PsiqueMag
Revista Científica Digital de Psicología
https://doi.org/10.18050/psiquemag

Universidad César Vallejo

The potential of artificial intelligence in the improvement of student learning and well-being: innovative pedagogical practices from an educational neuroscience perspective

El potencial de la inteligencia artificial en la mejora del aprendizaje y bienestar estudiantil: prácticas pedagógicas innovadoras desde una neurociencia educativa

Diego D. Díaz-Guerra[1]

[1] Universidad Central "Marta Abreu" de Las Villas, Cuba

Fecha de recepción: 29.09.2024
Fecha de aprobación: 30.11.2024
Fecha de publicación: 17.12.2024

Cómo citar: Díaz-Guerra, D. (2024). The potential of artificial intelligence in the improvement of student learning and well-being: innovative pedagogical practices from an educational neuroscience perspective. *Psiquemag 13* (2), e130210. https://doi.org/10.18050/psiquemag.v13i2.3138

Abstract

Artificial intelligence represents a cutting-edge technological system that is expected to transform the contemporary educational landscape. In this sense, the analysis of how the brain processes information to learn represents a starting point for the configuration of this technology in education. To really understand how artificial intelligence is being integrated into the educational context and the role of educational neurosciences in it, a documentary review was carried out that studied 89 empirical investigations published in Scopus between 2019 and 2024 in English. The result was that this technological advance constitutes an unprecedented advantage for the personalization of learning based on the individual needs of students. Even so, it is important to take into account the ethical challenges inherent in the use of technologies. Considerations on data protection and information security must be taken into account for its implementation. Overall, this research offers an analysis of the possibilities of implementing these technologies in education to improve student learning and well-being.

Keywords: artificial intelligence, learning, well-being, education, neurosciences.

Resumen

La inteligencia artificial representa un sistema tecnológico de vanguardia que se espera transforme el panorama educacional contemporáneo. En este sentido, el análisis de cómo el cerebro procesa la información para aprender representa un punto de partida para la configuración de esta tecnología en la educación. Para conocer realmente cómo se está integrando la inteligencia artificial en el contexto educativo y la función de las neurociencias educacionales en ello, se realizó una revisión documental que estudió 89 investigaciones empíricas publicadas en Scopus entre 2019 y 2024 en idioma inglés. Se obtuvo como resultado que este avance tecnológico constituye una ventaja sin precedente para la personalización del aprendizaje en función de las necesidades individuales de los estudiantes. Aun así, es importante tener en cuenta los desafíos éticos inherentes al empleo de tecnologías. Consideraciones sobre la protección de datos y seguridad de la información deben tenerse en cuenta para su implementación. En conjunto, esta investigación ofrece un análisis de las posibilidades de implementación de estas tecnologías en la educación para la mejora del aprendizaje y bienestar estudiantil.

Palabras clave: inteligencia artificial, aprendizaje, bienestar, educación, neurociencias.

INTRODUCTION

According to Posso-Pacheco *et al.* (2024), education is undergoing a remarkable transformation, which, Valencia Celis *et al.* (2023) emphasize, is increasingly associated with the development of new teaching methods. From the perspective of neurosciences applied to education, Yin (2022) and Yue et al. (2022) emphasize the need for a neuropsychology adapted to technological advances to improve the educational process, especially with the emergence of Artificial Intelligence (*Artificial Intelligence*, AI, for its commonly used abbreviation).

In this context, the study of education from neuroscience focuses on understanding the brain mechanisms underlying learning and, based on these data, as Ruiz Díaz De Salvioni (2023) points out, developing strategies to facilitate academic performance in students. Following this line focused on the analysis of academic performance and its study from neuroscience, Boussouf *et al.* (2024) suggest that the capacity of AI to analyze information in detail should not be disregarded in the design of strategies to improve student learning. This idea is corroborated by Chen *et al.* (2020), who predict that the combination of technologies and the brain principles of learning facilitate the acquisition of knowledge. Going further, Xuan *et al.* (2021) also emphasize the potential of these two disciplines to foster an educational environment focused on the needs of each student.

Following this line of ideas, integrating educational neuroscience and AI improves the two essential aspects in the pedagogical context: learning and student well-being (Del Campo Saltos *et al.*, 2023). Although it is important to point out, in order to avoid theoretical reductionism, that the integration of these two components includes addressing crucial aspects for adequate student development and, therefore, integrates the study of motivation, self-esteem and resilience (Dubinsky *et al.*, 2019; Schwartz *et al.*, 2019; Mykhaylenko *et al.*, 2024).

