extra incentive to complete the course by improving healthy competitiveness through leaderboards, points, and achievements.
- **Automation of administration tasks**: The LMS has automation tasks to avoid repetition, and the team wastes time on tedious tasks. Tasks related to user management, content, or administration in general are supported by functionality that avoids spending a lot of time on them.
- **Multilanguage**: LMS must include multilingual support features so that learning and training content is not affected by language barriers. Some LMSs integrate geolocation features that allow them to automatically present the appropriate version of the course immediately upon access.
- **Use of A.I and M.L.**: Artificial intelligence helps an LMS create personalised learning experiences for users by providing course formats appropriate to their needs and by suggesting topics that the user may find interesting depending on the courses you have already completed [40,41].

LMSs provide a variety of benefits, regardless of the type of organisation or business that uses them. In summary, it is possible to identify the advantages offered by these systems in the following points [42]:

- Record all activities, and actions of all users of the educational platform, being able to monitor the progress, and performance of users.
- Offer greater accessibility to e-learning with almost no limitations by having the ability to personalise the training and learning experience.
- Possibility of exporting reports to analyse the educational process.
- User management by creating groups to execute massive actions.
- Construction of educational structures made up of tutors assigned to learning groups.
- Content management by creating categories and programmes for digital distribution, being able to easily and efficiently update modules and activities, and ensuring that training and learning materials are distributed effectively.
- It allows you to securely organise and store all the data in one place. This helps teachers to maintain learning materials more easily. It also helps to produce effective training that is consistent throughout the organisation. Additionally, most LMSs include advanced encryption features that help ensure that data and content remain secure.

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4.0.2. Different Approaches

In the ever-evolving landscape of e-learning, choosing the right LMSs is essential for educational institutions, corporations, and training providers. This section aims to provide a comprehensive comparative analysis of two widely used LMS platforms (Canvas [43–46] and Moodle [47–50]) and two new proposals (Chamilo [51–55] and TalentLMS [56–58]).

Canvas, developed by Instructure, stands out for its intuitive user interface, robust features, and scalability [59]. Its cloud-based architecture allows seamless integration with other tools and applications, promoting a flexible and adaptive learning environment. Canvas excels in fostering collaboration through features such as discussion forums, real-time feedback, and collaborative document editing.

Moodle, an open source LMS, has gained widespread acclaim for its versatility and customisation capabilities[60]. Moodle's extensive community support ensures a wealth of plugins and extensions, enabling institutions to tailor the platform to their unique needs. Its commitment to open standards and interoperability improves its compatibility with various types of content and third-party tools.

Chamilo, an open source project, positions itself as a user-friendly and scalable solution. Its modular design allows organisations to choose and implement features according to their requirements. Chamilo places a strong emphasis on accessibility, making it an inclusive option for diverse learners. The platform's tracking and reporting functionalities contribute to effective learner progress assessment.

TalentLMS distinguishes itself with a modern user-centric design and a strong focus on simplicity. Geared towards businesses and corporate training, TalentLMS offers a streamlined user experience without compromising on essential features. Its cloud-based infrastructure ensures easy deployment and management, making it an attractive choice for organisations with diverse training needs.

In the following subsections, each software will be explained in detail, and a comparison between its features will be presented.

4.0.3. Canvas

Canvas[1] is a web-based LMS. Learning institutions, faculty, and students use it to access and manage course learning materials and communicate about skill development and learning achievements. Canvas includes a variety of customisable course creation and management tools, user and course analytics, statistics, and internal communication tools.

It includes a variety of built-in course-building and management tools that help with customisation by creating unique and accessible teaching and learning experiences. Although Canvas is primarily web-based software, Canvas can be accessed by any user on a mobile device through Canvas apps. Teacher, Canvas Student, and Canvas Parent.

Teachers will have the ability to create and design course content through assignments, discussions, custom modules, quizzes, and information pages. They may also choose to foster a collaborative learning experience through collaborations, conferences, and groups. Depending on course settings, students can access these areas in Canvas to find learning materials and interact with other course users. Canvas also allows institutions and instructors to add state, and institutional learning outcomes to rubrics to measure and track student learning achievement, and skill development. Additionally, course creators can use the course import tool to upload LMS course packages and/or pre-existing course materials.

Instructors can provide students with comprehensive feedback on assignments and quiz submissions using their Speed Grader feature and manage grade reports in Canvas Gradebook. They can also facilitate real-time course interactions through chat and communicate course news and updates to students through announcements, as well as the calendar and syllabus. Instructors and administrators can

[1] https://www.instructure.com/canvas

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gain a greater understanding of student success and make informed educational decisions using the data provided in Canvas Analytics. Administrators can also access SQL data about their Canvas users and usage details from Canvas Data Services. Canvas also includes the Canvas App Centre, where administrators, designers, and instructors can enable a variety of external applications and services. The ever-growing library of apps offers a wide range of interactive resources, content repositories, assessment tools, social media integrations, and other digital learning and teaching resources.

Canvas includes the following six standard user roles: Administrators, Designers, Instructors, Teaching Assistants, Students, and Observers. However, institutions can create any number of custom user roles with varying access to Canvas. The user's assigned role determines their access to Canvas and their interactions. For example, Canvas administrators may have access to create user accounts, add course enrolments, and manage institutional grading periods. Instructional designers can use Canvas to create and manage course content and review course analytics to identify areas for improvement in teaching and learning. School counsellors can use Canvas to review student course progress and assess student performance. Parents and guardians can use Canvas to review and communicate with instructors about student course progress, including assignment submissions and grades.

