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Article

# Artificial Intelligence (AI) and Learning Management Systems (LMS): A bibliometric analysis

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**Abstract:** The advent of Artificial Intelligence (AI) has transformed Learning Management Systems (LMSs), enabled personalized adaptation and facilitated distance education. This study employs a bibliometric analysis based on PRISMA-2020 to examine the integration of AI in LMSs from an educational perspective. Despite the rapid progress observed in this field, the literature reveals gaps in the effectiveness and acceptance of virtual assistants in educational contexts. Therefore, the objective of this study is to examine research trends on the use of AI in LMSs. The results indicate a quadratic polynomial growth of 99.42%, with the years 2021 and 2015 representing the most significant growth. Thematic references include authors such as Li J and Cavus N, the journal Lecture Notes in Computer Science, and countries such as China and India. The thematic evolution can be observed from topics such as regression analysis to LMS and e-learning. The terms e-learning, ontology, and ant colony optimization are highlighted in the thematic clusters. A temporal analysis reveals that suggestions such as a Cartesian plane and a league table offer a detailed view of the evolution of key terms. This analysis reveals that emerging and growing words such as Learning Style and Learning Management Systems are worthy of further investigation. The development of a future research agenda emerges as a key need to address gaps.

**Keywords:** virtual assistants; educational effectiveness; PRISMA 2020; digital technologies; adaptive learning

## 1. Introduction

The advent of Artificial Intelligence (AI) has transformed Learning Management Systems (LMS) in education. AI-powered LMSs now facilitate adaptive personalization of content and distance education during the ongoing global pandemic. AI in LMSs has enabled the adaptation of educational content in a personalized way, offering students more dynamic and relevant learning experiences. Recent studies on deep learning and on LMSs during the pandemic have provided valuable insights, underscoring the importance of these systems for sustainable education in times of crisis (Alasiry and Muniasamy, 2020; Cavus et al., 2021).

The convergence of AI and LMS has the potential to transform the landscape of education. This integration offers a more personalized and adaptive approach to teaching and learning. By combining AI and LMS, educators can create adaptive personalization of educational content and a more dynamic interaction between

students and learning platforms. By leveraging advanced AI algorithms, LMS can analyze the progress and individual preferences of students, thus optimizing their learning experience. Current studies propose integrated frameworks that use AI to provide a comprehensive view of student performance and enable continuous adaptation of teaching strategies (Aljohani et al., 2019).

Moreover, the implementation of AI-based conversational agents, such as chatbots, further enriches the LMS experience by providing instant and personalized responses to student queries. This conversational interaction not only enhances student engagement but also frees up educators from administrative tasks, allowing them to focus on more meaningful teaching activities (Shukla and Verma, 2019). Conversely, it is demonstrated how the student's interaction with the learning management system can reveal behavioral patterns and learning preferences, thereby enabling an even more precise adaptation of educational content and activities (da Costa et al., 2020). These advances underscore the transformative potential of Artificial Intelligence in LMSs, redefining educational approaches towards greater personalization and effectiveness in teaching and learning.

The integration of AI in LMS has become increasingly relevant in the field of educational research. Recent research highlights the importance of an approach focused on the analysis of course-specific data to improve the educational experience. This approach allows for a deeper understanding of students' individual progress and needs, as well as providing valuable insights for the optimization of educational resources and strategies (Aljohani et al., 2019).

Conversely, the proposal of integrated models for digital educational platforms underscores the necessity for comprehensive approaches in the implementation of digital technologies in education. This comprehensive approach acknowledges the significance of AI in LMSs as a foundational element for enhancing the efficiency and effectiveness of digital educational environments (Gillet et al., 2022). Similarly, other research that has focused on the use of virtual assistants, automated content creation, and the adoption of AI in dental education, respectively, demonstrates the breadth of application and the transformative potential of AI in various educational contexts. This research highlights the potential for the integration of AI in LMSs to improve the learning experience and drive innovation and progress in teaching and learning. Furthermore, the integration of AI in LMSs not only enhances the learning experience but also fosters innovation and progress in teaching and learning (Ahmed and Ganapathy, 2021; Gubareva and Lopes, 2020; Islam et al., 2022).

The incorporation of AI into LMS signifies a transformative shift in the landscape of education, enabling unprecedented personalization and adaptation of content. The recent literature on the subject indicates that deep learning and AI-based techniques have the potential to transform e-learning, offering more personalized and effective learning experiences (Alasiry and Muniasamy, 2020). The deployment of sophisticated algorithms enables the precise adaptation of content to the individual requirements of each student, thereby optimizing the interaction between them and the learning system. Nevertheless, despite these advances, significant shortcomings have been identified in the effectiveness and acceptance of AI-based techniques in adaptive LMS. These deficiencies may originate from the intricacy involved in implementing adaptive algorithms that are capable of effectively adjusting to individual learning

styles (Nadimpalli et al., 2023). Furthermore, the lack of clarity and explainability in AI-based educational recommendation systems presents ethical and trust challenges that affect their adoption and acceptance in educational settings (Pesovski et al., 2022).

These challenges underscore the pressing need to address the impediments to AI adoption in education, particularly with regard to the transparency and adaptability of AI-based tools. Strategies to overcome these obstacles should prioritize improvements in the explainability of recommendation systems and the development of adaptation methods that are more intuitive and accessible to users. The implementation of techniques that enhance comprehension and foster trust in AI-based tools can facilitate greater uptake and more effective utilization of these technologies in LMSs (Pesovski et al., 2022). Moreover, it is imperative that educators receive ongoing training in the utilization of these technologies to ensure their successful integration and positive impact on teaching and learning (Nadimpalli et al., 2023).

Despite the rapid advancement in the use of AI in LMS, the scientific literature reveals certain gaps that deserve attention. For example, gaps are noted in the effectiveness and acceptance of AI-based techniques in adaptive Learning Management Systems. These deficiencies may arise from the complexity of implementing adaptive algorithms that effectively fit the individual needs and learning styles of students. Similarly, the lack of transparency and explainability in AI-based educational recommendation systems poses ethical and trust challenges that can hinder their adoption and acceptance in educational environments (Pesovski et al., 2022). Additionally, gaps have been identified in the effectiveness, acceptance, and ethical aspects of virtual assistants in educational contexts (Gubareva and Lopes, 2020).

These gaps underscore the necessity for further research aimed at addressing the effectiveness, acceptance, and ethical implications of integrating AI into LMSs. Such research would facilitate the development of more transparent, accountable, and effective systems to enhance the learning experience of students. Consequently, the objective of this research is to examine the current research trends on the use of AI in LMSs. In light of the above, the following research questions are also posed:

- What are the years where there has been the most interest in the use of Artificial Intelligence in Learning Management Systems?
- What type of growth is there in the number of scientific articles on the use of Artificial Intelligence in Learning Management Systems?
- What are the main research references on the use of Artificial Intelligence in Learning Management Systems?
- What is the thematic evolution derived from scientific production on the use of Artificial Intelligence in Learning Management Systems?
- What are the main thematic clusters on the use of Artificial Intelligence in Learning Management Systems?
- What are the growing and emerging keywords in the research field of the use of Artificial Intelligence in Learning Management Systems?
- How are the keywords in the scientific literature on the use of Artificial Intelligence in Learning Management Systems classified according to their function?
- What topics are positioned as protagonists for the design of a research agenda on the use of Artificial Intelligence in Learning Management Systems?

This article is structured into six sections that address different aspects of the topic. It begins with a concise summary that provides an overview of the main findings and conclusions of the study. The introduction sets the context of the topic and highlights the importance of integrating Artificial Intelligence into Learning Management Systems. The methodology describes the approach and procedures used to conduct the research, including data collection and analysis. The results present the key findings obtained through the study. The discussion interprets the results and relates them to the existing literature, analyzing their meaning and relevance. Finally, the conclusions summarize the main points of the study, highlight their implications, and suggest areas for future research.

