







Incidences of artificial intelligence in contemporary education

Incidencias de la inteligencia artificial en la educación contemporánea

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ABSTRACT

The term "Artificial Intelligence" was coined in 1956 at a conference at Dartmouth College and since then it has undergone constant development and has evolved radically. Prominent pioneers of the term include John McCarthy, Marvin Minsky, Allen Newell, and Herbert A. Simon. The application of AI in education worldwide has increased dramatically with its importance growing at an increasing rate. The objective of this research is to bibliometrically analyze applications of AI in contemporary education. The methodology includes a Prisma of the articles of three fundamental databases: Scopus (n=390), Mendeley (n=113), and Science Direct (n=3,594). A total of n=4,097 articles in English and Spanish were analyzed. The systematic literature review of recent works employed a mixed approach using quantitative and qualitative methods. It was inferred by the authors that AI is revolutionizing education by offering personalized and efficient solutions to improve students' learning. One of the main conclusions of this research is that in contemporary education, students are one of the groups that are most affected by AI. Furthermore, the human intelligence of teachers plays a fundamental role since they adapt their methodologies to leverage new technologies. Finally, it is worth noting that decisions made in schools and universities support new educational models based on technology.

RESUMEN

El término «Inteligencia Artificial» fue acuñado en 1956 en una conferencia en Dartmouth College, y desde entonces, este ha experimentado un desarrollo constante y ha evolucionado de manera significativa. Algunos de los pioneros más destacados incluyen a John McCarthy, Marvin Minsky, Allen Newell y Herbert A. Simon. La aplicación de la inteligencia artificial en la educación ha aumentado considerablemente a nivel mundial en la dinámica era digital. El objetivo de la investigación es analizar bibliométricamente las incidencias de la IA en la educación contemporánea. La metodología contiene un Prisma de tres bases de datos fundamentales Scopus (n=390), Mendeley (n=113) y Science Direct (n=3.594), para un total de n=4.097 artículos en idioma inglés y español. La revisión sistematizada de la literatura reciente tiene un enfoque mixto, cuantitativos y cualitativos empleando varios paradigmas de la investigación en función del objetivo, se obtiene que la IA ha revolucionado la educación, ofreciendo soluciones personalizadas y eficientes para mejorar el aprendizaje de los estudiantes. En las principales conclusiones se plantea que en los términos teóricos de mayor impacto están los estudiantes como elemento principal de la IA de la educación contemporánea. Por otra parte, los profesores juegan un papel fundamental en este proceso a través de sus metodologías y el uso de estas tecnologías. Así mismo están los currículos educacionales mediante la toma de decisiones en los colegios y universidades que están apostando por nuevos modelos tecnológicos educativos.

KEYWORDS | PALABRAS CLAVE

Artificial intelligence, education, contemporary, e-learning, online teaching, deep learning.
Inteligencia artificial, educación, contemporáneo, aprendizaje electrónico, enseñanza en línea, aprendizaje profundo.

1. Introduction and state of the art

Artificial intelligence (AI) has a profound impact on everyday life. AI is used in different high-stake applications, for example, healthcare, business, government, education, and justice, leading toward a more algorithmic society (Kaur et al., 2022). The influence of algorithms is increasing through its growing presence in most domains, without being noticed and sometimes usurping the identity of other social actors (García-Orosa et al., 2023). The use of AI systems in educational contexts is showing potential opportunities for its use by teachers and students (Flores-Vivar & García-Peñalvo, 2023), enhancing new didactic models.

The use of digital games in learning and early identification of dropout risk in higher education by incorporating AI are critical research topics (Bañeres et al., 2023). In addition, the adoption of AI in educational applications can enhance students' learning competencies and is significant in knowledge-sharing processes across different sectors (Alhumaid et al., 2023) and for epistemic network analysis (Wang et al., 2023). To improve student engagement and motivation, scholars suggested using an AI-based educational data mining approach that enables early recognition and development of personalized recommendations in the flipped classroom (Sayed et al., 2023; Huang et al., 2023).

1.1. Artificial intelligence in education

AI performance prediction modeling is widely used to identify at-risk students and consequently establish student-centered learning pathways, and optimize instructional design and development (Ouyang et al., 2023). Alternatively, it is necessary to reflect on AI, chatbots, and plagiarism in higher education (King & chatGPT, 2023). The above tools, if misapplied, will not develop knowledge, professional competencies, or critical thinking skills, which are vital in diverse professions.