Now, the interest of this research in offering considerations on the importance of understanding how the brain processes, interprets, and ultimately enables learning focuses on the validity of studies that point to the importance of this body of knowledge for designers of AI systems(S-AI), for example, to develop effective systems to improve the well-being and learning process of students (Baena-Navarro *et al.*, 2024; Holzer *et al.*, 2021; Immordino-Yang *et al.*, 2019). In this sense, Gama Espinosa *et al.* (2024) emphasize that systems based on the use of AI have been shown to adapt learning content more dynamically according to the neurotypical particularities of students (Amaya Amado *et al.*, 2024; Hamal *et al.*, 2022; Wei *et al.*, 2021).

This research is justified in that, although several investigations highlight the importance of the integration of neurosciences and AI in education, it is not clear from the literature in which scenarios this complementation can be best exploited to improve the teaching/learning process. Thus, this study aims to analyze recent contributions in the literature to identify the main educational contexts that can benefit from the use of AI from a neuroscience-based approach.

METHOD

Type of study

A qualitative, documentary review approach was used, in accordance with the specifications of Wilson & Anagnostopoulos (2021). In order to comply with the objectives set, the research was structured in three stages focused on clearly defining the scope of the study, the methodology for the search and selection of information, and the process of analysis and synthesis of the texts.

According to Furlong and Lester (2022) this is the appropriate structure for a qualitative documentary review study.

Stage 1: Definition of the scope of the investigation

Clear criteria were established for the selection of sources. They considered the relevance, methodological quality and timeliness of the studies. The inclusion and exclusion criteria for this research are shown in Table 1. To ensure that the results of this research were based on research of high scientific rigor, no opinion texts or non-academic sources were selected.

Table 1

Criteria for selection of bibliographic sources

Criteria	Content
Relevance	Research directly addressing the integration of educational neuroscience and AI
Methodological quality	Original research, review or meta-analysis with methodological soundness in their results.
Actuality	Articles published between 2019 and 2024 in English

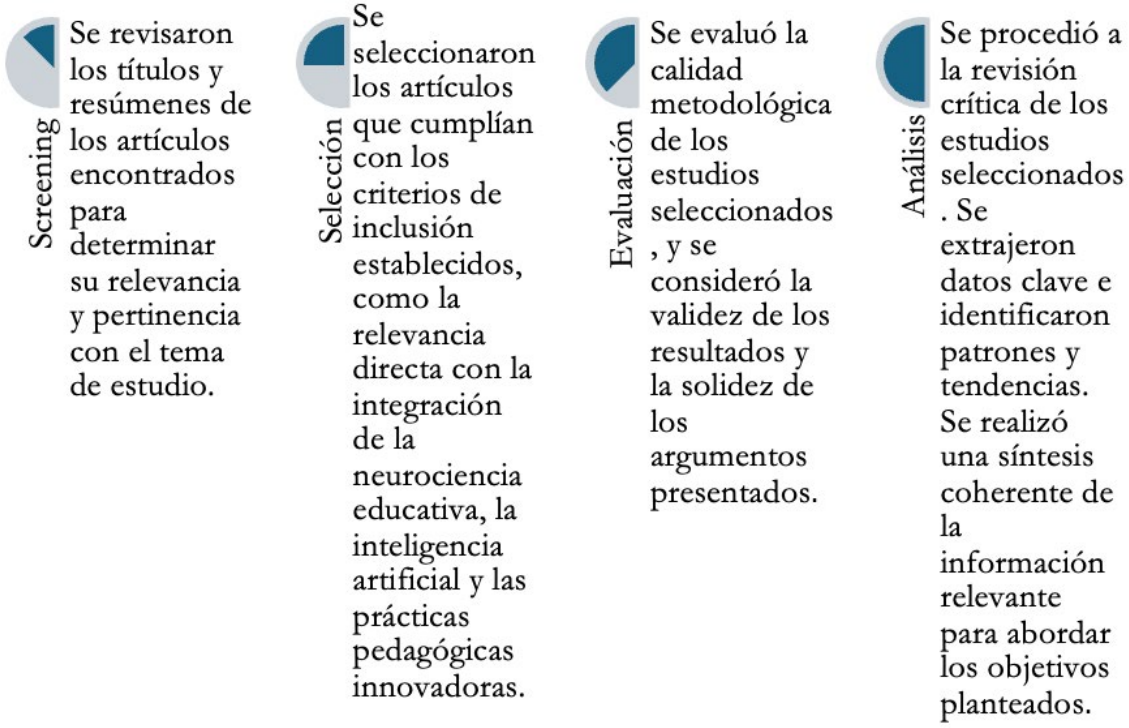
Source. Prepared by the authors.

Stage 2: Process of search and selection of bibliographic sources

The search for bibliographic sources was carried out in the Scopus database by combining keywords and content and temporality filters reflected in the information search formula: (TITLE-ABS-KEY ("artificial intelligence" AND "enhancing learning") OR TITLE-ABS-KEY ("student well-being" AND "innovative pedagogical practices") OR TITLE-ABS-KEY ("educational neuroscience")) AND PUBYEAR > 2019-2024 AND LANGUAGE("English"). As can be seen, Boolean operators and date and language filters were used to identify research in a precise way, and a structured selection process was used to identify relevant content as suggested by Furlong and Lester (2022) (see Figure 1).

