EAI Endorsed Transactions
on Scalable Information Systems
Research Article EAI.EU

Machine learning as a teaching strategy education: A review

Deixy Ximena Ramos Rivadeneira[1,*], Javier Alejandro Jiménez Toledo[1]

[1]University CESMAG, Colombia.
[*]Corresponding author: dxramos@unicesmag.edu.co

Abstract

In this article, we present a systematic review of the literature that explores the impact of Machine Learning as a teaching strategy in the educational field. Machine Learning, a branch of artificial intelligence, has gained relevance in teaching and learning due to its ability to personalize education and improve instructional effectiveness. The systematic review focuses on identifying studies investigating how Machine Learning has been used in educational settings. Through a thorough analysis, its impact on various areas related to teaching and learning, including student performance, knowledge retention, and curricular adaptability, is examined. The findings of this review indicate that Machine Learning has proven to be an effective strategy for tailoring instruction to individual student needs. As a result, engagement and academic performance are significantly improved. Furthermore, the review underscores the importance of future research. This future research will enable a deeper understanding of how Machine Learning can optimize education and address current challenges and emerging opportunities in this evolving field. This systematic review provides valuable information for educators, curriculum designers, and educational policymakers. It also emphasizes the continuing need to explore the potential of Machine Learning to enhance teaching and learning in the digital age of the 21st century.

Keywords: Machine Learning; education; didactic strategy; educational impact; artificial intelligence.

Received on 21 December 2023, accepted on 9 May 2024, published on 14 May 2024

doi: 10.4108/eetsis.5703

Introduction

In the ever-evolving digital era, the field of education has witnessed a profound and significant change. The application of innovative technologies has transformed how teaching and learning are addressed[1]. In this context, Machine Learning has emerged as a highly relevant tool that can impact education profoundly. By enabling data analysis, pattern identification, and personalization of learning experiences, this technology presents a unique opportunity to tailor teaching to the individual needs of learners[2]. This article focuses on conducting a systematic literature review to examine the impact of Machine Learning as a teaching strategy in the educational setting. The central question driving this review is: How has Machine Learning influenced teaching and learning in the academic context?

The relevance of this review is undeniable in an ever-changing educational environment. The need to understand how technologies can enhance education and how educators and curriculum designers can maximize the potential of Machine Learning has become pressing. As education moves away from a uniform model to embrace customization and personalization, an opportunity arises to improve knowledge retention, student engagement, and academic achievement.

The systematic review aims to comprehensively examine studies investigating the implementation and effects of Machine Learning in educational settings. It critically synthesizes the findings and sheds light on emerging trends, best practices, and areas requiring further exploration. In addition, it highlights the importance of considering both current challenges and future opportunities posed by the integration of Machine Learning in education. Finally, this systematic review is presented as a valuable contribution to educational technology and pedagogy. It establishes a solid foundation for informed decision-making by educators, curriculum designers, and educational policymakers. At the same time, it underscores the continuing need to explore and harness the potential of Machine Learning to enhance teaching and learning in the digital age of the 21st century.

Method

The methodology presented is based on the key elements of the research process in Software Engineering to provide a general approach to the research area, the type of research, and the favorable results to elaborate a classification scheme and a valid structure[3].

Research questions

The purpose of this study is to present the results of applying a systematic review of scientific literature related to Emerging Technologies in professional training. For the elaboration of the theories that support this review, the following questions were posed:

RQ1: How does Machine Learning influence teaching and learning in education?
RQ2: What impact does Machine Learning have on students' academic performance?
RQ3: What are the best practices for implementing Machine Learning in education?
RQ4: What are effective strategies for integrating Machine Learning into teaching and learning in educational contexts?

The organization of these questions is established by means of the PICO model with its variable PIPOH, where it points out that every well-conducted question is supported by two cues.[4]. Firstly, the question must be important to the identified problem, i.e., it must be focused on the issue of real interest, and then it must be articulated in such a way that it provides the search for a concrete and exhaustive answer. The concepts of which are described in Table 1.