The personalized intelligent manufacturing paradigm with cognitive automation capabilities (Li et al., 2023) has attracted increasing attention by offering an adaptable and flexible solution. The paradigm leverages the advantages of both deep neural networks and reinforcement learning by adopting the power of representation learning, to make accurate and fast decisions when faced with dynamic and complex situations.

This intelligence system develops foresight science with a systematic approach to generate future predictions in planning and management using analytical and predictive tools to understand the past and present (Ednie et al., 2023), while providing information on the future of education. The adoption of appropriate practices using AI-enabled techniques facilitates teaching and learning performance in higher education (Hua-Hu, 2023).

The analysis of learning tactics and strategies in an online environment (Lahza et al., 2023) is a form of pedagogical support for collaborating with students in the development of academic-related content. Analysis of learning tactics is emerging as a viable approach to engage students in higher-order learning. In all the above instances, ethical considerations of AI must be considered (Sun & Ye, 2023). One of the ultimate challenges in philosophy is therefore, determining what deserves moral regard.

Digital explosion and entrepreneurship education is having an impact on promoting entrepreneurial intent for business students (Dabbous & Boustani, 2023) and thus, empowering AI as a form of entrepreneurship. Adoption of AI-based teaching robots (T-bots) for learning using the technology adoption model and context-specific variables (Hussain, 2023) aligns with education efforts in fostering intelligent decisions.

It has become essential for today's learners to gain basic literacy and AI competencies, yet educators do not care about these era-defining trends in contemporary pedagogy (Chai et al., 2023). According to Zhen et al. (2023), virtual technology is widely employed in various sectors such as personal assistance, intelligent customer service, online in various educational modalities and for assessing physical activity in high school children (Ahmed et al., 2023), data visualization, augmented reality, and virtual reality (Cerqueira et al., 2023).

An informed perspective of learning through AI raises concerns on how to train users in handling changes brought about by the introduction of the technology (Arbelaez-Ossa et al., 2023; Ursani & Ursani, 2023). The future of standardized assessment, validity, and confidence in assessment and

scoring algorithms (Aloisi, 2023), therefore considers challenges of using AI to aid standardized high-risk assessment.

1.2. Artificial intelligence software applied in education

Among the AI tools applied in online education are special types of software. English teaching and learning in this information age should be carried out with the help of intelligent system software to counter the disadvantages of the traditional system of teaching and learning (Dong, 2022). According to the current circumstances of teaching in addition to learning, semantic Web technology and AI technology are combined to build an advanced system of teaching and learning.

In the context of AI, scientific research practice has been simplified in terms of technological form and content, that limits students' ability to comprehensively apply technology. The above-mentioned scenario, therefore, becomes an obstacle in the development of superior technological features in the context of AI (Hu et al., 2023). Online and adaptive learning has already advanced within academia. However, the most significant changes are yet to come. These evolving technologies have the potential to change traditional roles in colleges and universities to the point where many educators will reconsider their roles as teachers, researchers, and administrators (Picciano, 2019).

The future of higher education and education through online technology, specifically adaptive learning and analytics infused by AI software, is increasingly developing as part of teaching methodology. Transformation of educational concepts, reform of teaching courses, and reorganization of teaching materials are critical ways to strengthen the quality of contemporary education through AI (Zhou, 2023). This is related to the development of teaching materials suitable for various regions and schools to deepen students' understanding and enhance their interest in courses.

It also serves to make decisions in application domains such as justice, health care, and education (Hort et al., 2023) and as deep learning systems trained to read, classify, and respond to human emotions (Ho et al., 2023). Computer-assisted instruction also has some degree of lock-in. The use of AI causes students to learn passively, without goals, education, and guidance (Shen & Tan, 2023). Based on the above scenarios, there are models for evaluating the effectiveness of AI-based computer-assisted physical education teaching and training, which help to focus goals and determine guidance.

Real object understanding using 3D haptic virtual reality for online education is another tool (Allaoua-Chelloug et al., 2023). This computer vision technology incorporates tasks that implement basic filtering for image classification. The main areas of research in this field include object detection and recognition, and interesting aspects of education at different levels.

Detailed exploration of AI and digital education provides a sustainable impact on youth and society (Tongkachok et al., 2023). Therefore, using AI launches some digital applications for digital education, an element that increased during the COVID-19 pandemic. For all the above instances, it is necessary to define the research question: What are the incidences of AI in contemporary education through a bibliometric analysis? Establishing as a general objective: To analyze bibliometrically the incidences of AI in contemporary education.