Figure 1

Proceso de selección de fuentes



Source. Prepared by the authors.

Stage 3: Process of analytical synthesis of the texts

As suggested by Wilson & Anagnostopoulos (2021), the content analysis methodology was used to identify the main units of analysis in the literature consulted. The coding method selected was the open coding method of Siddaway et al. (2019) whereby a previously defined code is assigned to the data to identify the units of analysis by keywords. After identifying the units of analysis by keywords in the ATLAS.ti software, they were grouped into thematic content units as suggested by Furlong & Lester (2022) to achieve a thematic synthesis consistent with the search results. Finally, 89 articles were selected for this research.

RESULTS AND DISCUSSION

The units of analysis by keywords subtracted from the 89 selected articles allowed the elaboration of thematic units of content (see Figure 2). Precisely according to these units, this section was structured.

Figure 2

Keyword frequency analysis

Source: ATLAS.ti

However, when interpreting the key words, it was observed as a limitation that they did not clearly reflect the main application scenarios of AI in pedagogy, nor its relationship with educational neuroscience. To address this limitation, a manual coding of the content was carried out in a mind map format (see Figure 2). This mind map sought to reflect the theoretical organization necessary for the elaboration of the thematic content units and to understand the theoretical interconnection among the selected investigations.

Figure 3

Thematic units of content

Source. Prepared by the authors

Integration of AI and educational neurosciences in pedagogy

As a starting point, it is important to clarify that learning is a complex cognitive process that involves the interconnection of cognitive, emotional and contextual factors. On this basis, the joint papers by Feng & Law (2021) and Nazari *et al.* (2021) highlight that the integration of educational neurosciences and AI offers remarkable advantages for improving learning and, ultimately, the education system in general.

Primeramente, esta interacción permitió personalizar el sistema de enseñanza-aprendizaje. Esto fue posible gracias a que los sistemas tecnológicos que usa AI demostraron la capacidad de analizar los patrones cognitivos de aprendizaje de los estudiantes y ajustar el contenido a sus particularidades personales (Maghsudi *et al.*, 2021; Murtaza *et al.*, 2022).

Secondly, the capacity of the AI to provide instant feedback was shown in the study by Cañón Solano *et al.* (2024) to allow students to identify their strengths and weaknesses in the

study, as well as to receive recommendations for improvement. Another similar study conducted by Zhang *et al.* (2021) showed its predictive power in relation to academic performance as a function of information processing, as well as the possibility of suggesting preventive measures.

Despite these benefits, one cannot fail to mention the ethical and privacy issues inherent in the use of AI. In this regard, Bozkurt *et al.* (2021) warns of the importance of protecting students' personal data. In parallel, Zapata Muriel *et al.* (2024) point out that the S-AI used should be designed based on scientific evidence and used ethically because of the information handling involved.

Although these ethical challenges raise issues of concern to say the least, it cannot be ignored that this integration implies an advance in the educational process by generating personalized learning systems and improving decision making (Zapata Muriel *et al.*, 2024). As Acuña Mendoza and Torres Brugués (2024) excellently remark, educators can make these systems an unsurpassed tool for developing more efficient learning strategies. In this line of thought, Ahmad *et al.* (2021) and Tapalova *et al.* (2022) mention that they also allow the creation of more flexible learning scenarios, which in their studies proved to increase the inclusion and equity of the educational system.

Based on this synthesis, it is the opinion of the author of this text that the educational system should not depend only on the personalization of these technologies, which would lead to the suppression of the role of the educational counselor. Rather, the importance of human interaction in the pedagogical process and the value of the joint work of technology/human is emphasizedTo substantiate this assertion, Tymoshenko *et al.* (2024) emphasize that AI should not replace the affective/emotional/social connection that teachers establish with their students. Ultimately, the use of AI should only occur in an environment where the holistic well-being and development of the students who benefit from this technology is prioritized (Pérez Gamboa *et al.*, 2022).

Improved student learning and well-being

This thematic unit of content is focused on continuing the aspects addressed in the previous section, but from the perspective of improving learning and well-being through the use of AI as adequately remarked by Kumar *et al.* (2023). In this sense, Dignum (2021) speaks of AI facilitating teachers and counselors to identify difficulties in student performance from an unprejudiced conception (García-Martínez *et al.*, 2023).