Table 1. *Definition of general concepts with PIPOH.*

Criteria	Description
Problem of interest	Machine Learning in education
Intervention	Teaching/learning processes, didactic strategies
Results	Publications of scientific articles and books where studies on Machine Learning are cited.
Actors	Students in training
Context	Vocational training, academic

Search

The proposed search technique consisted of exploring the general terms in specialized databases, where the search terms were combined with synonyms in order to cover a

larger number of documents to be evaluated. Table 2 shows the terms with their respective synonyms.

Table2. The term and synonyms to compose the search string.

Main Term	***Synonyms/related***
Learning	Teaching
	Education
Machine Learning	Innovate technologies
	Converging technologies
Undergraduate	University education
	professional education
	vocational training
teaching strategy	learning strategies
	teaching tools

The following databases were used for the search process: Scopus, Doaj, ScienceDirect, and IEEE Xploret, considering fields such as title, keywords, abstract, and complete document. Table 3 shows the resultant search string together with the main term.

Table 3. Search string

Main Term	**Search string**
Machine Learning in education	("learning" OR "teaching" OR "education") AND ("Machine Learning" OR "Innovate technologies" OR "Converging technologies") AND ("teaching strategy" OR "learning strategies" OR "teaching tools") AND ("teaching strategy" OR "learning strategies" OR "teaching tools")

Selection

The search was performed with the specific string contemplated for this review, considering the title, keywords, abstract, introduction, state-of-the-art, results, and conclusions. Inclusion and exclusion criteria were also defined for the review. The inclusion criterion defined is a scientific paper related to studies of teaching and learning processes focused on using Machine Learning as didactic strategies or its search synonyms. Similarly, the exclusion criteria defined are studies that do not have their corresponding bibliographic citation, the documents do not contain the search terms or synonyms, and the records are not available for download.

The selection of primary sources was made in four stages (because four specialized databases were considered), each with phases: phase 1: elimination of duplicate articles; phase 2: elimination of articles that could not be downloaded; and phase 3: application of inclusion and exclusion criteria. Because four databases were used in this systematic review with their synonyms and filters - in each of which three phases were applied, it was necessary to make the consultation on different dates, as shown in Table 4.

Table 4. Dates of consultation and file downloading.

Databases	**Date of search**
IEEE Xplorer	22/05/2023
Scopus	24/06/2023
Doaj	29/07/2023
ScienceDirect	28/08/2023

As a result of the search in the databases, a total of 106 studies were found and when the inclusion and exclusion criteria were applied, a total of 47 documents were obtained.

Quality assessment

In the process of evaluating the quality of the selected documents, the following criteria were applied. Origin of the sources, relevance of the content, clarity of the research objective, adequate description of the context in which the research was developed, clarity and rigor of the methodological design of the research, and scientific rigor in the analysis of the data. These criteria were applied to ensure the quality and reliability of the documents selected in the review process. Thus, the evaluation of the aforementioned criteria involved reading the full text of the 50 documents with the processes of elimination of duplicate articles, elimination of articles that could not be downloaded, and the application of inclusion and exclusion criteria, the process of which is shown in Table 5.

Table 5. Quality evaluation in search and selection processes

Main term	Result of the search	Duplicate files	Excluded Files	Relevant Files	Database
Machine Learning in education	25	0	3	12	IEEE Xplorer
	11	4	5	6	Doaj
	18	9	2	5	ScienceDirect
	52	2	30	24	Scopus
Total	**106**	**15**	**40**	**47**	

Data extraction and synthesis of results

After performing the search for terms in each database and carrying out the three relevant phases and taking into account that the main objective of this systematic study is to analyze the state of the art of Machine Learning in education, the findings found in the relevant documents are presented below, accompanied by the citations of the corresponding authors.