2. Material and methods

In this work, a descriptive and retrospective bibliometric analysis was conducted on the impact of AI in online education, using, as a guide, an adaptation of the proposal of Matthew et al. (2021). The PRISMA methodology was applied, thus endorsing the systematic review.

This review has a mixed approach as a contribution to the application of several types of research paradigms adapted from the post-positivist paradigm since it is evident that AI is a phenomenon that exists but is not yet fully explored. The qualitative and quantitative approach is combined with critical theory. The constructivist paradigm is also mixed since the articles taken as references are based on research that was built on socially proven realities, according to different contexts and times, where the countries, as well as their situations and analysis, are different.

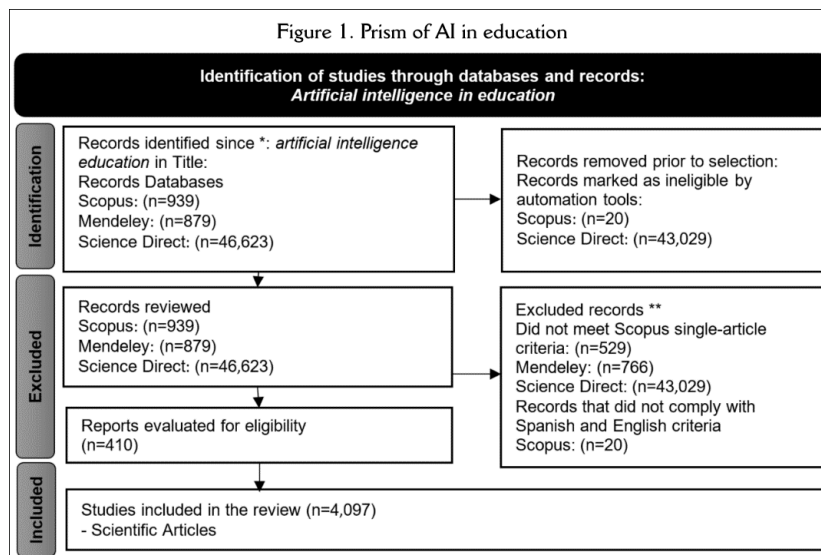
2.1. Instrument for data collection

For the research, conceptual categories are established considering the incidence of AI in education, from which the dimensions (D) and indicators (I) that lead the research are defined and are based on the analysis of the previously established information:

- D.1: Authors. I: Total citations, citations per year, publication timeliness, affiliation, country, H index.
- D.2: Journals. I: Main publications, journal quartiles, indexation, impact factor, and countries.
- D.3: Contributions I: Subject matter, methodologies used, analysis techniques, and samples used.

2.2. Population and sample

The steps carried out for the visual design of the PRISMA diagram (Figure 1) are described below.



Note. Adapted from Matthew et al. (2021).

1) Identification of the key steps of the systematic review: the systematic review generally includes sub-steps such as:

- Search for studies: The following search equation was used: title ("artificial and intelligence and + and education") and limit-to (language, "English") or limit-to (language, "Spanish"). As can be seen in the equation, English and Spanish were the inclusion criteria.
- Selection of studies: To obtain the best results in the exploration carried out, search strategies were applied to all the literature indexed in Scopus, Mendeley, and Science Direct related to this topic up to 2023.
- Data extraction: The tools of the bibliometric package of the R statistical program (Aria & Cuccurullo, 2017) were used to extract the information of the variables to be analyzed according to the dimensions explained above.
- Evaluation of the quality of the evidence: After the previous steps, the results were analyzed descriptively, and based on this information, the tables and graphs presented in the results section were prepared.

3. Analysis and results

As established in the methodology, the study starts by identifying incidences represented by the conceptual categories related to the object of study, extracted from the keywords of the research included in the sample. The students are the main element of the AI, since their performance with AI varies depending on their human condition. On the other hand, teachers play a fundamental role in this process through their methodologies and the use of these technologies, where the basis of everything is in the technological

publications between 2021 and 2023. In general, there are 10 authors; eight of them belong to developed countries and two to underdeveloped countries. The number of publications within the last five years is seven and three within the last 10 years. Likewise, the mean overall average citation index is 113, the mean citation index per year is 20 and the mean H-index is 19. The leading country in AI in contemporary education according to its authors is Australia (2), considering the top 10 authors.