From a neuropsychological perspective, AI can leverage the executive functioning capacity of the students to improve their ability to adopt content and adjust the pace of learning to their needs. To give an example, it has been shown that these technological systems can analyze cortical activation patterns in areas associated with executive functioning with an emphasis on the neuropsychological particularities of each learner. This, as demonstrated by Nadji-Tehrani and Eslami (2020) and Richards *et al.* (2019), can improve the retention and comprehension abilities of the students.

According to the information processing theory, which establishes that the brain processes information sequentially, Kim *et al.* (2023) found that S-AI when analyzing learning patterns in students favored the improvement of executive functions such as self-regulation and autonomy when studying. In parallel, Iterbeke *et al.* (2020) and Miranda-Moreno & Sandoval-Obando (2024) state that this is due to the fact that instantaneous feedback significantly consolidates memory and learning.

Another important point to be addressed is neurodiversity in education. In this order of ideas, the AI proved in the study by Jiménez-Pitre *et al.* (2023) to facilitate educational accessibility and inclusion by offering learning opportunities adapted to the needs of the students. This allowed greater inclusion in students with disabilities or special needs Salas-Pilco *et al.*, 2022; Srivastava *et al.*, 2021).

The analysis of emotional response patterns in students was another key element highlighted in studies such as those of Klos *et al.* (2021) and Pal *et al.* (2022), from which it was possible to develop strategies for the reduction of academic stress and anxiety. In addition, this pattern identification evidenced to predict mental health problems Machuca-Contreras et al., 2024; Pérez Valdivia *et al.*, 2024) and to offer suggestions for more efficient student support (Barrera León *et al.*, 2024; Li *et al.*, 2022; Liu & Wang, 2022).

As noted in the previous section, it is essential that system developers and educators work

together to address the ethical challenges involved in the use of AI in education (Noroña González *et al.*, 2023). For this reason, López González (2023) emphasizes that only an ethical and responsible approach will ensure that these technologies contribute positively to the well-being of students and to the educational process.

Challenges in the implementation of AI in education

One of the main challenges in the implementation of AI-based teaching practices, as noted above, is how to ensure that educational data obtained from students are handled with privacy and security (Araujo Inastrilla, 2023; Cabuquin *et al.*, 2024; Gonzalez-Argote, Alonso-Galbán, *et al.*, 2023¸ Luan *et al.*, 2020; Zhan *et al.*, 2022). Based on this concern, Chavez *et al.* (2023) and Yi & Li (2022) warn about the need for educational policies and regulations that guarantee the protection of these personal data in students as a starting point for the use of these technologies in this context (Ogolodom *et al.*, 2023; Velásquez Castro & Paredes-Águila, 2024).

While, on the one hand, the need for the human factor in the implementation of S-AI has been advocated, on the other hand, the biases and prejudices inherent to human beings are not ruled out. In this sense, Baker and Hawn (2021) emphasize that this can lead to unfair and discriminatory outcomes, mainly in socially disadvantaged groups (Chen *et al.*, 2020; Palomino Quispe *et al.*, 2024; Sahlgren, 2021; Zafari *et al.*, 2022). Additionally, for educators to use AI in personalizing learning requires that they have an understanding of the principles of educational neuropsychology (Sanchez Cabezas *et al.*, 2024). For this reason, Chen *et al.* (2020) and Maghsudi *et al.* (2021) note the need for them to understand how the brain processes information to support learning based on the neuroplasticity theory.

Transparency is another key factor to take into account for the implementation of educational practices based on AI and emerges as a determining factor in the presence or not of the discriminatory biases addressed in the previous paragraph (Buiten, 2019). In this sense, it is well noted by Pagano *et al.* (2023) that transparency will also be necessary for educators and students to understand the decision-making process behind the data generated. Furthermore, in order to be able to adapt to the particularities of the student body, the design of S-AI must be sensitive to curricular changes (Chiu, 2021; Dai *et al.*, 2022; Gonzalez-Argote, Lepez, *et al.*, 2023).

Another challenge that should not be overlooked in this analysis is related to the acquisition of competencies based on the development obtained in experience (Estrada-Araoz *et al.*, 2024). From this point of view, education transcends the mere acquisition of knowledge by contributing to the acquisition of social skills and critical thinking, according to Cantón Balcázar (2024) and Junco Luna (2023). Therefore, it is worth noting that the AI can replace the human role in some tasks, but should never under any circumstances bypass human interaction and the emotional factor as essential elements for learning and development (Anderson *et al.*, 2022; Cope *et al.*, 2020; Dai *et al.*, 2022; Ninaus & Sailer, 2022; Oladokun *et al.*, 2024). For this worrying situation to be avoided, Abramowitz & Antonenko (2022) point out that teachers must possess skills in using these technologies effectively, as well as manage to efficiently interpret the data generated and offer support networks to their students in their learning process (Ayouni *et al.*, 2021; Dai *et al.*, 2022; Chen *et al.*, 2020; MacCann *et al.*, 2019; Olusegun Oyetola *et al.*, 2024; Rozov, 2020).