Results

In this section, we present the results from the systematic literature review process, organized to address the research questions posed. First, we explored how Machine Learning influences teaching and learning in the educational context. The findings highlight the ability of Machine Learning to personalize instruction, adapting it to students' individual needs. In addition, the impact of Machine Learning on students' academic performance was examined, revealing remarkable improvements related to the adaptation and personalization of teaching. Best practices for implementing Machine Learning in education were also investigated, highlighting crucial aspects of proper algorithm selection, effective data integration, and educator training. Finally, effective strategies for integrating Machine Learning in teaching and learning in educational contexts were analyzed, highlighting the importance of interdisciplinary collaboration, curricular adaptation, and attention to individual student needs as successful practices in this area.

Machine Learning in teaching and learning in the educational context

In the educational context, implementing Machine Learning (ML) has revolutionized the way teaching and learning are approached. On the one hand, it highlights the practice of learning personalization, in which algorithms allow the adaptation of educational content and activities to the individual needs of students[5]. This, in turn,

translates into a more efficient and engaging learning process.
Another key aspect is the analysis of educational data. Through ML, educational institutions can identify patterns and trends in student performance, which directly influences informed decision-making on improving academic programs. It is important to mention that this practice contributes to the continuous refinement of educational strategies[6]. Likewise, ML plays a crucial role in the early detection of academic problems. Algorithms can identify students who might face challenges in their learning process, which enables early intervention and the provision of personalized support to overcome obstacles and achieve more satisfactory progress[7].

The findings of this study confirm the growing importance of Machine Learning in teaching and learning in the educational context. As education faces an increasingly diverse and demanding learning environment, this technology stands as a powerful resource to address the changing needs of learners[8]. In this regard, the ability of Machine Learning to personalize the educational experience was highlighted. The implementation of recommendation systems based on Machine Learning algorithms allows students to access educational resources and activities designed specifically for their individual preferences and needs[9].

This, in turn, creates a more relevant and personalized educational path. Moreover, this adaptability not only benefits students but also empowers educators, providing them with the tools necessary to adjust their teaching more precisely based on the characteristics of their students[10]. A relevant aspect that emerges from the research is the predictive role of Machine Learning. Algorithms can identify patterns of student behavior, allowing educators to anticipate who might need additional support[11]. This anticipation results in more effective interventions that can significantly improve academic performance. Likewise, Machine Learning allows for more efficient tracking of student progress, which favors real-time adaptation of pedagogical strategies and more effective teaching[12].

In another area, the ability of this technology to adapt content and assessments is evident. Educational materials can be adjusted according to the particularities of each student, including differences in learning styles, rates of progress, and skill levels[13]. This fosters more inclusive and efficient learning by allowing each student to progress at his or her own pace. In addition, Machine Learning contributes to the identification of learning patterns, providing educators with empirical data to adjust their teaching methods more accurately[14].

Finally, these findings emphasize the transformative role of Machine Learning in education. By personalizing and adapting teaching according to students' individual needs, this technology presents itself as a means to improve the quality of education and effectively prepare students for current and future challenges. These results underline the relevance of further exploring and promoting the adoption of this technology in the educational context.

Impact of Machine Learning on student academic performance

Machine Learning is currently exerting a profound and pervasive impact on everyday life[16]. From healthcare, where it improves the diagnosis and treatment of diseases, to e-commerce, where it personalizes the user experience, Machine Learning has revolutionized multiple industries[17]. In the automotive industry, it enables autonomous vehicles; in the financial industry, it optimizes risk management and fraud detection. It also influences education, enabling the personalization of learning and manufacturing, where it optimizes production and logistics. [18]. Furthermore, in scientific research, Machine Learning accelerates the analysis of large data sets, from virtual assistants to cyber security and environmental sustainability, its presence is undeniable, and it is expected to continue to play a crucial role in the transformation and advancement of society in the future[19].