Table 1. Authors' dimension

Names and surnames	Citations	Citations by year	Present	Index H	Affiliation	Country
Popenici, S.	240	34	2017	3	Charles Darwin University	Australia
Roll, I.	200	25	2016	23	Technion - Israel Institute of Technology	Israel
Chen, L.	138	35	2020	1	Yango University, Fuzhou	China
Timms, M.J.	136	17	2016	12	Australian Council for Educational Research	Australia
Wartman, S.A.	86	14	2018	20	Academic Health Centers	United States of America
Chatterjee, S.	70	18	2020	29	Indian Institute of Technology Kharagpur	India
Winkler-Schwartz, A.	70	14	2019	15	Institut-Hôpital Neurologique de Montréal	Canada
Guan, C.	68	17	2020	57	Nanyang Technological University	Singapore
Hinojo-Lucena, F.	68	14	2019	16	Universidad de Granada	Spain
Knox, J.	56	14	2020	13	Centre for Research in Digital Education, The University of Edinburgh	United Kingdom

Note. Developed by the authors. Based on Bibliometrix results from Scopus, Mendeley, and Science Direct 2023 databases.

3.2. D.2: Journals

A scientific journal is a periodical that contains original, peer-reviewed articles in a specific field of science. Scientific journals are a means of disseminating recent research and discoveries to a community of researchers and specialists in a subject and are an important part of the review and validation process in science. For all the above reasons, it is necessary to establish the essential elements of the main journals that publish topics related to AI in contemporary education as a dimension of research (Table 2).

Table 2. Dimension of scientific journals

Scientific journals	Quartiles of the journals	Journal Indexing	Journal impact factor	Country
Research and Practice in Technology-Enhanced Learning	Q-1	JCR, SJR	18	Singapore
International Journal of Artificial Intelligence in Education	Q-1	JCR, SJR	53	USA
IEEE Access	Q-1	JCR, SJR	158	USA
International Journal of Artificial Intelligence in Education	Q-1	JCR, SJR	53	USA
Academic Medicine	Q-1	JCR, SJR	162	USA
Education and Information Technologies	Q-1	JCR, SJR	48	USA
Journal of Surgical Education	Q-1	JCR, SJR	59	USA
International Journal of Innovation Studies	Q-2	SJR	12	China
Education Sciences	Q-2	JCR, SJR	30	Switzerland
Learning, Media, and Technology	Q-1	JCR, SJR	49	UK

Note. Developed by the authors. Based on Scopus, Mendeley, and Science Direct 2023 databases.

Considering Table 2, it can be stated that within the 10 scientific journals that publish the most on the topic of AI in education, 80% are in the first quartile of publication (Q-1) and 20% in the second quartile (Q-2). Ninety percent belong to the Journal Citation Reports (JCR) and 10% to the Scimago Journal & Country Rank (SJR). The above defines a position that all publications related to the research are high impact and evaluated by double-blind peer review systems, Open Access, and are collected in world-class journals compiled by the Scopus database. The average impact factor of the journals is 64.2.

Countries publishing related reputable journals include the United States of America that is in first place with six journals, while Singapore, China, Switzerland, and the United Kingdom all have one journal. All the publications that promote the topic of AI in contemporary education are from developed countries centered on three continents: North America, Europe, and Asia. South America and Africa are absent in journals of this type. This last indicator coincides with the same indicator of the authors' countries, which solidifies that AI in education is a topic that is promoted by developed countries.

3.3. D.3: Contributions

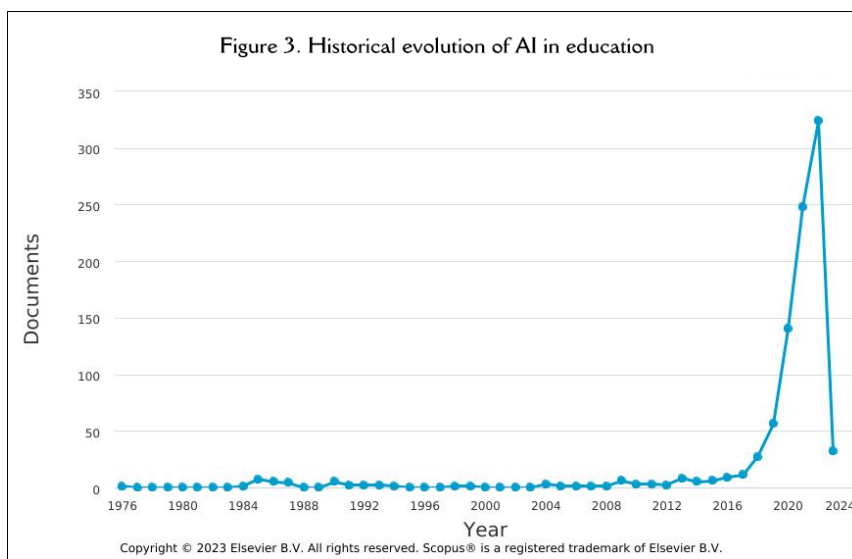
Scientific contributions are original and significant contributions that scientists make in their areas of research to expand knowledge and solve problems. These contributions may include discoveries, theories, methods, innovative techniques, experiments, and studies that confirm or refute hypotheses. The scientific contributions of AI in contemporary education are critical for the progress of science and the improvement of the quality of life, so we analyze in this research (Table 3) the main impacts of these methodologies and techniques.