CONCLUSIONS

This study evidenced the role of AI integration in education. In this context, the technology behind this advance appears as an unprecedented personalization of teaching by adapting to the need of each student. However, it should be noted that there are still a number of concerns or ethical considerations to be taken into account to ensure its proper implementation in educational settings.

It is essential to guarantee the transparency and security of the data, as well as the protection and security of the information handled by the S-AI. For these technologies to be applied efficiently in the educational context, it is necessary to take into account the particularities of learning of each student, in this sense, educational neurosciences provide a unique point of view by analyzing the particularities of student development and how the brain processes information to learn. Finally,

another essential element is the training of teachers on the use of AI, which will guarantee an efficient application and an open mentality in the face of the emerging boom of these technologies.

Financing:
This study did not have any source of financing.

Rol de los autores / Authors Roles:

DDDG: Design conception, analysis of results and review..

Competing interests: The author declares under oath not to have incurred in any conflict of interest in the preparation of this paper.

REFERENCES

Abramowitz, B., & Antonenko, P. (2022). In-service teachers' (mis)conceptions of artificial intelligence in K-12 science education. *Journal of Research on Technology in Education,* 55, 64 - 78. https://doi.org/10.1080/15391523.2022.2119450

Acuña Mendoza, D. L., & Torres Brugés, W. J. (2024). ICT as a Dynamizing Axis in the Generation of Indicators for the Social Appropriation of Knowledge in the Research Groups of the University of La Guajira. *Southern perspective / Perspectiva austral, 2,* 58. https://doi.org/10.56294/pa202458

Ahmad, S., Rahmat, M., Mubarik, M., Alam, M., & Hyder, S. (2021). Artificial Intelligence and Its Role in Education. *Sustainability, 13*(22), 12902. https://doi.org/10.3390/su132212902

Amaya Amado, D. P., Cárdenas Diaz, F. A., Cabrera Pantoja, R. D. P., & Bastidas Sanchez, L. M. (2024). Benefits of Artificial Intelligence and its Innovation in Organizations. *Multidisciplinar (Montevideo),* 1, 15. https://doi.org/10.62486/agmu202315

Araujo Inastrilla, C. R. (2023). Data Visualization in the Information Society. *Seminars in Medical Writing and Education, 2,* 25. https://doi.org/10.56294/mw202325

Ayouni, S., Hajjej, F., Maddeh, M., & Al-Otaibi, S. (2021). A new ML-based approach to enhance student engagement in online environment. *PLoS ONE, 16.* https://doi.org/10.1371/journal.pone.0258788

Baena-Navarro, R., Serrano-Ardila, L., & Carriazo-Regino, Y. (2024). Innovative model for the integration of ICTs in rural environmental education: Towards a sustainable pedagogy. *Southern perspective / Perspectiva austral, 2,* 35. https://doi.org/10.56294/pa202435

Baker, R., & Hawn, A. (2021). Algorithmic Bias in Education. *International Journal of Artificial Intelligence in Education,* 32, 1052 - 1092. https://doi.org/10.1007/s40593-021-00285-9

Barrera León, D., Tello Flores, R. Y., Ramos Guzmán, F., & Pérez Gamboa, A. J. (2024). Acompañamiento a la promoción de proyectos de vida de jóvenes seropositivos. Un estudio cualitativo complejo. *Región Científica, 3*(1), 2024248. https://doi.org/10.58763/rc2024248

Boussouf, Z., Amrani, H., Zerhouni Khal, M., & Daidai, F. (2024). Artificial Intelligence in Education: A Systematic Literature Review. *Data and Metadata, 3,* 288. https://doi.org/10.56294/dm2024288

Bozkurt, A., Karadeniz, A., Bañeres, D., Guerrero-Roldán, A., & Rodríguez, M. (2021). Artificial Intelligence and Reflections from Educational Landscape: A Review of AI Studies in Half a Century. *Sustainability, 13*(2), 800. https://doi.org/10.3390/SU13020800

Buiten, M. (2019). Towards Intelligent Regulation of Artificial Intelligence. *European Journal of Risk Regulation, 10,* 41 - 59. https://doi.org/10.1017/err.2019.8

Cabuquin, J. C., Acidre, M. A. S., Manabat, M. A. A., Aruta, M. G. H., Sangutan, J., & Beltran Yu, R. F. (2024). The role of ChatGPT on academic research: Perspectives from filipino students across diverse educational levels. *Salud, Ciencia y Tecnología - Serie de Conferencias, 3.* https://doi.org/10.56294/sctconf2024.1205

Cañón Solano, A. V., Cardona Arboleda, L. D., Coral García, C. C., & Carmona Dominguez, C. D. (2024). Benefits of artificial intelligence in companies. *Management (Montevideo), 1,* 17. https://doi.org/10.62486/agma202317