4.0.4. Moodle

Moodle[2] was devised by Martin Dougiamas, and since its inception, its main goal has been to properly contribute to the e-learning system, and to facilitate online education and online teaching [61].

Moodle stands for Modular Object-Orientated Dynamic Learning Environment, and statistics reveal that around 14 million consumers are participating in around 1.4 million courses propagated by this LMS. It is a free software, LMS that provides a platform for e-learning, and greatly helps conceptualise the various courses, course structures, and syllabus, thus facilitating interaction with students.

Although Moodle has certain features common to almost all similar e-Learning tools, it also offers certain plugin options. As an e-learning platform, Moodle features: blogging, chat capability, importing activities from the database, glossary creation, support systems that enable multilingual operation, comprehensive content management, quiz creation, and regular evaluations. In summary, it is possible to synthesise all the possibilities of Moodle in the following points:

Moodle allows for automated loading of courses, teachers, and students, helping to carry out data imports in a massive way.

It is possible to integrate Google Analytics into Moodle itself, to analyse the growth of visitors and devices, as well as monitor schedules to streamline teaching actions.

Statistics data from the technical support ticket system can be used, so we can predict a future workload regarding demand growth in the Virtual Campus.

It is possible to customise modules where students see the planning of each subject, to be able to control access to them. It is possible to quickly see which students have connected to the course each day and which have not.

It is possible to extract the information daily from the accesses, and, when a student does not appear for a few days, it is possible to automate sending an email reminding them of access to the platform. For students, they must know that teachers are here. It may be interpreted as a threat, but the objective is not to ask for explanations; it is useful to encourage them and try to re-engage them in the course.

The current infrastructure facilities adopted by Moodle allow it to support many plugin options, such as graphical themes, content filters, enrolment and authentication processes, as well as question and resource patterns. Any operating system allows the use of an e-Learning platform such as Moodle,

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2 https://moodle.org/

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and some of the systems that Moodle can run on without alteration include Mac OS X, Windows, Linux, Unix, etc.

4.0.5. TalentLMS

This product is focused on small organisations and covers the need to cover the obstacles that prevent these organizations from using e-learning tools. To be productive, small businesses need a suite of applications and various related services, such as setup and maintenance, course creation, and end-user support. Creating a flow with several interconnected applications requires a lot of time, resources, and money. Not surprisingly, most small organisations find e-learning an unfeasible activity and turn to other training methods. To simplify the entire technology adoption work, TalentLMS[3] is optimised for efficient usage offering a self-explanatory user interface, fewer settings, fewer steps to fill out any form, etc.

Furthermore, with TalentLMS it is possible to create courses by transforming and reusing content from various sources to tell interesting stories with digital learning attributes. It is possible to reuse content from presentations, YouTube, Wikipedia, Slideshare, Scribd, and many more sources. So teachers can create courses in a few minutes.

TalentLMS is hosted in the cloud, which means comfort and security for institutions, since it can be managed and can grow as much as desired, manage costs, and have a fully automated environment. In other words, it allows you to focus on results, and not on technology. The tool is designed from the ground up to work with mobile devices and tablets, its UI being optimised for them.

4.0.6. Chamilo

This tool allows an organisation and/or institution to configure, and distribute courses to its staff or students while preserving important data, and information on learning, and skill achievement by collecting such information to view performance.

It is used by a large community around the world (more than 21 million users), coordinated by its non-profit association “Chamilo”, and developed by its official providers and external collaborators, who share the ambition to make education better and more accessible to all. At the enterprise level, it is an ideal tool for HR staff, as they need applications to understand the profile of their organisation, in terms of general professional skills, making it much more difficult to find the right staff for new projects.

Chamilo LMS[4] enables institutions to easily create courses, host training sessions, receive automated feedback, build skills based on completed training sessions or work experience, search for skill profiles within your institution, and provide a private space for development collaborators to the institution to communicate after the training sessions, maintaining and strengthening relationships.

This platform focusses on ease of use, offering ergonomics favoured by an interface that allows you to perform any action with a minimum of clicks. In short, Chamilo offers the creation of courses complemented with a series of tools to promote learning: organisational tools (Calendar, event list, Outlook import, session planning), survey tools (creation, and management of surveys, and reminders about unfilled surveys), monitoring, and reporting (activity reports, progress, complete statistics) or content import, and export tools (SCORM or IMS/QTI among others). It also has educational tools such as forums, Wikis, glossaries, short questions, or exercises together with tools dedicated to gamification (digital skills badges, research, skills wheel, etc.). A novel point is the creation of questions and exercises (ability to create many types of questions, creation of a question bank, quick questions, hot potatoes to promote competitiveness or the ability to import content from QTI or Excel among other aspects), and the creation of learning routes to see the development of the students. It has

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[3] https://talentlms.com
[4] https://campus.chamilo.org/

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an internal social network (personal profile, messaging, chat, social wall, relationships, deployment of skills, etc.) to share the progress that students make and teach news such as the use of immersive learning through virtual reality. At the level of creating learning metrics, it has its own statistics module to analyse almost the use and performance of the students to provide this information to the tutors.

4.0.7. Comparision

Table 4 has been created to comprehensively outline the features to be analysed across different LMSs. This table ensures clarity and organisation, enabling a detailed comparison of each system's capabilities.