Table 3. Scientific contributions			
Subject	Methodology	Analysis techniques	Sample
Impact of AI on teaching and learning in higher education.	Systematic review	Bibliometrics	Not applicable (N/A)
Evolution and revolution of AI in education.	Systematic review	Modeling approach, literature review, system description, system evaluation, or learning theories.	47 items
Dynamic modeling of spatial and satellite coalition robots.	LAGRANGE function, Newton-Euler function	Integral effort learning control scheme based on the Barrier-Lyapunov function.	N/A
Educational cobots and intelligent classrooms.	Sociocriticism	Problem formulation	N/A
AI in medical education.	Systematic curricular attention	Statistical domain expertise, machine learning, and robotics	N/A
AI in secondary and higher education.	Quantitative analysis	Structural equations	329 subjects
AI in medical education.	Benchmarking	Virtual reality simulation. Machine learning to evaluate the surgical experience	12 items
AI and innovation in education.	Systematic review	Bibliometrics	400 items
AI in higher education.	Systematic review	Bibliometrics	132 items
AI in Chinese education.	Quantitative analysis	Documentary review	3 companies

Note. Prepared by the authors. Based on the Scopus, Mendeley, and Science Direct 2023 databases.

All contributions revolve around AI in online education. However, similarities and differences among them are enhanced. For example, employing AI in teaching and learning, in the evolution and revolution of education, and the insertion of robots in different educational areas through dynamic modeling. Contemporary trends are developing such as educational robots (T-bots) and intelligent classrooms, and the inclusion of AI in medical education, at educational levels, as an innovative element of different environments, settings, and learning objectives.

AI in education is a new cycle of technological innovation that, with the development of science and technology, is here to stay. AI is of vital importance in understanding, management, and teacher training for the teaching of new generations for the immediate future that is not long in coming.



Note. Scopus 2023 database.

Within the methodologies shown in these articles on AI in contemporary education, it is evident that 80% are theoretical reviews and 20% are quantitative analyses. Systematic reviews, socio-critical elements, curricular attention, benchmarking and LAGRANGE function, and Newton-Euler function are derived from the above.

Among the techniques that can be identified are the following: Bibliometrics 30% of publications, documentary review 10%, modeling approach, literature review, system description, system evaluation or learning theories 10%, integral effort learning control scheme based on the Barrier-Lyapunov function 10%, problem formulation 10%, statistical expertise domain, machine learning, and robotics 10%, structural equations, virtual reality simulation and machine learning to evaluate surgical experience 10%.

Concerning the selected samples, it can be said that 40% defined it as only empowering reflection articles, another 40% used a sample of articles, 10% worked on a review of documents in companies, and only 10% did it with subjects. This shows an incipient lack of concrete practice in the different social realities. Once the previous results have been determined, it is necessary to define the evolution of AI in education to arrive at the present. For this purpose, the trajectory of scientific articles in the Scopus database was consulted (Figure 3).

AI in education has experienced constant advance since its conception in 1956, establishing its first theoretical antecedents in 1976. Some important milestones refer to the fact that it was in 1956 when the term AI was first discussed at a conference at Dartmouth. In the 1960s-70s, the first AI systems were developed, including pattern recognition and natural language understanding. In the 1980s-90s, advances in information processing and data storage were developed that enabled AI systems to improve on tasks such as machine learning and planning. In the 2000s-2010s, significant advances in deep learning and massive data analysis occurred, allowing AI to improve in tasks such as image recognition and text generation.

From 2015 to the present, AI has continued to evolve at a rapid pace, with advances in technologies such as reinforcement learning, natural language processing, and robotics. AI has also been integrated into a wide variety of practical applications, including facial recognition, virtual assistant, and enterprise data analytics. AI is beginning to be used to personalize education, adjusting the pace and content according to the needs of individual students.