## 2. Materials and methods

The relevance of utilizing AI in LMS is becoming increasingly evident in academic and educational contexts. The integration of AI in LMS has markedly transformed the interaction between students and educational content, as well as the manner in which educators personalize learning. In this context, literature reviews, especially those guided by rigorous methodologies such as PRISMA 2020, play a crucial role in the evaluation and synthesis of existing literature. The application of PRISMA-2020 in this bibliometric analysis has provided a robust methodological framework for the critical review of research on AI in LMS. This approach has facilitated a comprehensive and systematic evaluation of the literature, enabling the identification of emerging trends, research gaps and areas of future development. The methodology has thus contributed significantly to the advancement of knowledge in this dynamic and constantly evolving field (Page et al., 2021).

### 2.1. Eligibility criteria

In this bibliometric analysis, specific inclusion and exclusion criteria were applied. For inclusion, titles and keywords were considered the primary metadata, focusing on the precise combination between Artificial Intelligence and Learning Management Systems, in addition to the various ways of citing them. With regard to the exclusion phases, the first is dedicated to records with erroneous indexing, the second phase excludes documents without access to the full text, which is reserved only for systematic literature reviews, and bibliometrics focuses exclusively on metadata. In the third phase, non-relevant texts and documents with incomplete indexing are eliminated, thus guaranteeing a rigorous and precise analysis of the existing literature in this specific field.

### 2.2. Information sources

The Scopus and Web of Science databases were selected on the basis of their relevance and reliability within the academic field. These databases are widely acknowledged as the principal sources of scientific literature, offering comprehensive coverage of the global academic landscape. The decision is supported by a study that demonstrates the utility and relevance of Web of Science and Scopus in academic research. These databases offer a comprehensive range of scientific journals, conferences, and other types of publications, as well as robust analytical tools. They provide accurate and detailed bibliometrics (Liu and Zhu, 2020).

Furthermore, it is essential to emphasize the diversity and quality of the information sources consulted in the analysis, in addition to the choice of Scopus and Web of Science. These databases provide access to a wide range of publication types, including peer-reviewed journal articles, conference proceedings and books, thereby enhancing the scope and depth of the bibliometric analysis. Moreover, both Scopus and Web of Science offer sophisticated tools for data extraction and analysis, including citation metrics and co-citation networks. These facilitate the identification of emerging trends and the evaluation of the impact of publications. The selection of these information sources guarantees a comprehensive and up-to-date overview of the scientific literature, enabling an accurate evaluation of the evolution of the field and the identification of pivotal areas for future research (Alviz-Meza et al., 2023).

## 2.3. Search strategy

Two bespoke search equations were devised in order to satisfy the predefined inclusion criteria and to accommodate the distinctive search characteristics of each database. This guarantees the accuracy and relevance of the data collected. Customized search strategies are indispensable for ensuring the accuracy and relevance of bibliometric data collection. The creation of two specialized search equations allows for the optimization of information retrieval in accordance with predefined inclusion criteria and the adaptation to the specific characteristics of each database. This enables the refinement of the search to include only those studies that meet the requisite standards of relevance and quality, while minimizing the inclusion of irrelevant or duplicate results.

The adaptation of the search equations to the distinctive characteristics of Scopus and Web of Science, including their keyword taxonomies and search filters, guarantees the specific coverage of the field of study. Furthermore, this process of adjustment enables the capture of the most pertinent publications, thereby facilitating a more accurate analysis and a more robust evaluation of the extant literature. The utilization of particular search terms and sophisticated filters in each database contributes to a search strategy that optimizes the relevance of the data obtained, thereby facilitating a more comprehensive view of the research landscape in the domain of Artificial Intelligence and Learning Management Systems.

For Scopus database: ((Title (“Artificial Intelligence” or “AI” or “Machine Intelligence” or “Cognitive Computing”) and Title (“Learning Management Systems” or “LMS” or “Educational Technology Platforms” or “ Digital Learning Management” or “Online Course Platforms”) or (Key (“Artificial Intelligence” or “AI” or “Machine Intelligence” or “Cognitive Computing”) and Key (“Learning Management Systems” or “LMS” or “Educational Technology Platforms” or “Digital Learning Management” or “Online Course Platforms”))).

For the Web of Science database: ((TI = (“Artificial Intelligence” or “AI” or “Machine Intelligence” or “Cognitive Computing”) and TI = (“Learning Management Systems” or “LMS” or “Educational Technology Platforms” or “Digital Learning Management” or “Online Course Platforms”)) or (AK = (“Artificial Intelligence” or “AI” or “Machine Intelligence” or “Cognitive Computing”) and AK = (“Learning Management Systems” or “LMS” or “Educational Technology Platforms” or “Digital Learning Management” or “Online Course Platforms”))).

## 2.4. Data management

Microsoft Excel® was employed to extract, store, and analyze data from the selected databases, to visualize bibliometric networks, and to perform visual analyses. The VOSviewer® software was utilized to support this choice, as evidenced in Hou and Yu (2023). Moreover, the combination of VOSviewer® with Microsoft Excel® enabled the precise creation of graphs to represent bibliometric indicators. This methodological approach, supported by specialized tools and previous studies, ensures rigor and reliability in the analysis and presentation of the results.

## 2.5. Selection process

In accordance with the guidelines established by the PRISMA 2020 statement, it is essential to report on the use of internal automatic classifiers, as well as internal or external validation, in order to mitigate the risk of lost studies or erroneous classifications (Page et al., 2021). In the present study, automation tools were used in Microsoft Excel®, which were designed internally by the team of researchers. The aforementioned tools were created and utilized independently by all members of the research team during the application of the inclusion and exclusion criteria. This strategy of collaborative collaboration and convergence of results minimized the risk of loss of studies or classification errors, thus ensuring the integrity and reliability of the bibliometric selection process.

## 2.6. Data collection process

This study adheres to the guidelines set forth by the PRISMA-2020 statement for the collection of reporting data (Page et al., 2021). Microsoft Excel® was employed as an automated tool to facilitate the organization and analysis of the data obtained from the two selected databases. All authors of the study assumed the role of reviewers of the compiled reports, performing this task independently. Additionally, a collective data validation process was conducted, during which the authors collaborated to confirm the precision and consistency of the results obtained, thereby achieving complete convergence in the findings.

## 2.7. Data elements

A comprehensive search was conducted in the selected databases to identify all relevant articles addressing this topic. This approach ensured the inclusion of all pertinent studies. However, in the event that missing or unclear information was encountered in some articles, an exclusion criterion will be applied to guarantee coherence with the objectives and scope of the research. This strategy aims to maintain the consistency and relevance of the data collected for bibliometric analysis.

## 2.8. Study risk of bias assessment

The risk of bias assessment process in the included studies was conducted in a rigorous and collaborative manner. All authors participated in this process, independently evaluating each study using the same automated Microsoft Excel® tool used for the collection of data. This strategy was implemented with the objective of guaranteeing the quality and integrity of the results obtained, by allowing a thorough and consistent assessment of the risk of bias in the selected studies.

## 2.9. Effect measures

It is crucial to note that, although effect measures such as the risk ratio or the difference in means are more prevalent in primary research, different metrics are employed for the synthesis and presentation of results in this study. This is because it is a bibliometric study based on secondary research sources. Indicators such as the number of publications, the number of citations, and the temporality of use of each keyword are analyzed. These analyses are carried out using tools such as Microsoft Excel® for data processing and VOSviewer® to determine the thematic association between the different nodes identified in the keyword co-occurrence network.

## 2.10. Synthesis methods

A meticulous process was employed to determine the eligibility of studies for inclusion in the bibliometric synthesis. This entailed tabulating the intervention characteristics of each study and comparing them with the predefined inclusion criteria. In addition, rigorous methods were applied to prepare the collected data. To address the management of missing summary statistics and perform data conversions where necessary, data tabulation and visualization methods were adopted, following the guidelines described in a study on bibliometric indicators of scientific quality (Durieux and Gevenois, 2010). These indicators were applied in an automated manner using Microsoft Excel® to all documents that passed the exclusion phases established in the selection process.