Table 4. Comparison of LMS Features (Part 1)

Feature	Canvas	Moodle	Chamilo LMS	TalentLMS
Account management				
Add users	✓	✓	✓	✓
Archive users	-	✓	✓	✓
List users	✓	✓	✓	✓
Search user	✓	✓	✓	✓
Search user list	✓	-	✓	✓
Bulk actions	✓	✓	✓	✓
Create custom fields	-	-	✓	✓
Upload users	✓	-	✓	✓
Customization				
Create categories	-	✓	✓	✓
Create categories associated with a purchase or rate	-	-	✓	✓
Manage category	-	✓	✓	✓
Assign courses to categories	-	✓	✓	✓
Authentication and Integration				
Active Directory	-	✓	✓	✓
LDAP	-	✓	✓	✓
Own login	-	✓	✓	✓
Entry without login	-	✓	✓	✓
SAM.L.2	-	-	✓	✓
API	-	-	✓	✓
Allow self-registrations	✓	✓	✓	✓
Validation of self-registrations by administrator	-	✓	✓	✓

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Table 4. *Cont.*

Feature	Canvas	Moodle	Chamilo LMS	TalentLMS
Content management				
Task assignment management	✓	✓	✓	✓
Integrated content authoring management tools	✓	✓	✓	✓
Content reuse	✓	✓	✓	✓
Edit course settings	✓	✓	✓	✓
Video integration	✓	✓	✓	✓
Course backups	-	✓	✓	✓
Ability to drag, and drop content to create it	-	✓	✓	-
Ability to create customs learning paths	-	✓	✓	✓
Live event programming	✓	✓	-	✓
Surveys	-	✓	✓	✓
Battery of questions	✓	✓	✓	✓
Upload courses, and content	✓	✓	✓	✓
Course settings and tools				
Discussion forums	✓	✓	✓	✓
Gamification	-	✓	-	-
View student workload	✓	✓	✓	✓
Live chat	✓	✓	✓	✓
Grouping content into themes	-	✓	✓	✓
Videoconferences	✓	✓	✓	✓
Weekly upload format	✓	✓	-	-
Teaching type				
Asynchronous	✓	✓	✓	✓
Asynchronous with mentor	-	✓	✓	✓
Synchronous	✓	✓	✓	✓
Synchronous with virtual class	✓	-	✓	✓
Mix	-	✓	✓	✓
Content availability				
Offline	-	✓	-	* Mobile app with preloaded content
Online	✓	✓	✓	✓

Table 4. Comparison of LMS features (Part 2)

Feature	Canvas	Moodle	Chamilo LMS	TalentLMS
Gamification				
Insignia	✓	✓	✓	✓
Badge customization	-	✓	-	✓
Leaderboards	-	✓	✓	✓
Levels	✓	✓	-	✓
Points	✓	✓	✓	✓
Rewards	✓	✓	✓	✓
Custom mechanics	-	✓	✓	✓

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Table 4. *Cont.*

Feature	Canvas	Moodle	Chamilo LMS	TalentLMS
Adaptability				
Management of external content pages	-	✓	✓	✓
Management of content blocks	-	✓	-	-
Custom calendar management	✓	✓	-	✓
Languages, and multilanguage	-	✓	✓	✓
Location management	-	✓	-	✓
Graphic themes available	-	✓	✓	✓
Certificate and compliance management				
Management of the entire certification life cycle	-	-	-	✓
Management of certifications	-	-	✓	✓
Predefined Certifications Template	-	-	✓	✓
Unique courses for certifications	-	-	✓	-
Unique preparation Pathway for certifications	-	-	✓	✓
Certificate expiration notifications	-	-	✓	✓
Certificate expiration management	-	-	✓	✓
Due Date notifications	-	-	-	✓
Management of expiration dates	-	-	-	✓
Course enrolment management				
Course attendance tracking	✓	✓	✓	✓
Progress tracking	-	✓	-	✓
Automated enrollment	-	✓	✓	✓
Guest access	-	✓	✓	✓
Manual enrollment	✓	✓	✓	✓
Self-enrollment	-	✓	✓	✓
Registration with code	-	-	✓	-
Reports				
Scheduling automated Reports	-	-	-	✓
Scheduled reports	-	-	✓	✓
Charts, and Dashboards	✓	-	✓	✓
Email with reports	✓	✓	-	✓
Export reports	✓	✓	✓	✓
Configuration options in note reports	-	✓	✓	✓
Automatic email reports at predefined time intervals	-	✓	-	✓
Custom report generator	✓	✓	-	✓
Email notification settings	-	✓	✓	✓
Real-time system logs	-	✓	✓	✓
Security				
Anti-spam	-	✓	-	✓
Anti-virus	-	✓	-	-
IP blocker	-	✓	-	-
Restrict email domains	-	✓	-	✓
Obligation to use strong passwords	-	✓	✓	✓
Custom role creation	✓	✓	-	✓
Role assignment	✓	✓	✓	✓
Role permissions	✓	✓	✓	✓
Role hierarchy	-	✓	-	✓
Role hierarchy by group	-	✓	-	✓

5. Student Information Systems

A SIS also referred to as a student administration system, school administration software, or student administration system [25], serves as a comprehensive tool that extends beyond the functionalities

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of LMSs or virtual learning environments. Unlike these platforms that focus primarily on electronically publishing course materials and conducting assessments, an SIS integrates features similar to ERP and corporate systems.