Cantón Balcázar, A. L. (2024). El estado de las habilidades ciudadanas en estudiantes universitarios de Chile, Colombia y México. *Región Científica, 3*(1). https://doi.org/10.58763/rc2024244

Chavez, H., Chavez-Arias, B., Contreras-Rosas, S., Álvarez-Rodríguez, J., & Raymundo, C. (2023). Artificial neural network model to predict student performance using nonpersonal information. *Frontiers in Education, 8.* https://doi.org/10.3389/feduc.2023.1106679

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access, 8,* 75264-75278. https://doi.org/10.1109/ACCESS.2020.2988510

Chiu, T. (2021). A Holistic Approach to the Design of Artificial Intelligence (AI) Education for K-12 Schools. *TechTrends, 65,* 796 - 807. https://doi.org/10.1007/s11528-021-00637-1

Cope, B., Kalantzis, M., & Searsmith, D. (2020). Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. *Educational Philosophy and Theory, 53,* 1229 - 1245. https://doi.org/10.1080/00131857.2020.1728732

Dai, Y., Liu, A., Qin, J., Guo, Y., Jong, M., Chai, C., & Lin, Z. (2022). Collaborative construction of artificial intelligence curriculum in primary schools. *Journal of Engineering Education, 112,* 23 - 42. https://doi.org/10.1002/jee.20503

Del Campo Saltos, G., Villlota Oyarvide, W., Andrade Sánchez, E., & Montero Reyes, Y. (2023). Bibliometric analysis on neuroscience, artificial intelligence and robotics studies: Emphasis on disruptive technologies in education. *Salud, Ciencia y Tecnología, 3,* 362. https://doi.org/10.56294/saludcyt2023362

Dignum, V. (2021). The role and challenges of education for responsible AI. *London Review of Education, 19*(1). https://doi.org/10.14324/LRE.19.1.01

Dubinsky, J., Guzey, S., Schwartz, M., Roehrig, G., MacNabb, C., Schmied, A., Hinesley, V., Hoelscher, M., Michlin, M., Schmitt, L., Ellingson, C., Chang, Z., & Cooper, J. (2019). Contributions of Neuroscience Knowledge to Teachers and Their Practice. *The Neuroscientist, 25,* 394 - 407. https://doi.org/10.1177/1073858419835447

Estrada-Araoz, E. G., Manrique-Jaramillo, Y. V., Díaz-Pereira, V. H., Rucoba-Frisancho, J. M., Paredes-Valverde, Y., Quispe-Herrera, R., & Quispe-Paredes, D. R. (2024). Assessment of the level of knowledge on artificial intelligence in a sample of university professors: A descriptive study. *Data and Metadata, 3,* 285. https://doi.org/10.56294/dm2024285

Feng, S., & Law, N. (2021). Mapping Artificial Intelligence in Education Research: a Network-based Keyword Analysis. *International Journal of Artificial Intelligence in Education, 31,* 277-303. https://doi.org/10.1007/S40593-021-00244-4

Furlong, D., & Lester, J. (2022). Toward a Practice of Qualitative Methodological Literature Reviewing. *Qualitative Inquiry, 29,* 669 - 677. https://doi.org/10.1177/10778004221131028

Gama Espinosa, J. C., Leiva Sánchez, L. M., & Fajardo Pereira, M. A. (2024). Benefits of Artificial Intelligence in human talent management. *Multidisciplinar (Montevideo), 1,* 14. https://doi.org/10.62486/agmu202314

García-Martínez, I., Fernández-Batanero, J., Fernández-Cerero, J., & León, S. (2023). Analysing the Impact of Artificial Intelligence and Computational Sciences on Student Performance: Systematic Review and Meta-analysis. *Journal of New Approaches in Educational Research, 12,* 171-197. https://doi.org/10.7821/naer.2023.1.1240

Gonzalez-Argote, J., Alonso-Galbán, P., Vitón-Castillo, A. A., Lepez, C. O., Castillo-Gonzalez, W., Bonardi, M. C., & Gómez Cano, C. A. (2023). Trends in scientific output on artificial intelligence and health in Latin America in Scopus. *ICST Transactions on Scalable Information Systems.* https://doi.org/10.4108/eetsis.vi.3231

Gonzalez-Argote, J., Lepez, C. O., Castillo-Gonzalez, W., Bonardi, M. C., Gómez Cano, C. A., & Vitón-Castillo, A. A. (2023). Use of real-time graphics in health education: A systematic review. *EAI Endorsed Transactions on Pervasive Health and Technology, 9,* e3. https://doi.org/10.4108/eetpht.v9i.3209

Hamal, O., Faddouli, N., Harouni, M., & Lu, J. (2022). Artificial Intelligent in Education. *Sustainability*, 14(5), 52862. https://doi.org/10.3390/su14052862