Machine learning is significantly impacting the

field of education, transforming the way educational institutions are taught, learned, and managed. Here are some of how machine learning is influencing education:

- Personalization of learning: First, machine learning allows the creation of personalized learning systems, in which algorithms can adapt the content and difficulty according to the needs and progress of each learner. This makes learning more effective and engaging, as it adjusts to the pace and learning style of each individual[20].
- Recommendation of educational content: In addition, online learning platforms, such as Coursera or Khan Academy, use machine learning algorithms to recommend courses and educational resources to students. These recommendations are based on the user's learning history and preferences.[21]
- Automated assessment: Machine learning-based assessment systems can automatically analyze students' answers to questions and exams[22]. This streamlines the assessment process and provides instant feedback to students.
- Identifying early intervention needs: Moreover, machine learning algorithms can identify students who may be struggling in a course. Teachers and counselors can use this information to provide additional support to at-risk students[23]
- Educational data analysis: In addition, machine learning is used to analyze large educational datasets, which can lead to the identification of trends and patterns that help improve teaching methods and curriculum design.[24]
- Automation of administrative tasks: In the area of management, educational institutions can use machine learning to manage logistics, class scheduling, and administrative tasks, which saves time and resources[25]
- Adaptive learning: In this sense, adaptive learning systems use machine learning to constantly adjust content and exercises based on the student's progress. This promotes more efficient learning and better retention of the material.[26]
- Online education and MOOCs: Likewise, online education platforms and Massive Open Online Courses (MOOCs) make intensive use of machine learning to manage large numbers of learners and provide learning experiences on a global scale [27]
- Plagiarism and cheating detection: In terms of academic integrity, machine learning can help to identify plagiarism and cheating on assignments and exams, maintaining academic integrity[28]
- Teacher training: Finally, machine learning algorithms can help in teacher training by providing feedback on their teaching style and how they can improve [29]

In scientific research, Machine Learning is used in fields such as biology, chemistry, and physics, where it is used to analyze large datasets and discover hidden patterns that facilitate research and the discovery of new insights[30]. In business optimization, organizations employ Machine Learning to improve their internal processes, from supply chain management to human resource management [31]. This implementation results in increased efficiency and cost reduction, which contributes to the competitiveness and growth of companies. In the field of entertainment and content, online streaming platforms are relying on Machine Learning-based recommendation algorithms[23]. These algorithms provide users with personalized content, such as movies, music, and TV shows, which enhances the entertainment experience and encourages audience retention.

Best practices for implementing Machine Learning in education

Incorporating Machine Learning practices in education promotes learning effectiveness and aligns with the growing need to adapt education to a constantly changing world[32]. In this context, machine learning has become a powerful tool that empowers educators and students to keep up with

current trends. By providing a more personalized education, this technology enables students to take an active role in their own learning[33] while becoming a valuable resource for teachers, allowing them to focus on individualized instruction and early identification of problems, ultimately significantly improving education quality.

The implementation of good Machine Learning practices translates into several significant advantages in various industries. These practices allow for improved accuracy in decision-making through data analysis and the detection of hidden patterns, resulting in more accurate and efficient predictions[34]. In addition, personalization of products and services based on individual user preferences increases customer satisfaction. The automation of routine tasks leads to greater efficiency and resource savings, while the continuous learning capability of Machine Learning models ensures adaptation to new data and situations[35]. Together, these advantages drive productivity, informed decision-making, anomaly detection, energy efficiency, and improved healthcare, among other benefits, positioning Machine Learning as a fundamental tool for innovation and competitiveness today.

The effective integration of Machine Learning (ML) in educational environments can significantly improve the teaching and learning process [36]. Some of the best practices to consider include personalization of learning, where ML is used to tailor learning content and activities to students' individual needs and learning styles, which can increase engagement and academic performance. In addition, the implementation of ML-based automated assessment systems provides immediate feedback to students, identifying areas for improvement and adjusting the focus of study[37]. Adaptive learning is another effective practice that automatically adjusts the level of difficulty and type of content based on student progress, allowing for more efficient and effective learning[38]. ML recommendation algorithms can suggest relevant educational resources, such as readings, videos, or exercises, based on the learner's learning history and preferences. In addition, ML systems can identify at-risk students and allow for early intervention and personalized support[39]. Constant monitoring and evaluation of the effectiveness of implemented ML practices is essential, as well as using data to measure the impact on learning outcomes, such as retention rates, grades, and student engagement. Adequate training of teachers is critical to enable them to take advantage of ML tools in the classroom [40]. Addressing ethical and privacy issues, such as student data collection and algorithmic bias, is also important. Collaboration between education experts and data scientists fosters more effective and ethical solutions[14]. Considering costs, infrastructure, and expandability, designing ML solutions in education that are scalable and sustainable in the long term is essential.