- **ERP Functionality:** An SIS goes beyond traditional learning management, resembles ERP systems in its comprehensive features.
- **Billing and Accounting Administration:** Efficiently manages the accounting and billing processes, resulting in significant savings in time and cost.
- **Automation of Administrative Processes:** Automates various administrative tasks, including general ledger maintenance, billing, accounts payable and receivable, advanced accounting and financing details.
- **Contact Management Automation:** Incorporates automated contact management functionalities, facilitating systematic and regular email communications. Sends notifications regarding unpaid invoices or debts to creditors and families.
- **Data Warehousing:** Forms a robust data warehouse, compiling diverse details that can be used to generate reports and analytics crucial for informed decision making [25].

5.0.1. Features and Benefits

SIS plays a crucial role in the educational landscape, offering a suite of features designed to streamline administrative processes and improve data management. These systems are characterised by their user-friendly interfaces, which ensure ease of use for various stakeholders. Beyond simplifying data entry, SIS excels in handling large volumes of information, supporting parallel usage without compromising performance.

Key benefits include an organised and accessible presentation of student details, real-time reporting functionalities, and seamless integration with other modules. SIS tools exhibit scalability, adapting to the dynamic needs of educational institutions by accommodating multiple users and incorporating multimedia content. Security measures are paramount, restricting access to designated users and implementing multiple levels of protection to safeguard sensitive information.

In essence, the features and benefits of SISs converge to establish a solid foundation for efficient data management, reporting, and secure access within educational environments. SISs generally have the following characteristics [62]:

It offers an easy-to-use interface for any user: Since all applications are orientated towards correct and direct use, most of the fields in forms are made to fill in the required fields, and facilitate the work, leaving the extra details in optional fields.

They are tools designed to work with a large volume of data and are suitable for tens or hundreds of users to work in parallel without compromising system performance. In addition, these systems offer all the details of students or users in an accessible, indexed, classified, and clear way without the user using the application getting lost in the sea of data. To manage all the information, these systems present functionality to facilitate the generation of reports in real-time, and personalised reports for the analysis of the data to decipher all the information that is collected and extracting information from the data to help the users, and departments to make better decisions. Furthermore, these modules are accompanied by the ability to support all types of requests and generate adequate notifications for all sanctions and changes in school performance variables associated with students [63].

At the information import level, these systems allow integration with other modules to be able to bring and load the information in an accessible, and fast way. An important point is the support of batch uploads from various sections to keep the system up-to-date with current information. At the configuration level, the SIS tools allow scalability to support multiple connected users, and allow easy reconfiguration of the system, helping to expand the supply of data, as well as introducing more users or storing images. Videos or multimedia content relevant to the organisation. At the security level, these tools allow only designated users to access the full capabilities of the system. This security

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is completed with several levels to restrict access to undefined users, and information received from other sources is subjected to security scans [64].

5.0.2. Different Approaches

Choosing the right SIS is critical for educational institutions to streamline administrative tasks, improve communication, and improve overall efficiency. In this comparative analysis, we explore the key features and strengths of four prominent SIS platforms: Gradelink [65,66], Teachmint [67,68], MySchool [69–71], and Alma [72].

Gradelink stands out for its user-friendly interface and comprehensive gradebook functionality. This cloud-based SIS simplifies grade management, attendance tracking, and communication between teachers, students, and parents. Gradelink's robust reporting tools provide valuable insights into student performance, aiding educators in making informed decisions. The mobile accessibility of the platform ensures seamless communication and data access on the go.

Teachmint is a versatile SIS designed for remote and hybrid learning environments. It offers features such as attendance tracking, class scheduling, and interactive online classrooms. TeachMint's emphasis on simplicity and accessibility makes it an ideal choice for educators transitioning to digital platforms. The intuitive interface of the platform and integrated communication tools foster effective collaboration between teachers and students.

MySchool is known for its all-in-one approach, which combines SIS with LMS, and communication tools [73]. MySchool streamlines administrative tasks, simplifies grade management, and facilitates effective communication between stakeholders. The platform's customisable dashboards provide a tailored user experience, while the integrated LMS ensures a cohesive learning environment for students.

Alma stands out as a comprehensive SIS with a focus on data-driven decision-making. Alma's unified platform covers grading, attendance, scheduling, and communication. Its powerful analytics tools enable educators to track student progress, identify trends, and implement personalised interventions. Alma's modular design allows institutions to scale features according to their evolving needs.

In the following subsections, each software will be explained in detail, and a comparison between its features will be presented.

5.0.3. Gradelink

Gradelink[5] establishes communication between all actors related to education (management body, IT administrators, teachers, families and students) in a single system that handles all needs such as enrolment registration, grade tracking, or transcript printing. Report cards, among others. It has an intuitive graphical interface and allows all the information to be available to everyone in real time regardless of the number of users that use it since it works completely online through the web browser, also allowing you to work with the application from anywhere.

This tool does not need any special hardware or software, since it runs on mobile and desktop devices, making it easy for families and students to access the data. Among the multiple data it offers, it is worth mentioning access to grades, conduct, performance, teacher comments, and even the next delivery dates. In addition, the tool allows automatic monitoring of grades, so that teachers and families can receive email alerts that inform them about current progress of students.

At the security level, all accounts are protected by a secure login. The tool has a data backup system and automatic backup creation since the application saves the data in the cloud.