Holzer, J., Lüftenegger, M., Käser, U., Korlat, S., Pelikan, E., Schultze-Krumbholz, A., Spiel, C., Wachs, S., & Schober, B. (2021). Students' basic needs and well-being during the COVID-19 pandemic: A two-country study of basic psychological need satisfaction, intrinsic learning motivation, positive emotion and the moderating role of self-regulated learning. *International Journal of Psychology, 56,* 843 - 852. https://doi.org/10.1002/ijop.12763

Immordino-Yang, M., Darling-Hammond, L., & Krone, C. (2019). Nurturing Nature: How Brain Development Is Inherently Social and Emotional, and What This Means for Education. *Educational Psychologist, 54,* 185 - 204. https://doi.org/10.1080/00461520.2019.1633924

Iterbeke, K., Witte, K., & Schelfhout, W. (2020). The effects of computer-assisted adaptive instruction and elaborated feedback on learning outcomes. A randomized control trial. *Computers in Human Behavior.,* 120, 106666. https://doi.org/10.1016/j.chb.2020.106666

Jiménez-Pitre, I., Molina-Bolívar, G., & Gámez Pitre, R. (2023). Visión sistémica del contexto educativo tecnológico en Latinoamérica. *Región Científica, 2*(1), 202358. https://doi.org/10.58763/rc202358

Junco Luna, G. J. (2023). Study on the impact of artificial intelligence tools in the development of university classes at the school of communication of the Universidad Nacional José Faustino Sánchez Carrión. *Metaverse Basic and Applied Research, 2,* 51. https://doi.org/10.56294/mr202351

Kim, H., Chae, Y., Kim, S., & Im, C. (2023). Development of a Computer-Aided Education System Inspired by Face-to-Face Learning by Incorporating EEG-Based Neurofeedback Into Online Video Lectures. *IEEE Transactions on Learning Technologies, 16,* 78-91. https://doi.org/10.1109/TLT.2022.3200394

Klos, M., Escoredo, M., Joerin, A., Lemos, V., Rauws, M., & Bunge, E. (2021). Artificial Intelligence–Based Chatbot for Anxiety and Depression in University Students: Pilot Randomized Controlled Trial. *JMIR Formative Research, 5.* https://doi.org/10.2196/20678

Kumar, D., Haque, A., Mishra, K., Islam, F., Kumar Mishra, B., & Ahmad, S. (2023). Exploring the Transformative Role of Artificial Intelligence and Metaverse in Education: A Comprehensive Review. *Metaverse Basic and Applied Research, 2,* 55. https://doi.org/10.56294/mr202355

Li, C., Yang, M., Zhang, Y., & Lai, K. (2022). An Intelligent Mental Health Identification Method for College Students: A Mixed-Method Study. *International Journal of Environmental Research and Public Health,* 19. https://doi.org/10.3390/ijerph192214976

Liu, J., & Wang, H. (2022). Analysis of Educational Mental Health and Emotion Based on Deep Learning and Computational Intelligence Optimization. *Frontiers in Psychology, 13.* https://doi.org/10.3389/fpsyg.2022.898609

López González, Y. Y. (2023). Aptitud digital del profesorado frente a las competencias TIC en el siglo XXI: una evaluación de su desarrollo. *Región Científica, 2*(2), 2023119. https://doi.org/10.58763/rc2023119

Luan, H., Géczy, P., Lai, H., Gobert, J., Yang, S., Ogata, H., Baltes, J., Guerra, R., Li, P., & Tsai, C. (2020). Challenges and Future Directions of Big Data and Artificial Intelligence in Education. *Frontiers in Psychology, 11.* https://doi.org/10.3389/fpsyg.2020.580820

MacCann, C., Jiang, Y., Brown, L., Double, K., Bucich, M., & Minbashian, A. (2019). Emotional intelligence predicts academic performance: A meta-analysis. *Psychological bulletin, 146*(2), 150-186. https://doi.org/10.1037/bul0000219

Machuca-Contreras, F., Lepez, C. O., & Canova-Barrios, C. (2024). Influence of virtual reality and augmented reality on mental health. *Gamification and Augmented Reality, 2,* 25. https://doi.org/10.56294/gr202425

Maghsudi, S., Lan, A., Xu, J., & Schaar, M. (2021). Personalized Education in the Artificial Intelligence Era: What to Expect Next. *IEEE Signal Processing Magazine, 38,* 37-50. https://doi.org/10.1109/MSP.2021.3055032

Miranda-Moreno, V. M., & Sandoval-Obando, E. (2024). La educación expandida en contextos educativos formales e informales. *Región Científica, 3*(2), 2024321. https://doi.org/10.58763/rc2024321