## 2.11. Assessment of reporting bias

It is important to consider the risk of bias due to the lack of results in the synthesis. This may arise from reporting biases. It is therefore essential to recognize that there is the possibility of a bias towards certain synonyms found in thesauri such as the IEEE, which can influence the inclusion criteria, the search strategy and the data collection itself. Likewise, when working with documents that have incomplete indexing and may contain less relevant texts, it is crucial to apply strict exclusion criteria. This is done to avoid the omission of valuable information that could contribute significantly to the construction of knowledge on the topic addressed.

## 2.12. Certainty assessment

The evaluation of certainty in the body of evidence is carried out in a global and contextual manner. This differs from the evaluation of certainty in primary studies, which is done individually. In this context, certainty is evaluated based on the independent application of the inclusion and exclusion criteria. Furthermore, the definition of bibliometric indicators that reflect the quality and relevance of the data collected is also undertaken. In addition, potential biases are identified and defined in the methodological design, and the limitations of the study are highlighted in the discussion phase, which contributes to a more comprehensive and critical analysis of the body of evidence obtained.

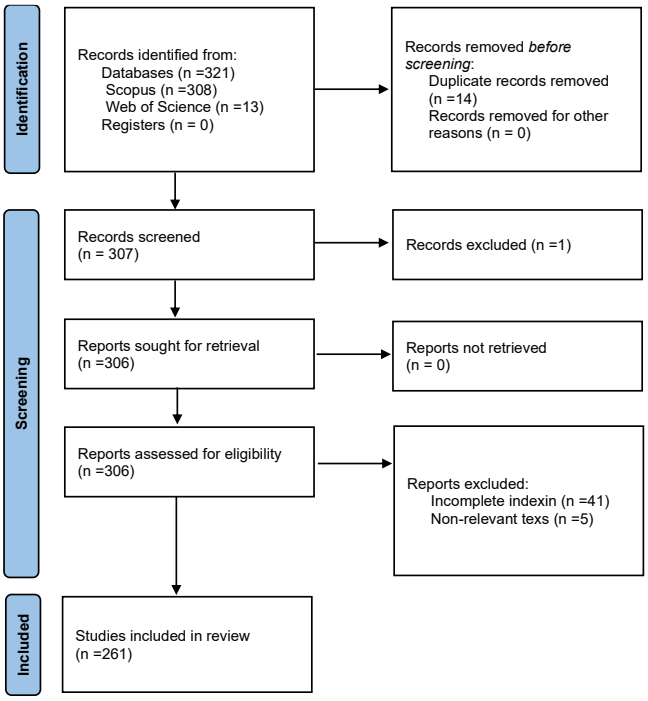


**Figure 1.** PRISMA-2020 flowchart.
Own elaboration based on Scopus and Web of Science.

This bibliometric analysis was conducted in several stages (**Figure 1**). Initially, an identification phase was carried out, followed by the elimination of duplicate records. Subsequently, three exclusion phases were conducted according to defined criteria, resulting in the inclusion of 261 articles in the study. These stages ensure the integrity and relevance of the data analyzed in the research.

## 3. Results and discussion

This section offers an overview of the trends, patterns, and relationships identified from the bibliometrics carried out. The results provide a deep understanding of the current research landscape in this field, revealing valuable insights about the focus areas, emerging themes, and the temporal evolution of studies related to the integration of Artificial Intelligence in Learning Management Systems.

A quadratic polynomial growth trend of 99.42% was identified, as illustrated in **Figure 2** of the study. The highlighted years were 2021, 2015, 2020, and 2017. These results indicate a significant increase in the publication of articles on the subject, demonstrating a continuous and growing interest of the scientific community in exploring the applications of Artificial Intelligence in education. This underscores the relevance of researching and analyzing emerging trends in this constantly evolving field.

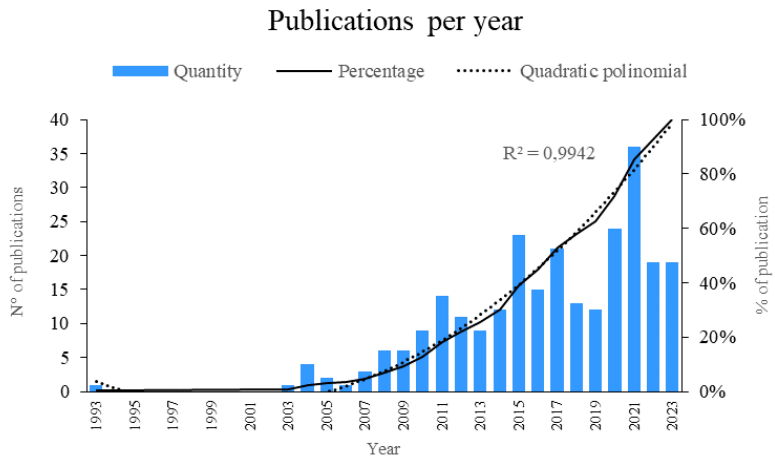


**Figure 2.** Publications by year.
Own elaboration based on Scopus and Web of Science.

Two groups of authors were identified. The first, led by Li J, Cheng L, Samat A, Du P, and Liu S, stands out for its impact, although with low scientific productivity. The second, led by Cavus N, stands out for its high productivity. This contrast illustrates the diversity in contributions to the field, with some authors focusing on quality and others on quantity of scientific publications (**Figure 3**).

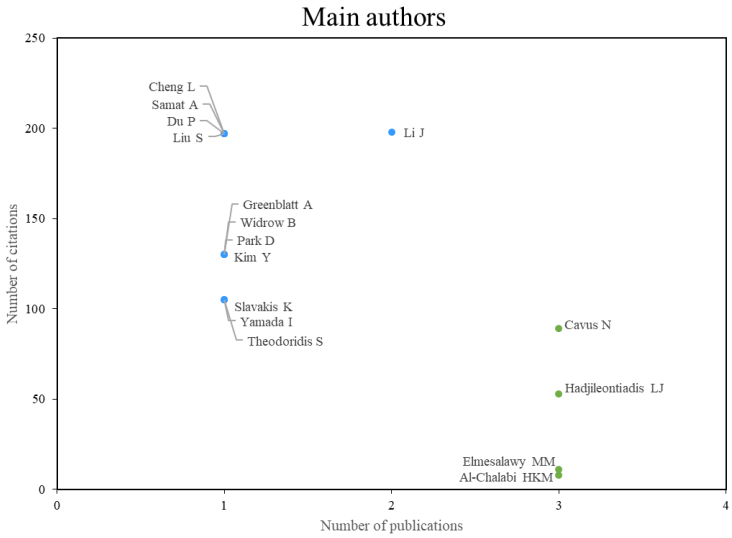


**Figure 3**. Main authors.
Own elaboration based on Scopus and Web of Science.

The bibliometric analysis revealed the existence of three distinctive groups of scientific journals in relation to the use of Artificial Intelligence in Learning Management Systems. The first group comprises the most outstanding journals in terms of productivity and impact, including Lecture Notes in Computer Science. The second group of journals stands out mainly for their impact, despite registering lower scientific productivity. This is exemplified by publications such as the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing and Neural Networks. Finally, the journal whose prominence lies in its high scientific

productivity, rather than in its number of citations, was identified. The Association for Computing Machinery (ACM) International Conference Proceeding series is one of the most prominent in this group. This analysis provides a more detailed understanding of the publishing landscape in the field of Artificial Intelligence and Learning Management Systems, highlighting the different characteristics and approaches of the leading scientific journals in this field (**Figure 4**).