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[5] https://www.gradelink.com/

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5.0.4. Teachmint

It is a cloud-hosted school management and administration application that has been created and designed to help educational centres manage enrolment, schedules, classes, questions, and complaints that students can make[6]. In addition, the tool has the organisation of human resources processes, the results of candidacies, and everything related to human resources management. Being able to track the communication issued to the candidates through emails and calls, or even export the data of the candidates for future needs.

This application has a financial module that allows centres to manage expenses, see bank movements, control monthly payments, and make transfers or deposits, allowing educational institutions to design their economic strategies. It has a reporting module to create summaries of different kinds, such as obtaining information on finances, student progress, attendance, and exams, among other metrics. Finally, the permission that teachers must identify and plan the achievement of learning objectives, organise classes around them, and monitor the curriculum that revolves around the above is highlighted. The tool facilitates the creation of schedules for the institution's staff concerning the spaces, and resources that are available (inventory, laboratories, gym, etc.).

5.0.5. MySchool

This tool[7] has been created as a highly configurable web-based, robust, secure, and cloud-based management system. It is certified to ISO 27001 and ISO 9001, providing security in data management and in the service offered in this regard. In addition, having both certifications demonstrates the company's commitment to providing a solid and reliable platform.

Within its website, it is announced that this application is implemented in institutions and companies around the world, defining itself as an easy-to-use solution since it works on all devices and only requires a browser and an Internet connection.

5.0.6. Alma

Alma[8] is a web platform, hosted in the cloud, that integrates all features of an SIS, as well as functionalities related to an LMS, offering a complete application for educational management regardless of the size of the institution and its size.

Its objective is to simplify all operations in general, from everything related to administrative functions to everything related to the world of the classroom. To do this, it has programmable functions, automation, and the ability to record all communication movements with both students and their families. At the data level, the tool can schedule classes, perform curricular programming, and a powerful report module to summarise all the information available to the system, even being able to configure personalised reports on multiple variables at the same time to make easier decision-making. In addition, this tool adapts to the size of the institution, offering different service packages and prices to obtain the best cost/benefit.

The software offers flexible data migration options, parent and student portals, and customised features based on school needs. Attendance management, bus route tracking, tuition management, curriculum design, curriculum and biographical mapping, and demographic data management are some of the features that this software offers. The tool also helps streamline communication between students, teachers, and parents by offering features such as text alerts, email communication, voice messages, group messages, secure staff notes, and a bulletin board. The product also offers DA and reporting capabilities, such as ad-hoc, and custom reports, filters, and visual analysis tools to help understand student, and school data to make better decisions.

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6 https://www.teachmint.com/
7 https://www.trymyschool.com/
8 https://www.getalma.com/

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5.0.7. Comparision

As shown in Table 5, we present a comparison of the features of SIS. Due to its length, the comparison has been split into two parts for better readability.

6. The Future of LMS and SIS Adoption

Note that institutions and companies face the cost of licences for the use of software from some of the platforms presented. Other approaches, on the other hand, are open source and are left to a third party or the institution itself to maintain and host the tool. Although it may seem contradictory, these types of solutions are the most used. For example, it is possible to find that the most well-known open source educational platform in the world is Moodle with more than 150 million users; however, it has begun to lose users and be replaced by other options with more modern and friendly technologies such as Canvas or Chamilo, which currently has more than 20 million users [74].

On the other hand, the market for commercial LMS platforms such as Blackboard is increasingly fierce, and their market share is increasingly reduced due to the increase in commercial options in the academic area with lower costs and better interfaces.

A growing trend in the part of online education within schools is the use of software such as Google Classroom and/or Edmodo: These platforms could not be called LMS since they do not comply with the standards determined by the Learning Technology Standards Committee (I.E.E.E.) [75], however, they show better results in terms of digital learning and adaptation within the classroom. Both platforms allow the creation of social learning environments very similar to Facebook or Instagram in schools, if we focus more on results and less on the formality of what is established, these two platforms would be among the best options available.

The use of technologies that will make it possible to more personally customise the user experience or extract data from the tools is beginning to be noticed to make the most of all the information available. Each LMS software has an API available to extract data [76]. An API (Application Programming Interface) is a system that, given credentials, allows you to connect to it and extract data. An API is a standard that allows programmes and software to communicate with each other. Having an API within a system is common within the technology sector. A software company releases its API to the public so that other software developers can design products that work with its service. For example, Facebook has an API so that other companies can develop games or applications. In the education sector, having a good and easy-to-use API is key to attracting developers to create content or features for your platform, making it more attractive. Working with an API indeed requires engineering tasks or tasks typical of Big Data environments. To simplify the process, it is possible to adopt tools such as xAPI, which allows you to connect various learning sources to the LMS platform to contribute or collect data [77]. Another focus is on content adaptability and data import. Many LMSs can import or export content according to industry standards. Content standardisation allows the development and use of the content to be able to compare the topics used by teachers as apps. As a general rule, the content created and stored in an LMS must be packaged according to interoperable standards such as SCORM and xAPI allowing operability and integration with each other.

Both standards and functionalities are detailed below.