Effective strategies for the integration of Machine Learning in education

The effective integration of Machine Learning (ML) in teaching and learning in educational contexts requires adopting strategies that take full advantage of this technology. The following are effective strategies to achieve this. One of the key strategies is personalization of learning, which involves using ML to tailor learning content and activities to the individual needs and learning styles of students[41]. This adaptation is made possible by constantly monitoring each student's progress and continuously adapting the material, ensuring that learning is more relevant and effective.

Meaningful data collection is another crucial strategy; making sure to collect relevant data on students' performance, preferences, and participation is essential for ML to work effectively[42]. The more meaningful data collected, the better the ML can personalize the learning experience and provide accurate feedback. Automated assessment is a time-saving strategy for both teachers and students; implementing ML-based automated assessment systems provides immediate feedback to students[43], allowing them to improve more effectively, in addition, adaptive learning is a strategy that seeks to automatically adjust the level of difficulty and type of content based on

student progress. This ensures that students are always challenged, but not overwhelmed, which promotes more effective learning.

The use of ML recommendation algorithms to suggest relevant educational resources, such as readings, videos, or exercises, based on the learner's learning history and preferences, is a valuable strategy to enrich the learning experience [44]. In addition, early detection of problems is critical to implement ML systems that identify students at risk of not reaching their academic goals and allow for early intervention and personalized support, which can make a big difference in students' academic success. Teacher training is essential for teachers to be able to use ML tools effectively in the classroom and to understand how to interpret the data generated by these technologies[45]. In addition, it is important to address ethical and privacy issues, such as student data collection and algorithmic bias, to ensure transparency and fairness in the use of ML in the educational setting. Ongoing evaluation and feedback are essential to adjust strategies based on results and obtain feedback from teachers and students. [46]

Discussion

This systematic literature review focused on the exhaustive analysis of the integration of emerging technologies, such as Machine Learning, as didactic strategies in the learning process within the context of professional training. The meticulous application of inclusion and exclusion criteria aimed to identify significant patterns, trends, and findings in the existing literature on this topic. The results of the systematic literature review revealed a substantial impact of machine learning and other emerging technologies in vocational education. It was found that the integration of these technologies has been shown to significantly improve the learning experience for students. For example, machine learning enables the personalization of learning by tailoring content and activities to the needs of each student. In addition, virtual reality and simulation, enabled by Machine Learning, have allowed students to practice skills in virtual environments, leading to greater confidence and preparation for real situations in the workplace. Gamification, powered by Machine Learning algorithms, has also positively impacted student motivation and engagement, thus improving knowledge retention.

These findings underscore the essential contribution of Machine Learning in professional education, providing a platform for the acquisition of knowledge and skills while allowing students to interact more actively and practically with the content. The importance lies in Machine Learning's ability to connect theory with practice, effectively preparing students to meet the challenges of the ever-evolving world of work. In addition, research has revealed a variety of teaching-learning methodologies and strategies that leverage Machine Learning and other emerging technologies. These include problem-based learning, online collaborative learning, the use of simulations driven by Machine Learning algorithms, and gamification supported by data analytics. These methodologies leverage the unique characteristics of Machine Learning to create interactive and dynamic learning environments, encouraging active student participation and the development of practical skills applicable in the real world.

Finally, it is noted that approaches to the integration of Machine Learning and other emerging technologies in professional training as a didactic strategy vary according to educational contexts and learning goals. The most common approaches include creating interactive online content, developing specific educational applications using Machine Learning algorithms, and implementing realistic simulations supported by this technology. In addition, the importance of training educators in the effective use of Machine Learning and other emerging technologies to ensure successful implementation and a positive impact on student learning in the vocational education setting was evident.