In 2017, AI tools were developed that allowed teachers to evaluate and improve their teaching, as well as allowing students to get real-time feedback on their performance. In 2019, virtual reality and augmented reality began to be used to enhance the learning experience, allowing students to interact with content in a more immersive way.

The COVID-19 pandemic empowered distance education and AI-developing solutions to support online learning becoming a necessity. In 2021, AI was increasingly used to create chatbots and virtual assistants to help students resolve queries and enhance their learning experience and its elements that are still being developed to this day.

4. Discussion and conclusions

The results provide evidence that AI research may be on the rise, agreeing with Hinojo-Lucena et al. (2019). After 2000, recognition is made on the era of cognitive intelligence, mimicking human intelligence and cognitive abilities as planned by Garcia-Orosa et al. (2023). In the last decade, from 2010, the term general intelligence is discussed, with the creation of general AI systems, which can perform a wide range of tasks, including learning new knowledge and skills.

However, discriminatory characteristics are not evident given that AI does not inherently establish gender or race patterns. All this relates to possible algorithmic biases that could negatively affect certain social groups if any historical discriminatory elements are included in the algorithms. Technologies most in demand are those based on AI, such as intelligent tutoring systems, adaptive learning management systems, and video games (Vila & Penín, 2007).

AI is impacting human relationships, through communication, relationships, and ways of interacting with the surrounding world. On the one hand, it improves communication and collaboration through online platforms and instant messaging applications. On the other hand, self-service for example employs

machines with a more natural and fluid interaction. However, there are also challenges such as the increasing dependence on technology and its negative impact on people's social skills and ability to communicate. In addition, there are concerns about the privacy and security of personal information, as well as the possibility of excessive automation of human jobs. While humans sometimes find it difficult to be impartial, an ethical challenge of AI systems (Flores-Vivar & García-Peñalvo, 2023) is to make them fair and impartial rather than to perpetuate discrimination or injustice.

In partial fulfillment of the research objective, it was concluded that AI has revolutionized education, offering personalized and efficient solutions to improve student learning. There are also concerns about its long-term impact and its potential to replace teachers. One of the main conclusions obtained is that AI focuses on developing algorithms and techniques that allow machines to perform tasks that normally require human intelligence. Among the various functions it performs are decision-making, learning, and problem solving.

The way of working has changed, for instance in medicine where medical diagnostic systems help healthcare professionals diagnose illnesses, personalize treatments, and improve efficiency in providing health care. Robots are also being developed to perform specific tasks, such as cleaning houses and patient care in hospitals. AI is used in voice and face recognition applications, such as Apple's Face ID and Google's camera assistant, to verify the identity of users. It is applied to automate repetitive jobs, such as inventory management and data classification.

Another important conclusion is the possible resistance of several scientific and academic communities in the indiscriminate application of AI, given that it could be transforming human relationships when not used responsibly. One of the most obvious applications, which requires efficiency and responsibility, is the automation of processes, generating higher levels of productivity, as well as the analysis of substantial amounts of data and the discovery of patterns and trends. In addition, it is being used to develop new products and services, as well as to improve customer experience.

Industrial security does not escape the influence of AI, for example, through the development of surveillance and threat detection systems. However, it is essential to analyze the ethical and social challenges involved. As technology advances, AI is expected to have an increasing impact on human life. The world is transforming, and dissimilar opportunities are offered to improve people's lives. As future lines of research, a more in-depth study of the contributions of AI research in education will be conducted to determine its impact on student learning. An analysis of the use of virtual assistants in learning will also be applied.

Authors' Contribution

Idea, J.R.S.N., Y.S.P.; Literature Review (State of the art), J.R.S.N.; Methodology, J.R.S.N., Y.S.P., D.D.P.B., M.J.C.; Data analysis, J.R.S.N., Y.S.P.; Results, J.R.S.N., Y.S.P., M.J.C., D.D.P.B.; Discussion and conclusions, J.R.S.N., Y.S.P., M.J.C., D.D.P.B.; Writing (original draft), J.R.S.N., Y.S.P.; Final draft, J.R.S.N., Y.S.P., M.J.C., D.D.P.B.; Project design and sponsorship, J.R.S.N., Y.S.P., M.J.C., D.D.P.B.

Funding Agency

University of Córdoba, University of Sucre, Loja Technical University.

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