6.1. SCORM

SCORM[9] stands for the Shared Content Object Reference Model and is a set of technical standards for e-learning software products [78]. SCORM dictates some rules to programmers on how to write code so that it can be interoperable with other LMS and is the most widely used standard for the interoperability of e-learning tools [79]. Specifically, SCORM governs how learning content and LMS

[9] https://scorm.com/

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Table 5. Comparison of SIS features (Part 1)

Feature	Gradelink	Teachmint	MySchool	Alma
Administrative management				
Accounting management	✓	✓	✓	✓
School district management	✓	✓	✓	✓
Admission's management	✓	✓	✓	✓
Billing control	✓	✓	✓	✓
Registration management	✓	✓	✓	✓
Financial management	✓	✓	✓	✓
Data management	✓	✓	✓	✓
Data import	✓	✓	✓	✓
Data export	✓	✓	✓	✓
Customisable reports	✓	✓	✓	✓
Third-party integrations	✓	✓	✓	✓
Performance metrics	✓	✓	✓	✓
Invoice management	✓	✓	✓	✓
Document storage	✓	✓	✓	✓
Management prospects and offers	-	✓	✓	✓
Inventory management	-	✓	✓	✓
Tax management	-	✓	✓	✓
Transport management	-	✓	✓	✓
Management of payroll	-	✓	✓	✓
Excursion management	-	✓	✓	✓
Communication management				
Alerts, and notifications	✓	✓	✓	✓
Contact management	✓	✓	✓	✓
Emails management	✓	✓	✓	✓
Communications management	✓	✓	✓	✓
Educational management				
Student behavior management	✓	✓	✓	✓
Suitable for primary education	✓	✓	✓	✓
Suitable for secondary education	✓	✓	✓	✓
Suitable for private programs	✓	✓	✓	✓
Suitable for specialized training	✓	✓	✓	✓
Individualized evaluations	✓	✓	✓	✓
Classrooms management	✓	✓	✓	✓
Courses management	✓	✓	✓	✓
Teachers' management	✓	✓	✓	✓
Other staff management	✓	✓	✓	✓
Resources management	✓	✓	✓	✓
Assessment management	✓	✓	✓	✓
Curriculum management	✓	✓	✓	✓
Registration management	✓	✓	✓	✓
Integrated LMS	✓	✓	✓	✓
Grade book	✓	✓	✓	✓
Student registration	✓	✓	✓	✓
Student information	✓	✓	✓	✓
Summary of classes	✓	✓	✓	✓
Attendance tracking	✓	✓	✓	✓
Progress tracking	✓	✓	✓	✓
Course authoring	-	-	✓	✓

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Table 5. Comparison of SIS features (Part 2)

Feature	Gradelink	Teachmint	MySchool	Alma
Technology and tools				
Report cards	✓	✓	✓	✓
Report Management	✓	✓	✓	✓
Statistics	✓	✓	✓	✓
Task setting	✓	✓	✓	✓
Grades	✓	✓	✓	✓
Calendar management	✓	✓	✓	✓
Attendance's management	✓	✓	✓	✓
Calendars management	✓	✓	✓	✓
Files management	✓	✓	✓	✓
Electronic payments	✓	✓	✓	✓
Teacher panel	✓	✓	✓	✓
Classroom panel	✓	✓	✓	✓
Laboratory panel	✓	✓	✓	✓
Agenda planning	✓	✓	✓	✓
Employee portal	✓	✓	✓	✓
Students' portal	✓	✓	✓	✓
Families' portal	✓	✓	✓	✓
Course programming	✓	✓	✓	✓
Expenses	✓	✓	✓	✓
Assessment management	✓	✓	✓	✓
GPS	-	✓	✓	✓
Custom brand	-	✓	✓	✓
Content library	-	✓	✓	✓
Workflow management	-	✓	✓	✓
Block content	-	-	-	✓
Block web content	-	-	-	✓
Own blackboard in courses	-	-	-	✓
Ad hoc reports	-	-	-	✓
Collaboration and interaction				
Chat	✓	✓	✓	✓
File sharing	-	-	-	✓
Screen sharing	-	-	-	✓
Real-time monitoring	-	-	-	✓
Diffusion	✓	✓	✓	✓
API	-	-	-	✓

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communicate with each other. SCORM does not discuss instructional design or any other pedagogical concern. It is purely a technical standard.

The SCORM standard ensures that all e-Learning content and LMS can work with each other. If an LMS is SCORM-compliant, it can play any content that is SCORM-compliant, and any SCORM-compliant content can be played on any SCORM-compliant LMS.

SCORM should not be seen as an obstacle in the way, but rather as a tool that enables effective and efficient online training. In essence, SCORM allows content authors to distribute their content to a variety of LMSs, and an LMS to handle content from a variety of sources without any issues.

6.2. xAPI

xAPI[10] is a technology that helps to store student interactions that provide homogeneity between different platforms and data interoperability. It collects all the interactions derived from clicks on an LMS platform, facial recognition, graphology, or sentimental recognition, among other types of data. This tool is community-driven and free to implement.

The Experience API (or xAPI or TinCan API) is a new specification for learning technology that allows data to be collected about the wide range of experiences a learner has (online and offline) [80]. This API captures data in a consistent format about the activities of a person or group from many technologies. Very different systems can communicate securely by capturing and sharing this stream of activities using the simple vocabulary of xAPI. In other words, it is possible to consider and add the interactions of the students outside the virtual learning environment: in social networks, forums, debates, and any digital environment clickable with a mouse or clickable on a touch screen. Thus, the tool can collect and store almost all possible data regarding the interaction with and of the students [81]. This amount of data is huge and can become almost exponential as the number of students grows.