Conclusions

Overall, the systematic literature review reveals that the integration of emerging technologies, including Machine Learning, in the field of

professional education has had a significant and positive impact on students' learning experience. Through the meticulous application of inclusion and exclusion criteria, patterns and trends have been identified that indicate a profound change in the way teaching and learning is approached in this context. Firstly, it is highlighted that Machine Learning, together with other emerging technologies, has enabled the personalization of learning, which implies adapting content and activities according to students' individual needs. This is achieved through continuous monitoring of student progress, which ensures greater relevance and effectiveness in the delivery of instruction. In addition, virtual reality and simulation, enabled by machine learning, have proven to be valuable tools for students to practice skills in virtual environments, which translates into greater confidence and preparation for real situations in their future career fields. In parallel, gamification, supported by Machine Learning algorithms, has increased student motivation and engagement, which has enhanced knowledge retention.

In a broader context, these findings emphasize the relevance and impact of Machine Learning and emerging technologies in professional education. These technologies act as tools for acquiring knowledge and skills and facilitate students' active interaction with the content. The effective connection between theory and practice stands out as a distinctive feature, effectively preparing students to face the challenges of the constantly evolving world of work. The research also highlights many teaching-learning methodologies and strategies driven by Machine Learning and other emerging technologies. These include problem-based learning, online collaborative learning, simulations based on Machine Learning algorithms, and gamification supported by data analytics. These methodologies capitalize on the unique characteristics of emerging technologies to create interactive and dynamic learning environments. In addition, these strategies promote active student participation and the development of practical skills with real-world applicability.

However, it is essential to recognize the need to train educators in effectively using these technologies, along with considering ethical and privacy issues related to student data collection. Interdisciplinary collaboration between educational experts and data scientists is a critical factor in developing effective and ethical solutions in professional education. Ultimately, this review underscores the importance of exploring and leveraging the potential of Machine Learning and emerging technologies to advance professional education. These tools offer significant opportunities to improve the quality of teaching and learning and to prepare students more effectively for their future career challenges in an ever-changing world.

References

1. Marimon, M., Cabero, J., & Castañeda, L. (2022). Building knowledge in the digital era : challenges and reflections. *RED. Journal of Distance Education*, *22*(69), 1-32. http://dx.doi.org/10.6018/red.505661.
2. Valladares, E., & Valarde, S. (2021). Towards the democratization of machine learning using AutoGOAL. *Cuban Journal of Digital Transformation*, *2*(1), 1-11.
3 Morales-carrillo, J., Cedeño-valarezo, L., Stefano, J., & Bravo, C. (2021). Software development methodologies and their scope of application : A systematic review. *Revista Ibérica de Sistemas e Tecnologias de Informação*, 29-46.
4 Díaz, J. D. M., Chacón, V. O., & Ronda, F. J. M. (2016). The design of clinical questions in evidence-based practice. Formulation models. *Global Nursing*, *15*(3), 431. https://doi.org/10.6018/eglobal.15.3.239221.
5 Aparicio, O. (2023). Artificial Intelligence and its impact on education: Transforming learning for the 21st century. *International Journal of Pedagogy and Educational Innovation*, *3*(2), 217-229. https://orcid.org/0000-0002-8178-1253
6 Rivas, B., Barrio, F., & Barri, M. (2021). Systematic analysis on the use of Augmented Reality in Early Childhood Education . *EDUTEC. Electronic Journal of Educational Technology*, *76*, 53-73.
7 Garrido, J. (2023). Immersive Reality:

Educational tool to develop computational thinking. *Revista Latinoamericana OGMIOS*, *3*(8), 70-81. https://doi.org/10.53595/rlo.v3.i8.085

8 Valero, J., Navarro, Á., & Larios, A. (2022). College dropout: Evaluation of different Machine Learning algorithms for its prediction. *Revista de Cincias Sociales*, *XXVIII*(3), 1-15.26 Quintanar, R., & Hernández, S. (2022). Technological Models of Adaptive Learning Applied to Education. *Revista Tecnológia -Educativa Docentes 2.0*, *15*(1), 41-58. https://doi.org/10.37843/rted.v15i1.308 Modelos

9 Guaillazaca, C., & Hernández, V. (2020). Agricultural Product Classifier for Quality Control based on Machine Learning and Industry 4 . 0. *Revista Técnico - Científica Perpectivas*, *2*(2), 1-8.