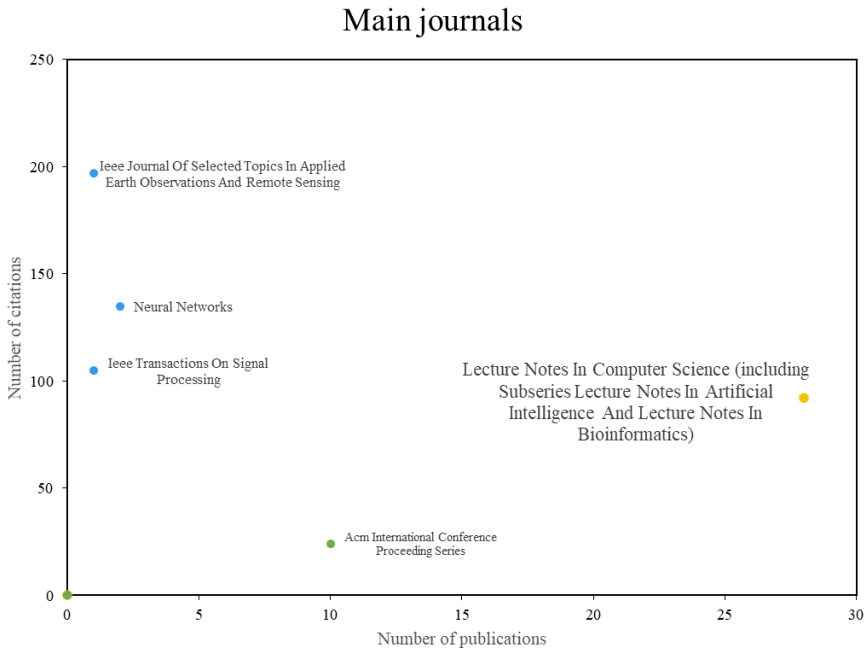


**Figure 4**. Main journals.
Own elaboration based on Scopus and Web of Science.

A comparative analysis of the leading countries revealed the existence of three distinct groups in relation to the use of Artificial Intelligence in Learning Management Systems (**Figure 5**). The first group comprises countries that have made the greatest impact in terms of productivity and impact, including China and India. The second group is characterized by a high impact despite lower scientific productivity, with the United States and Japan representing notable examples. Finally, a group of countries was identified whose prominence lies in their high scientific productivity, rather than in their number of citations. Spain stands out mainly in this regard. This analysis provides a more detailed view of the contribution of different countries in the field of Artificial Intelligence and Learning Management Systems, highlighting the varied characteristics and approaches of leading nations in this field.

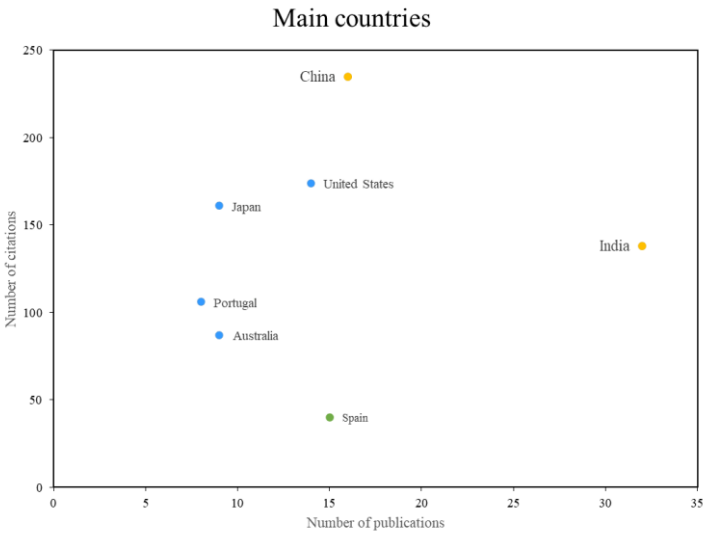


**Figure 5**. Main countries.

Own elaboration based on Scopus and Web of Science.

This research focused on analyzing the thematic evolution in the literature, covering the years 1993 to 2021 (**Figure 6**). The most used keywords in each year were examined, revealing significant trends. In the first year, 1993, concepts such as regression analysis were identified. In contrast, in more recent years, topics such as Learning Management Systems, e-learning, VLMS, and Web Content Accessibility Guidelines (WCAG) have emerged as prominent areas of research. This temporal analysis provides a historical and contextual perspective on how key topics have evolved.

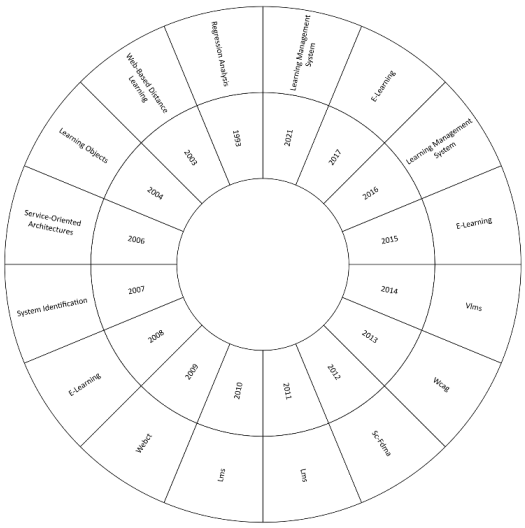


**Figure 6.** Thematic evolution.

Own elaboration based on Scopus and Web of Science.

This bibliometric analysis captures the trajectory and trends of research in Artificial Intelligence and Learning Management Systems. It presents the main network of co-occurrence of keywords through a total of seven thematic clusters, as seen in **Figure 7**. The blue cluster stands out, composed of terms such as e-learning, ontology, ant colony optimization, and data mining, as the most prominent. The yellow

cluster follows, with keywords such as learning analytics, big data, reinforcement learning systems (RLS), and educational data mining. Similarly, other clusters of purple, red, orange, light blue, and green colors are identified that represent other elements of conceptual affinity. This analysis provides a detailed view of the interrelationships and trends in the use of Artificial Intelligence in Learning Management Systems, highlighting the most relevant themes and their relationships within the examined bibliographic corpus.

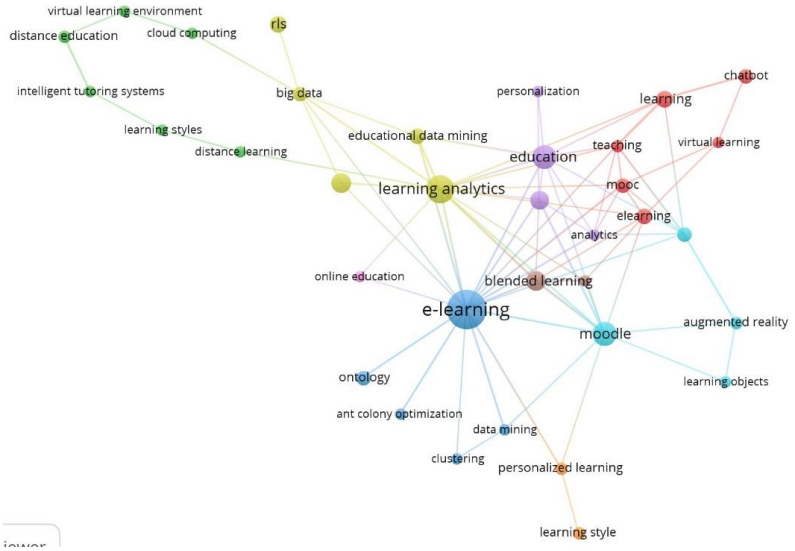


**Figure 7.** Keyword co-occurrence network.

Own elaboration based on Scopus and Web of Science.

This research proposes a Cartesian plane that evaluates the frequency of keywords on the frequent but highly current, such as learning style, higher education, machine learning, and virtual reality (**Figure 8**). Consolidated and increasing concepts, such as Learning Management Systems, are positioned in quadrant 1. This approach offers a detailed vision of the dynamics and evolution of the key terms, highlighting emerging and consolidated trends in the scientific literature on the topic.