This tool works by collecting student interactions. Its operation is because knowledge is acquired through interactions with other people, with the content, or even with the device with which one works. These actions can occur anywhere and signal an event in which learning could occur. xAPI allows you to collect and save each and every one of the actions that are performed regardless of the device, and without having a constant network connection.

Tracking learning events doesn't have to start or end in an LMS, it can start wherever the learner is, and on whatever device they choose to use. Its content is not linked to an LMS and can be exploited by many other applications. In addition, any enabled device can send information following the xAPI requirements.

In summary, xAPI was created to track information about the learning behaviour of users using LMS. The standard explained above, SCORM can only track what happens within an e-learning course: who takes the course, how well they do on the assessment, and related metrics, but it falls short of tracking usage of the tool. per se. To fill this gap, xAPI was developed to learn even more about the learning behaviour of a user. For example, xAPI allows you to know how students are learning or how many people are using the wiki that was created for teachers. xAPI can also be configured to collect information from multiple LMSs and deposit it in a central data repository, and this is where this tool comes in.

7. Learning Based on Data and Shreds of Evidence

Learning analytics is a pedagogical approach that uses data collection and analysis with ML techniques of student performance to tailor instruction in a personalised and real-time manner [82]. This implies that the techniques serve to continuously monitor and evaluate the progress of each student to make adjustments in the teaching approach and provide a more effective and efficient educational experience [83]. Thanks to new technologies and digital platforms, it is possible to collect,

[10] https://xapi.com/

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analyse, and evaluate student activities, work, actions, or tasks, and monitor a large amount of data accurately and quickly to propose new activities automatically.

This approach has been developed in recent years to customise the learning process to the individual needs and characteristics of each one. This has been made possible thanks to the advancement of technology, and computing, which have allowed the collection and massive analysis of data, typical of Big Data environments, on the performance, and behaviour of students. Currently, this adaptive learning is being used more and more widely thanks to the availability of digital tools and the ability to process large amounts of data using cloud technologies to adapt education to the individual needs of each student [84].

Learning conducted using these types of technique, also known as adaptive learning, offers many benefits for both students and teachers. For students, the intelligent system adapts the learning path to their individual needs, helping them to learn more effectively and quickly. Furthermore, the adaptive learning process is very motivating when compared to the classical teaching scheme, since students can see how they are progressing and gain self-confidence. This point can be improved with gamification techniques [85].

For teachers, adaptive learning allows them to better understand their students and their abilities, weaknesses, and strengths in learning, allowing them to provide a more individualised education that is appropriate for their learning objectives [86]. This allows them to focus their attention on less-consolidated aspects, address difficulties in a personalised way, or pose new challenges to more advanced students to maintain their interest. In summary, data-based learning offers direct benefits to improving learning and very clear advantages for all the actors present in education.

However, for adaptive learning to work effectively, it is necessary to collect information about students, their ways of learning, their weaknesses, and their strengths. Based on these data, the digital educational tools establish an adapted and personalised work plan for each student, especially focussing on the areas where the student needs more work or providing more challenges to motivate them, adapting the most appropriate learning approaches to their needs. The adaptive learning system must include constant interaction and feedback so that the adaptation process is continuous. However, for the teacher to be able to adjust the itinerary and provide individualised support to each student, the system must provide detailed information about the performance and needs of each one. Not all adaptive learning tools on the market offer this functionality, so it is important to choose a tool that provides this information.

Adaptive learning tools combine data collected from students (which can include a variety of quantitative and qualitative parameters) with statistical information, predefined responses, established learning patterns, and algorithms designed to process these data and identify the strengths and weaknesses of each student [87]. These systems take into account not only the answers of the students, but also the way they interact, the time they invest in completing a task, and their doubts. With this information, the digital platform creates a personalised learning path for each student. Also, as on-line platforms, these systems can compare data from different students to improve and adjust their results as they are used more. This includes customising different aspects of learning, such as content, format, and organisation. For example, the content can be modified in terms of the demand and difficulty of the activities, the skills or aspects worked on, and the topics covered. You can also change the statements, concepts, and skills that you want to develop or the situations that the student needs to solve. The format may also vary, including the type of activity and the general format. In addition, learning organisation can change, including the order and sequence of activities, since personalization of these aspects of learning allows the teaching process to be adapted to the specific needs of each student [88]. Adaptive learning does not limit the teacher's work or eliminate contact with students; on the contrary, it facilitates the teaching work, speeds up the learning process, provides valuable information about how students learn, and saves time so that the teacher can dedicate himself to other tasks. activities and work more directly with them in those aspects that present the greatest challenges to them. Instead of reducing the role of the teacher, data-driven learning allows you to

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focus on the individual needs of each student and provide a more effective and efficient education [89]. It can be applied to one or several subjects and combined with other information and communication technologies (IT tools). Although it can be used outside the classroom, to obtain the greatest possible benefit, it is advisable to use it intrinsically in the classroom. Thus, teachers can programme a topic, explain it, or start a project and, at the same time, programmeme the same topic on the adaptive learning platform. Therefore, as students progress, the intelligent system will detect difficulties and generate personalised learning paths for each student. The information provided by the system will allow the teacher to detect which topics present difficulties to the students and provide a richer and more effective guide during face-to-face time.