10 Chiza, L. L. (2021). Transmission Corridor Stability Margin Prediction Applying Data Mining Criteria and Machine Learning Algorithms. *Technical Journal "Energy," 18*(1), 37-47.

11 Mancilla, G., Leal, P., Sánchez, A., & Vidal, C. (2020). Factors associated to student success in online learning modality : a data mining analysis Factors associated to student success in online learning : a data mining analysis. *Formación Universitaria*, *13*(6), 23-36. http://dx.doi.org/10.4067/S0718-50062020000600023.

12 Villalonga, P., & Samá, C. (2023). Learning strategies of online engineering students. *Revista Iberoamericana de Educación a Distancia*, *26*(2), 237-256. https://doi.org/10.5944/ried.26.2.36257

13 Salas, R. A. (2023). Using deep learning to analyze Facebook and Google classroom in the educational field. *Pixel-Bit. Journal of Media and Education*, *67*, 87-122.

16 Francke, P., & Acosta, G. (2020). Impact of micronutrient supplementation on childhood chronic malnutrition in Peru. *Revista Medica Herediana*, *31*(3), 148-154. https://doi.org/10.20453/rmh.v31i3.3803

17 Álvarez Vega, M., Quirós Mora, L. M., & Cortés Badilla, M. V. (2020). Artificial intelligence and machine learning in medicine. *Revista Medica Sinergia*, *5*(8), e557. https://doi.org/10.31434/rms.v5i8.557.

18 Esperanza Manrique Rojas (2020). Machine Learning: analysis of programming languages and tools for development. *Revista Ibérica de Sistemas e Tecnologias de Informação*, 1-15.

19 Briganti, G., & Le Moine, O. (2020). Artificial Intelligence in Medicine: Today and Tomorrow. *Frontiers in Medicine*, *7*, 4-5. https://doi.org/10.3389/fmed.2020.00027

20 Melo, G., Coto, M., & Acosta, G. (2023). Education and Artificial Intelligence (AI). *Revista Científica Dominio de Las Ciencias*, *9*(4), 1-14. https://doi.org/10.23857/dc.v9i4.3587.

21 Lasso Cardona, L. A., & Conde Rodriguez, K. N. (2021). Khan Academy as a tool in the learning of mathematics and programming . *Revista Interamericana de Investigación Educación y Pedagogía RIIEP*, *14*(1 Se-Artículos Producto De La Investigación), 225-250. https://doi.org/10.15332/25005421.5777.

22 González, C. (2023). The impact of artificial intelligence on education : transforming the way we teach and learn. *Qurriculum Magazine*, 51-60. https://doi.org/10.25145/j.qurricul.2023.36.03

23 González, D. (2023). *The role of facebook, google and malware in the distribution of fake news: algorithms and technological escalation as media influence*.

24 Arana, C. (2021). Artificial Intelligence Applied to Education : Achievements , Trends and Perspectives. *Argentine Journal of Science and Technology*, *7*, 1-22.

25 Salmerón, Y., Enrique, H., & Murillo, W. (2023). The future of artificial intelligence for education in higher education institutions. *Revista Conrado*, *19*(93), 27-34.

27 Ruipérez, J. (2020). The Learning Analytics Implementation Process. *RIED. Revista Iberoamericana de Educación a Distancia*, *23*(2), 85-101. http://dx.doi.org/10.5944/ried.23.2.26283

28 Díaz, R., Machun, S., & Checa, M. (2022). Techniques and tools for virtual testing in

an e-learning model. *Conrado Journal*, *18*(3), 112-119.