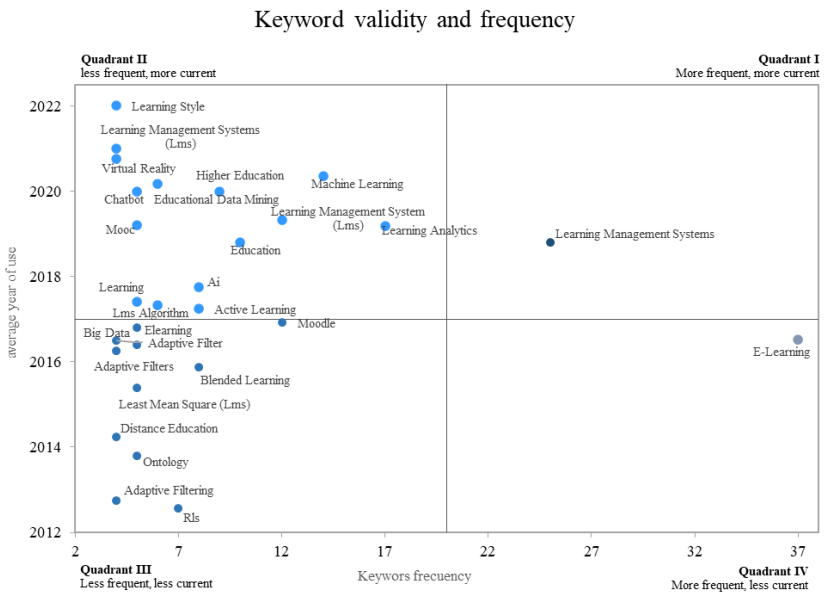


**Figure 8.** Frequency and validity of keywords.
Own elaboration based on Scopus and Web of Science.

## 4. Discussion

This section presents a detailed examination of the identified trends and patterns, facilitating an understanding of their practical implications in authentic educational contexts. The study's limitations are addressed, with a reflective evaluation of the methodological and data limitations presented. This section is of significant importance in order to contextualise the results and to provide guidance for future research and applications in the field of Artificial Intelligence and education.

### 4.1. Analysis of the growth of scientific literature on the use of Artificial Intelligence in Learning Management Systems

In the 2015, 2017, 2020, 2021 years, during which research into Artificial Intelligence in Learning Management Systems has increased, two studies have emerged as particularly noteworthy. In one of the studies, the authors developed an AI-based online learning system adapted to the post-Covid-19 era, emphasising the necessity for educational flexibility in the contemporary context. In the other study, a fuzzy cognitive map was presented that assessed the quality of user interaction in blended learning environments in higher education, thereby providing valuable insights into user interaction. These investigations reflect the diversity and relevance of studies in this field during those years, and they highlight significant advances in adapting Artificial Intelligence to new educational demands (Elmesalawy et al., 2021; Dias et al., 2015).

### 4.2. Analysis of research references on the use of Artificial Intelligence in Learning Management Systems

Notable contributors to the field of Artificial Intelligence and Learning Management Systems include Li J, Cheng L, Samat A, Du P, and Liu S. Their research has been instrumental in the utilisation of machine learning algorithms, such as

Extreme Learning Machines (ELMs), for hyperspectral image classification, thereby establishing a benchmark in this domain (Samat et al., 2014).

Notable scientific journals, including Lecture Notes in Computer Science (LNCS), have played a pivotal role in propelling the advancement of this field. A study featured in LNCS presents Dalite, an asynchronous instruction platform for MOOCs, which underscores the necessity for adaptability in online education (Bhatnagar et al., 2016). Similarly, the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing has published research on the utilisation of Artificial Intelligence in Earth observation, thereby enhancing environmental monitoring technologies (Zhang et al., 2022).

China and India have made notable contributions to research in this field. In 2014, China introduced an innovative technique for hyperspectral image classification (Samat et al., 2014). India has investigated the potential of Artificial Intelligence and e-learning to enhance the educational experience (Kavitha and Lohani, 2019). In contrast, the United States and Japan have led in terms of impact, with notable research contributions in the areas of multilayer neural network algorithms and online kernel-based classification (Slavakis et al., 2008; Widrow et al., 2013).

Spain has also made a contribution in this field, focusing on the design of adaptive learning paths using swarm intelligence. This highlights the role of Spanish research in the development of personalised learning strategies (Vazquez et al., 2011). These countries have played a pivotal role in the advancement of knowledge pertaining to the application of Artificial Intelligence in the field of education.

### 4.3. Analysis of the thematic evolution on the use of Artificial Intelligence in Learning Management Systems

In the initial stages of the study, the primary emphasis was on regression analysis, as evidenced by a study that investigated regional cerebral blood flow estimation through the use of neural network-based parametric regression analysis (Wu and Slater, 1993). However, in recent years, there has been a notable shift in this field. The concepts of LMS and e-learning have become increasingly prominent. Recent research proposes the use of multi-agent systems for the management of resources and activities in smart classrooms (Gómez, et al., 2021) and presents an adaptive and intelligent e-learning system based on deep reinforcement learning (Fouki et al., 2017). These approaches reflect a conceptual transformation in the field, with management and learning technologies becoming crucial research areas for understanding and improving educational systems using Artificial Intelligence.

The concept of Virtual Learning Management Systems (VLMS) has acquired considerable significance in the present context of Artificial Intelligence in LMS. A novel equalisation algorithm, the Variable LMS Algorithm Equalizer, has been devised which emphasises the significance of machine learning techniques in enhancing the efficacy of VLMS-based systems. This approach emphasises the necessity of addressing technical challenges in the design and implementation of *e*-learning platforms through the utilisation of advanced adaptive algorithms (Ghazi-Maghrebi and Razlighi, 2014).

Conversely, the concept of Web Content Accessibility Guidelines (WCAG) has been the subject of considerable attention in current research, particularly in relation

to the accessibility of online assessments for visually impaired users. In 2013, a study was conducted on the design of online assessments for blind users with the use of touchscreen devices. This study underscores the necessity of adhering to web accessibility standards to guarantee that all students, irrespective of their abilities, can fully access and engage in online learning environments (Fakrudeen et al., 2013). The emphasis on concepts such as VLMS and WCAG reflects a comprehensive approach to enhancing the accessibility and efficacy of Learning Management Systems, thereby propelling progress towards a more inclusive and effective educational paradigm.

### 4.4. Analysis of thematic clusters on the use of Artificial Intelligence in Learning Management Systems

The analysis of the keyword co-occurrence network revealed the existence of disparate thematic clusters, which group related terms in accordance with their conceptual affinity. The primary cluster, indicated by the blue colour, encompasses keywords such as “e-learning”, “Ontology”, “Ant Colony Optimization”, and “Data Mining”. This cluster is particularly noteworthy for its relevance in the field of Artificial Intelligence applied to Learning Management Systems. An intelligent e-learning scenario for knowledge retrieval was investigated, with a particular focus on the potential for adaptive learning paths to enhance performance. Additionally, the possibility of predicting student learning outcomes from system logs was explored. This reinforces the significance of data mining in this context (Martín and León, 2012; Vasić et al., 2015; Vázquez et al., 2012).

In contrast, the second most significant cluster, represented by the yellow colour, encompasses keywords such as Learning Analytics, Big Data, RLS and Educational Data Mining. This cluster demonstrates a growing interest in the application of data analytics and data mining in the field of education. The utilisation of big data analytics for the enhancement of student support in higher education has been investigated (Fan et al., 2016), and an adaptive noise suppression system has been developed employing a fuzzy neuro-inference approach (Martinek et al., 2019). Furthermore, the current trends, challenges, and opportunities of explanatory Artificial Intelligence in education have been investigated, with particular emphasis on the importance of understanding and explaining AI models used in Learning Management Systems (Rachha and Seyam, 2023).

### 4.5. Analysis of the frequency and conceptual validity around the use of Artificial Intelligence in Learning Management Systems

The Cartesian plane analysis demonstrates that in quadrant 4, there has been a decline in the utilisation or prevalence of certain concepts in recent years, when compared to previous periods. Among the keywords highlighted in this quadrant is the term “e-learning”. In the past, e-learning was primarily concerned with the dissemination of educational content via online platforms, with a particular emphasis on accessibility and flexibility for students. Instructional design approaches for e-learning were based on the integration of digital resources and pedagogical strategies to facilitate effective learning experiences in both face-to-face and online environments (Cheung et al., 2010).