On the other hand, thanks to the analytics generated, the following educational profiles benefit from its use:

- **Relationship between student, and family**: Data analysis can be used to track student performance and progress and can be supported by a large amount of information and data that is compared to reality. This information can be useful at events such as one-on-one tutoring sessions or evaluation meetings. Observing the evolution throughout the course for a particular subject or having grade predictions allows you to correct students when possible or detect if they are going through a bad patch. In addition, involving families in the process of monitoring student performance and progress can be beneficial to ensure that the necessary support is provided and steps are taken to ensure student academic success.
- **Relationship between student, and group or class**: Data analysis can be used to assess student performance and progress and to identify how it relates to class performance. Furthermore, analytics can be used to optimally group students to work in groups and maximise their performance in a particular subject or specific competency, as well as to promote co-existence [90].
- **Student-Teacher Relationship**: Data analysis is a very useful tool for educators and educational administrators. It allows the collection of information on the performance and progress of students, as well as analysing the behaviour and interaction of students in the classroom. Teachers can use this information to make informed decisions and provide feedback to students. They can also create their indicators for each subject or group and use the information to correlate behaviour with possible causes and effects. In short, data analysis can help improve student performance and co-existence at school.
- **Relationship between the student, and educational directors**: Educational leaders, such as stage directors or centre management teams, can use the information collected to assess the performance and progress of a stage or a centre in general. This allows them to measure teacher performance and see which methodologies work best for a particular group. In addition, they can recommend specific actions in evaluation meetings and make informed decisions on how to improve the overall performance of the centre. Schools must establish a culture of data use to get the most out of the analytics tools they use. If this is not done, each teacher can use different tools separately, which can result in a disorganised set of data and no robust information. Centres must encourage a systematic and structured approach to data use to obtain consistent and reliable results.

8. Final Considerations

DA applications are very efficient and effective when processing and analysing large amounts of data in real time. This makes it possible to test many students at the same time and find patterns and relationships that might be difficult for humans to detect. It has already been seen how these applications help improve teaching, learning, institutional decisions, and guidance, providing valuable information to make more effective and efficient decisions in the educational environment [91].

These applications claim to be capable of collecting and analysing large volumes of data, including data that may be challenging for humans to identify, and do so rapidly and effectively. This real-time analytical capacity, made possible by the potential of DA, is expected to improve teaching, learning,

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decision-making, and guidance in educational settings. DA offers to reveal connections or information that may be hard to discern due to human cognitive limitations and the intricate nature of managing numerous variables in an educational context. The use of data and evidence in education can serve as a means of fostering equity by allowing students from various regions to access top-notch educational opportunities and engage more efficiently with their peers. This may contribute to narrowing the existing achievement disparities in education and furnishing students with an improved overall educational experience. In addition, AI can be used to improve the effectiveness of educational procedures, which could allow students to learn more efficiently and productively.

If a discriminatory or biased society is reflected in the data used to train a DA system, there is a risk that the system perpetuates these same patterns. Therefore, it is essential to ensure that the data used to train a system is diverse and representative of the population it is intended to serve. Finally, it is important to note that no application is infallible and that you can make mistakes. Therefore, it is important to have verification and monitoring systems in place to ensure that the systems are working optimally and are not producing unintended adverse results. These types of application can provide a wealth of analytics, and analysis on student performance and behaviour, but it is important to note that these data can vary in quality, and can have adverse results if all relevant factors are not taken into account. Furthermore, it is important to ensure that the tools provide useful information to inform and make decisions to improve the education of students. The use of evidence-based data in education can bring benefits, but it also carries risks. One of the most important tasks is to obtain adverse results, that is, unwanted or even counterproductive negative consequences. To avoid these results, it is important to consider several factors, such as the quality of the data used, the representation of the results against reality, and the progressive implementation in the educational institution. In addition, it is necessary to establish clear protocols and create criteria to know when to follow or ignore algorithmic recommendations and promote a comprehensive and inclusive conversation about the role of DA in the mission of the institution. Data-driven assessment often fails to take into account the complexities and individual differences of students. Applications can collect and analyse large amounts of data, but can be insensitive to factors that are important to human evaluation, such as a deep understanding of a topic or sustained effort over time. Additionally, excessive use of data-based assessment can discourage teachers from using their judgment and being creative in their teaching. Therefore, it is important to consider how to balance the use of analytics with evaluation based on human judgment and to take into account the limitations of both approaches.

In brief, utilizing DA can be a beneficial instrument for enhancing student achievements and advancement, as well as for informing institutional choices and offering more efficient educational support. However, there are also risks associated with using data in education, such as the potential for adverse outcomes and the influence of private companies in the data collection and visualisation process [92,93]. It is important to consider these factors and take steps to minimise risks and maximise the benefits of technology in education. Analytics technology can be very useful in education, but note also that there may be divergent interests between companies that develop these applications, educational institutions, and students. This must be taken into account when implementing technology in the education system, and steps must be taken to ensure that it is used responsibly and that no adverse results or unintended negative consequences occur. Additionally, it is important to consider the impact that these tools may have on equal opportunities and the privacy of student data.

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Abbreviations

The following abbreviations are used in this manuscript:

API	Application Programming Interface
CC	Cloud Computing
DA	Data Analytics
DL	Deep Learning
ERP	Enterprise Resource Planning
IMS	Instructional Management System
IoT	Internet of Things
KM	Knowledge Management
KPI	Key Performance Indicator
LMS	Learning Management Systems
ML	Machine Learning
NN	Neural Networks
NLP	Natural Language Processing
QTI	Question and Test Interoperability
SaaS	Software as a Service
SIS	Student Information Systems
UI	User Interface

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