29 Mahesh, B. (2020). Machine Learning Algorithms - A Review. *International Journal of Science and Research (IJSR)*, *9*(1), 381-386. https://doi.org/10.21275/ART20203995

30 Gamarra, F. (2019). Modelo Basado En Machine Learning Para el neurorrendimiento académico de estudiantes universitarios. *Revista Ciencia Y Tecnología Para El Desarrollo-UJCM*, *5*(9), 5-12.

31 Pérez, V., Margoth, S., Casa, B., & Agustín, M. (n.d.). *Machine Learning application for the classification process of data associated with the Celina medical center*. 74-91.

32 Perez, T. (2023). User-Centered User Interface Design : Best Practices and Trends. *VICTEC. Academic and Scientific Journal*, 193-200.

33 Ayuso del Puerto, D., & Gutiérrez Esteban, P. (2022). Artificial Intelligence as an educational resource during initial teacher training. *RIED-Revista Iberoamericana de Educación a Distancia*, *25*(2). https://doi.org/10.5944/ried.25.2.32332

34 Ordóñez, H., Cobos, C., & Bucheli, V. (2020). Machine learning model for predicting theft trends in Colombia. *RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao*, *2020*(E29), 494-506.

35 Aboal, D., López, A., Maurizio, R., & Queraltó, P. (2021). Automation and employment in uruguay. *Desarrollo y Sociedad*, *2021*(87), 33-72. https://doi.org/10.13043/DYS.87.2

36 Obregón, L., Onofre, C., & Pareja, J. (2023). The impact of artificial intelligence in the educational field. *Revista Científica Ciencias Económicas y Empresariales*, *8*(3), 342-354. https://doi.org/10.23857/fipcaec.v8i3%0AFIPCAEC

37 Algaba, D., & Peñarrocha, I. (2016). Automated evaluation experiences in PID identification and tuning. *Proceedings of Las XXXVII Jornadas de Automática*, *3*, 957-962.

38 Morillo, M. del C., & González, D. (2016). *Adaptive Learning*. University of Valladolid.

39 Díaz, B., & Baquero, F. (2018). Yellow carrot (Daucus carota L .) as a biotechnological feed for cows Yellow carrot (Daucus carota L .), a biotechnological. *Science and Agriculture*, *15*(2), 1-17.

40 Romani, G., & Macedo, K. (2022). Implementation of the hybrid classroom and digital tools in students of a high school in Ica. *Quintaesencia Revista de Educación*, *13*, 14-19.

41 Velasco, A., Guerrero, P., & Fonseca, I. (2023). Personalized education . An effective approach to learning. *Ciencia Latina Revista Científica Multidisciplinar*, *7*(2), 1-16. https://ciencialatina.org/index.php/cienciala/article/view/5942.

42 Mantilla, M., Celis, E., & Rodriguez, A. (2021). Cooperative play as a pedagogical strategy to promote good solid waste management and collection. *Praxis*, *17*(1), 55-68.

43 Bedoya, J. J., Bedoya, R., & Hernández, C. (2019). Automated assessment of environmental competencies acquired by higher level students. *Revista Pedagógica*, *21*, 623-642. http://dx.doi.org/10.22196/rp.v20i45.4361

44 Tobar, R., Gao, Y., Mas, J. F., & Cambrón, V. (2023). Land use and land cover classification through machine learning algorithms : literature review. *Journal of Remote Sensing*, *62*, 1-19. https://doi.org/10.4995/raet.2023.19014%0AClasificación.

45 Miralles, C., & Cardona, M. (2020). The gender perspective in initial teacher education: a descriptive study of student perceptions. *Educación XXI*, *23*(2), 231-257. https://doi.org/10.5944/educXX1.23899.

46 Barcia, E., Soledad, J., Barcia, A., & Mendoza, J. (2023). Formative evaluation in pedagogical practice in Higher Education : Sitematic review. *Ciencia Latina Revista Científica Multidisciplinar*, *7*(3), 1-13.