However, the decline in the use of the term ‘e-learning’ in recent years may indicate an evolution in the field towards more specific and advanced concepts, such as adaptive learning, Artificial Intelligence applied to education, and learning analytics. These novel developments are prompting the incorporation of nascent technologies and pioneering pedagogical methodologies into Learning Management Systems, with the objective of enhancing learning personalisation and pedagogical efficacy.

The second quadrant of the Cartesian plane, which includes the concepts of “learning style” and “virtual reality,” underscores the growing significance of these concepts in AI-powered Learning Management Systems. Recent studies indicate that learning styles in distance education and VR and AI-based systems represent a significant emerging trend in the field of education. These approaches offer the potential for highly personalised and immersive learning experiences that could markedly enhance the learning process (Hirankerd and Kittisunthonphisarn, 2020; Schurz et al., 2021).

In alignment with these advancements, the influence of deep learning technologies, as a constituent of the nascent field of Artificial Intelligence, on the prospective trajectory of e-learning is being scrutinized. The results of recent studies suggest that deep learning techniques have the potential to personalise the learning experience and enhance the efficacy of Learning Management Systems. The integration of concepts such as learning styles and virtual reality is of paramount importance for the evolution of digital educational systems, and requires continued research and the application of innovative technologies (Alasiry and Muniasamy, 2020).

The analysis of quadrant 1 of the Cartesian plane demonstrates the increasing and established significance of LMS in the domain of research. These systems, which are designed for the management and administration of learning in digital environments, play a fundamental role in contemporary education. LMS provide educational institutions, companies and organisations with the capacity to effectively manage educational content, interactions between students and teachers, and monitor learning progress. The adoption of these systems has increased significantly in recent years, largely due to their ability to facilitate online teaching, corporate training and distance education (Nespereira et al., 2016).

At the present time, LMS are regarded as indispensable components in the digital transformation of education. The deployment of these systems is vital for the effective implementation of hybrid teaching models and the efficient delivery of educational content in virtual environments. It is anticipated that in the near future, LMSs will continue to evolve in order to integrate emerging technologies such as machine learning, which enables more personalised and adaptive learning experiences. The potential of machine learning-based approaches to enhance the efficacy of LMSs and forecast student performance in blended learning environments has been underscored by research (Nespereira et al., 2016).

### 4.6. Classification of keywords on the use of Artificial Intelligence in Learning Management Systems according to their function

**Table 1** was created to classify the principal emerging and growing keywords on the use of Artificial Intelligence in Learning Management Systems, according to their function. This table allows the specific characteristics and applications of each function to be identified, thereby providing a structured and organised vision of trends in research on this topic.

**Table 1.** Classification of keywords according to their function.

| Keyword | Associated tools | Applications | Characteristics |
|---|---|---|---|
| **Learning style** | Adaptive learning systems, educational software | Personalization of learning | Adaptation to learning styles |
| **Virtual reality** | VR headsets, immersive simulations | Educational simulations, virtual environments | Immersive experiences, 3D interaction |
| **Higher education** | Online platforms, e-learning resources | University level education, Online courses | Access to higher education, flexibility |
| **Machine learning** | Neural networks, deep learning algorithms | Pattern recognition, Predictions | Machine learning, predictive analytics |
| **Learning Management Systems** | Moodle, blackboard, Canvas | Content management, evaluation | Efficient management, automated evaluation |

Own elaboration based on Scopus and Web of Science.

## 4.7. Theoretical implications

This bibliometric analysis offers important theoretical implications for the field of education and technology. By analyzing the frequency of publications per year, it is possible to gain an overview of the evolution of research interest in this area. This allows the identification of temporal trends and possible turning points in the development of AI in LMS. Furthermore, examining the main theoretical references offers an overview of the currents of thought and conceptual frameworks that underpin research in this field. This contributes to the understanding of the theoretical foundations underlying the integration of AI. The evolution of research topics in the field of AI in educational environments can be observed through the thematic analysis of bibliometrics. This analysis reveals the changing dynamics of research topics in relation to AI and LMS, reflecting the progress and diversification of knowledge in this area. The co-occurrence of keywords provides information on the conceptual relationships between the most relevant terms, identifying areas of convergence and divergence in the research. Similarly, the analysis of emerging and growing keywords highlights the concepts and topics that are gaining relevance and attention in the academic literature, which may point to future directions for educational research and policy development.

However, one of the most significant aspects of this bibliometrics is the identification of research gaps in the field of AI in LMS. These gaps represent underexplored or insufficiently understood areas of knowledge, which require special attention from the research community. By identifying these gaps, scholars and practitioners can focus their efforts on addressing existing gaps in the literature, thereby promoting more significant and balanced advancement in the field of study.

In conclusion, these theoretical implications demonstrate the significance of bibliometrics as a valuable tool for comprehending and contextualizing research in AI and LMS, as well as for directing the future development of the discipline towards more relevant and impactful avenues.

The research findings indicate that, while virtual assistants have the potential to enhance personalized assistance and content customization, their efficacy is contingent upon the context and implementation (Gubareva and Lopes, 2020). The utilization of big data analytics can facilitate the acquisition of valuable insights into the efficacy of these technologies. However, the quality of interaction and users' perception of their utility still present considerable challenges (Fan et al., 2016). The perception of these assistants by the students and the degree of technological integration are crucial factors affecting their effectiveness. Some users may encounter difficulties in using them due to unintuitive interfaces or technological issues (Lohani and Kavitha, 2019).

Similarly, the acceptance of virtual assistants is contingent upon factors such as the availability of technological infrastructure and the extent of teacher training (Gillet et al., 2022). The effective implementation of technologies such as virtual assistants necessitates their proper integration into the classroom setting, accompanied by the provision of robust technical support (Gómez et al., 2021). If these aspects are not adequately addressed, there is a risk that the gap between theory and practice will be significant, which would limit the potential positive impact of virtual assistants on learning. It is therefore imperative that further research be conducted to elucidate the manner in which these factors interact and affect the acceptance and efficacy of virtual assistants. This research should be conducted with a view to developing strategies that optimize their implementation and maximize their impact on education.

## 4.8. Practical implications

By identifying the transition from the focus on regression analysis towards more complex topics such as Learning Management Systems, e-learning, vims, and WCAG, it becomes evident that there is a need to update and adapt teaching methods to align with emerging trends and concepts. As e-learning declines and the emergence of terms such as learning style, virtual reality, higher education, and machine learning indicates an evolution in the preferences and needs of students. This drives educational institutions to integrate virtual reality technologies, adjust styles of teaching, and develop specific strategies for higher education. The integration of these technologies, adjustments to teaching styles, and the development of strategies for higher education improve the quality and relevance of learning.

Moreover, the continued proliferation of terms related to LMS underscores the significance of these platforms in the contemporary educational landscape. The findings indicate that educators and learning systems designers should prioritize the enhancement and expansion of these technologies, with a particular focus on personalization, accessibility, and adaptability to accommodate the diverse needs of students. This analysis also highlights the necessity for further research to fully comprehend the pedagogical and practical implications of AI in education, which may influence the design of future educational environments to be more effective and student-centered.

In addition to the practical implications already mentioned, this study has significant implications for the development of educational policies. By understanding the current and future trends in the use of Artificial Intelligence technologies in education, policy makers can make informed decisions regarding the allocation of resources. The development of curricula and the implementation of initiatives to integrate technology effectively in educational systems can lead to the creation of policies that encourage innovation and the adoption of technology in the educational field. This, in turn, can promote the continuous improvement of quality and equity in education.

Another crucial aspect of the practical implications pertains to the professional development of educators. By identifying the emerging areas of research and the most pertinent technologies in the field of Artificial Intelligence applied to education, educators can access resources and opportunities for professional development that will enable them to Educators must also acquire the requisite skills and knowledge to effectively integrate these technologies into their teaching practice. This could include training and professional development programs focused on the use of Artificial Intelligence tools, as well as collaboration with educational technology experts to design and implement innovative and effective teaching strategies.

Moreover, in the field of research and innovation, this topic can serve as a catalyst for new lines of research and interdisciplinary collaborations. By identifying areas of research gaps and emerging trends in the use of Artificial Intelligence in education, researchers can identify opportunities to develop new methodologies, tools, and approaches that address current and future challenges in this field. This can foster collaboration between researchers from different disciplines, such as computer science, educational psychology, and pedagogy, to address complex problems from a variety of perspectives and generate significant advances in the field of educational technology. Approaches that address current and future challenges in this field can foster collaboration between researchers from different disciplines, such as computer science, educational psychology, and pedagogy. This approach allows researchers to address complex problems from a variety of perspectives, thereby generating significant advances in the field of educational technology.

In the business context, the practical implications can influence talent recruitment and development strategies. Companies that understand emerging trends and technologies in education can adapt their employee training and development programs to include Artificial Intelligence and learning components. Automated, this can improve employee training and performance, as well as increase the company’s competitiveness in a constantly evolving labor market.

Despite the potential of AI tools to transform education, the acceptance and effectiveness of these technologies are hindered by a number of challenges and barriers. One of the principal impediments to the adoption of these technologies is the user experience, which can be adversely affected by the lack of intuitiveness of the interfaces and the complexity of the technology. The absence of personalization in learning analytics dashboards may restrict the perceived usefulness of these tools by students and teachers, thereby hindering their adoption (Aljohani et al., 2019). Moreover, ethical considerations, including data privacy and algorithmic bias, are of paramount importance in determining the acceptance of AI tools (Cavus et al., 2021).

It is imperative that clear strategies are implemented to address these concerns in order to increase user trust and ensure that the technology is used equitably and safely. To enhance the uptake and efficacy of AI tools in education, it is vital to devise comprehensive strategies that encompass teacher training and the ongoing optimization of the user experience. Appropriate training in the utilization of emerging technologies can enhance the proficiency of educators, thereby facilitating a more efficacious integration within the classroom (Bhatnagar et al., 2016).

Similarly, it is vital to furnish users with the requisite technical assistance and educational resources to enable them to fully harness the capabilities of these tools. The fostering of a culture of feedback and continuous improvement can facilitate the adaptation of AI tools to the evolving needs of students and educators, thereby enhancing their acceptance and effectiveness. The implementation of these strategies can play a significant role in overcoming current barriers and promoting the wider adoption of AI in educational environments.

## 4.9. Limitations

The limitations of the present bibliometrics include the possibility of biases in the selection of databases and search terms utilized, which could have resulted in the omission of certain relevant studies. Additionally, the analysis was focused on indexed documents, excluding non-indexed works or publications in languages other than English and Spanish, which could have limited the geographical and linguistic diversity of the data. Furthermore, although bibliometric analysis tools are useful, they may not fully capture the complexity of the interactions between the topics studied, which could have influenced the interpretation of the results and identification of emerging trends. This underscores the need for caution in generalizing the findings and points to potential areas for future research that can more comprehensively address these limitations.

## 4.10. Investigative gaps

**Table 2** presents the main research gaps in the use of Artificial Intelligence in Learning Management Systems. These gaps indicate specific areas where further research is required to close gaps in knowledge and advance the field.

By identifying these gaps, researchers can direct their efforts toward topics and problems that have not yet been comprehensively addressed, which will contribute to the expansion and consolidation of knowledge in this area. Research gaps may include aspects such as the effectiveness of certain AI techniques in specific educational settings, the acceptance and adoption of AI-based Learning Management Systems by teachers and students, as well as related ethical and privacy considerations. With the use of data in these systems.

**Table 2.** Research gaps.

| Category | Investigative Gaps | Justification | Questions for future researchers |
|---|---|---|---|
| **Thematic Gaps** | 1. Evaluation of the effectiveness of artificial intelligence algorithms in personalizing learning. | Despite growing interest in the application of artificial intelligence in learning personalization, there is a lack of comprehensive research on the | How do different AI algorithms compare in terms of their effectiveness in personalizing learning in educational environments? What are the key factors |

| | | | |
|---|---|---|---|
| | | effectiveness of these algorithms in learning management environments. | that influence the effectiveness of these algorithms? |
| | 2. Impact of artificial intelligence on user experience and student satisfaction in learning management systems. | Although it has been shown that artificial intelligence can improve the efficiency and personalization of learning, a greater understanding of the impact of these technologies on user experience and student satisfaction is required. | How do students perceive the integration of artificial intelligence in learning management systems? What aspects of the user experience are positively or negatively affected by the implementation of artificial intelligence? |
| **Geographic Gaps** | 1. Evaluation of the use of artificial intelligence in learning management systems in non-Western educational contexts. | Most research on the use of artificial intelligence in learning management systems has focused on Western contexts, leaving gaps in our understanding of its application in other regions of the world. | What are the differences in the implementation and effectiveness of AI-based learning management systems in non-Western educational contexts? How can these systems be adapted to different cultures and linguistic contexts? |
| **Interdisciplinary Gaps** | 1. Integration of artificial intelligence with pedagogical approaches and traditional educational theories. | As artificial intelligence becomes more incorporated into learning management systems, there is a need to effectively integrate it with existing pedagogical approaches and established educational theories. | How can educators integrate artificial intelligence with traditional pedagogical approaches to improve teaching and learning? What are the challenges and opportunities of this integration in different educational contexts? |
| | 2. Exploration of the ethical and legal implications of the use of artificial intelligence in education. | The use of artificial intelligence raises ethical and legal challenges, such as data privacy, equity, and algorithmic discrimination, that require interdisciplinary attention to address effectively. | What are the most pressing ethical and legal implications of using artificial intelligence in learning management systems? How can policies and regulations ensure ethical and equitable use of these technologies in education? |
| **Temporal Gaps** | 1. Emerging trends in the use of artificial intelligence in learning management systems. | As technology and educational practices evolve, it is important to monitor emerging trends in the use of artificial intelligence in learning management systems to identify future research areas. | What are the emerging technologies in artificial intelligence that are being adopted in learning management systems? How are these trends changing the way we teach and learn in educational settings? |
| | 2. Impact of global events and socioeconomic changes on the implementation and effectiveness of learning management systems based on artificial intelligence. | Events such as the COVID-19 pandemic have accelerated the adoption of educational technologies, including artificial intelligence. However, a deeper understanding of how these events can influence the use and effectiveness of these technologies is required. | How have recent global events affected the implementation and effectiveness of AI-based learning management systems? What are the factors that influence the adaptation of these technologies to socioeconomic and cultural changes? |

Own elaboration based on Scopus and Web of Science.

## 4.11. Research agenda

Following an analysis of the relevant literature and the identification of 30 key concepts, as illustrated in **Figure 9**, a strategic research agenda for the field of AI in LMS has been developed. The concepts, derived from a comprehensive bibliometric analysis, reflect the current trends, challenges and emerging opportunities at the intersection of AI and LMS. The proposed research agenda is based on these concepts to provide guidance for future studies and developments in the area, with a particular focus on critical aspects such as adaptive personalization, the effectiveness of AI algorithms, and the ethical integration of emerging technologies. This is intended to address existing deficiencies in the existing literature and to encourage a more profound comprehension and sustained innovation in the deployment of AI in educational contexts.

Artificial Neural Networks (ANNs) have been instrumental in the development of Learning Management Systems based on Artificial Intelligence. Their capacity to learn complex patterns from raw data has enabled the creation of predictive and adaptive models that can enhance the personalization of educational content. For future research, it would be beneficial to delve into the design of more advanced neural network architectures that can integrate different types of educational data, such as text, images, and videos, in order to further improve the ability of Learning Management Systems to adapt to the individual needs of students.

E-learning has revolutionized the way knowledge is accessed and distributed, and Artificial Intelligence has played a crucial role in its evolution. Future research could investigate the potential of Artificial Intelligence to enhance the student experience in online learning environments. This could involve the creation of more interactive, adaptive, and personalized systems. Additionally, innovative approaches could be explored to evaluate the effectiveness of e-learning driven by Artificial Intelligence. This could include real-time student progress monitoring and automatic generation of personalized feedback.

Moodle, a widely used learning management platform, offers a virtual environment for teaching and learning. Artificial Intelligence can further enhance this platform by incorporating advanced features such as personalized recommendation of educational resources, automatic detection of learning problems, and the adaptation of course content according to the student's learning style. Future research could focus on optimizing the Artificial Intelligence algorithms within Moodle to improve the efficiency and effectiveness of the teaching-learning process.

Active learning is a pedagogical approach that places students at the center of the learning process. It has been demonstrated to significantly enhance knowledge retention and understanding. AI can play a pivotal role in identifying active learning strategies that are more effective and in adapting course content to encourage student participation and commitment. Future research could investigate how Learning Management Systems can more effectively integrate AI-powered active learning techniques, such as gamification and adaptive tutoring, to enhance the quality and effectiveness of online learning.

The concept of "learning style" has gained relevance in the field of Artificial Intelligence applied to Learning Management Systems. It is essential to recognize and adapt to the individual learning styles of students in order to improve the effectiveness of the educational process. In future research, the development of Artificial Intelligence algorithms capable of automatically identifying students' learning styles from contextual and behavioral data can be explored. Additionally, innovative approaches can be explored to personalize educational content and teaching strategies according to the detected learning styles, which could significantly improve the students' learning experience.

The relevance of distance learning has increased significantly in the context of globalization and technology, particularly in the current era. AI can play a pivotal role in enhancing this modality, facilitating interaction and collaboration between distance students and teachers. Future research may investigate the potential of AI to optimize the learning experience in distance learning environments. This could involve the implementation of intelligent virtual tutoring systems, which can automatically detect

learning problems and dynamically adapt course content according to the individual needs of students.

Virtual Reality (VR) is emerging as a promising technology in the educational field, offering immersive and involving experiences that can significantly improve the teaching-learning process. Future research can explore how AI can further enhance the use of VR in Learning Management Systems. This could involve developing adaptive and personalized virtual environments that fit the individual preferences and needs of students. Similarly, AI techniques can be investigated to evaluate the effectiveness of VR in improving learning outcomes and knowledge retention.

Higher education is a key area where Artificial Intelligence is playing an increasingly important role in optimizing teaching and learning processes. The application of AI algorithms in higher education can improve the personalization of learning by adapting educational resources and strategies to the individual needs of students. Future research can further explore the development of AI-based intelligent tutoring systems that provide personalized feedback and academic guidance to university students. Additionally, innovative approaches for automated assessment and monitoring of student progress can be explored, which could contribute to improving the quality and effectiveness of higher education.

"Blended Learning" combines face-to-face and online teaching methods. Its importance lies in its ability to take advantage of the best of both worlds. Artificial Intelligence can play a fundamental role in optimizing this educational modality, through personalizing course content, adapting teaching strategies, and improving interaction between students and teachers, both in the classroom and in virtual environments. Future research can investigate how Artificial Intelligence can further enhance blended learning, by implementing intelligent recommendation systems for online educational resources, automatically detecting learning difficulties, and improving personalized feedback for students. These studies could contribute to the consolidation of "blended learning" as a cutting-edge educational strategy in the field of learning management.

The term "RLS" refers to "reinforcement learning systems", a machine learning technique based on the interaction of the agent with its environment to learn to make optimal decisions. In the context of Learning Management Systems, RLS can be applied to dynamically adapt educational content and learning activities according to the progress and individual needs of students. Future research could investigate the potential of RLS to enhance student engagement and academic performance, as well as to improve the effectiveness of educational content recommendation systems.

The "LMS Algorithm" (Learning Management Algorithm) refers to the algorithms utilized in LMS to organize, manage, and deliver educational content to students. These algorithms are fundamental to optimizing the learning experience on LMS platforms, as they determine how content is presented and adapted according to the individual characteristics of the students. Future research may further develop and improve LMS algorithms to incorporate more advanced Artificial Intelligence techniques, such as machine learning and data mining, in order to provide more effective personalization of content and applications. Additionally, learning activities may be explored in order to determine how these algorithms can be integrated with

other emerging technologies, such as virtual and augmented reality, in order to create more immersive and effective learning environments.

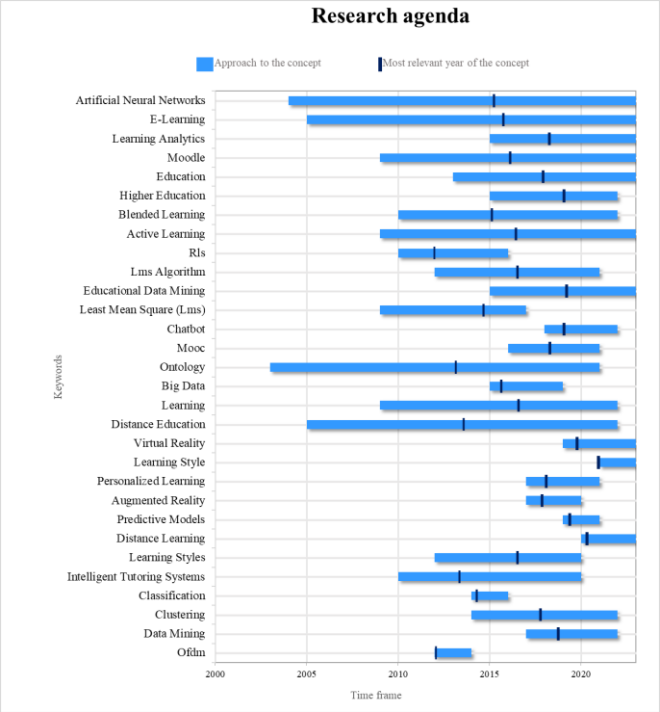


**Figure 9.** Research agenda.

Own elaboration based on Scopus and web of science.

## 5. Conclusion

The conclusions derived from this bibliometric analysis offer insights that are valuable to the academic community and professionals in the field. Firstly, the growing interest in this area during the years 2021 and 2015 is evident, indicating a particular focus on these periods. Likewise, the analysis of the growth of scientific literature demonstrates a quadratic polynomial trend, suggesting a significant and sustained development over time.

In addition, the most prominent authors, journals, and countries in this field are identified, including Li J, Cheng L, Lecture Notes In Computer Science, and China and India, respectively. This highlights the significance of their contributions to the scientific literature. The thematic evolution, from a focus on regression analysis towards more complex aspects such as Learning Management Systems, e-learning, vlms, and WCAG, reflects the conceptual transformation in the field. This indicates a shift towards more contemporary and relevant topics, as evidenced by the emergence of keywords such as learning style, virtual reality, higher education, and machine learning. These highlight the need to explore more specific and innovative areas within the field of Artificial Intelligence in education.

The existence of prominent thematic clusters is highlighted, including those composed of keywords such as e-learning, ontology, ant colony optimization, and data mining, which reflect key areas of interest in current research. Furthermore, an emerging focus is observed on topics such as learning style, distance learning, and virtual reality, indicating the evolution of research towards more specialized areas of

study and relevant to educational practice. The classification of keywords according to their function highlights the importance of delving into these key concepts for future studies. It also sets clear guidelines for the development of research in a context that is in constant expansion and change. These conclusions not only consolidate the current state of the field, but also serve as a platform for strategic planning of future research in the field of Artificial Intelligence and education.

Ultimately, the development of a future research agenda is emerging as a key need to address the identified thematic, geographical, interdisciplinary, and temporal gaps, with the aim of expanding and enriching knowledge in this constantly evolving field.

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