Murtaza, M., Ahmed, Y., Shamsi, J., Sherwani, F., & Usman, M. (2022). AI-Based Personalized E-Learning Systems: Issues, Challenges, and Solutions. *IEEE Access, 10,* 81323-81342. https://doi.org/10.1109/access.2022.3193938

Mykhaylenko, V., Safonova, N., Ilchenko, R., Ivashchuk, A., & Babik, I. (2024). Using artificial intelligence to personalise curricula and increase motivation to learn, taking into account psychological aspects. *Data and Metadata, 3*. https://doi.org/10.56294/dm2024.241

Nadji-Tehrani, M., & Eslami, A. (2020). A Brain-Inspired Framework for Evolutionary Artificial General Intelligence. *IEEE Transactions on Neural Networks and Learning Systems, 31,* 5257-5271. https://doi.org/10.1109/TNNLS.2020.2965567

Nazari, N., Shabbir, M., & Setiawan, R. (2021). Application of Artificial Intelligence powered digital writing assistant in higher education: randomized controlled trial. *Heliyon, 7.* https://doi.org/10.1016/j.heliyon.2021.e07014

Ninaus, M., & Sailer, M. (2022). Closing the loop – The human role in artificial intelligence for education. *Frontiers in Psychology, 13.* https://doi.org/10.3389/fpsyg.2022.956798

Noroña González, Y., Colala Troya, A. L., & Peñate Hernández, J. I. (2023). La orientación para la proyección individual y social en la educación de jóvenes y adultos: Un estudio mixto sobre los proyectos de vida. *Región Científica, 2*(2), 202389. https://doi.org/10.58763/rc202389

Ogolodom, M. P., Daniel Ochong, A., Brownson Egop, E., Ugwem Jeremiah, C., Kenneth Madume, A., Nyenke, C. U., Dambele, M. Y., Joseph, D. Z., Bakre, A. F. K., Balogun, E. O., Alazigha, N., Okeji, M. C., Ordu, K. S., Hyacienth Uche Chiegwu, H. U. C., Johnson, J., Mbaba, A. N. M., & Kelechi Nwodo, V. (2023). Knowledge and perception of healthcare workers towards the adoption of artificial intelligence in healthcare service delivery in Nigeria. *AG Salud, 1,* 16. https://doi.org/10.62486/agsalud202316

Oladokun, B. D., Dogara, K., & Yusuf, M. (2024). Students' Attitudes and Experiences with ChatGPT as a Reference Service Tool in a Nigerian University: A Comprehensive Analysis of User Perceptions. *Gamification and Augmented Reality, 2,* 36. https://doi.org/10.56294/gr202436

Olusegun Oyetola, S., Oladokun, B. D., & Dogara, K. (2024). LIS Educators' Perception Towards the Adoption of AI Tools in Nigerian Library Schools. *Metaverse Basic and Applied Research, 3,* 65. https://doi.org/10.56294/mr202465

Pagano, T., Loureiro, R., Lisboa, F., Peixoto, R., Guimarães, G., Cruz, G., Araujo, M., Santos, L., Cruz, M., Oliveira, E., Winkler, I., & Nascimento, E. (2023). Bias and Unfairness in Machine Learning Models: A Systematic Review on Datasets, Tools, Fairness Metrics, and Identification and Mitigation Methods. *Big Data and Cognitive Computing, 7,* 15. https://doi.org/10.3390/bdcc7010015

Pal, R., Adhikari, D., Heyat, M., Guragai, B., Lipari, V., Ballester, J., Díez, I., Abbas, Z., & Lai, D. (2022). A Novel Smart Belt for Anxiety Detection, Classification, and Reduction Using IIoMT on Students' Cardiac Signal and MSY. *Bioengineering, 9.* https://doi.org/10.3390/bioengineering9120793

Palomino Quispe, J. F., Choque-Flores, L., Castro León, A. L., Requis Carbajal, L. V., Ferrer-Peñaranda, L.-A., García-Huamantumba, E., Dávila-Morán, R. C., & Velarde Dávila, L. (2024). The Transformative Role of Technology in Medical Education. *Salud, Ciencia y Tecnología, 4,* 657. https://doi.org/10.56294/saludcyt2024657

Pérez Gamboa, A. J., García Acevedo, Y., García Batán, J., & Raga Aguilar, L. M. (2022). La configuración de proyectos de vida desarrolladores: Un programa para su atención psicopedagógica. *Actualidades Investigativas en Educación, 23*(1), 1–35. https://doi.org/10.15517/aie.v23i1.50678

Pérez Valdivia, Y. O., Rojas Sánchez, G. A., Sánchez Castillo, V., & Pérez Gamboa, A. J. (2024). La categoría bienestar psicológico y su importancia en la práctica asistencial: Una revisión semisistemática. *Revista Información Científica, 103.* https://doi.org/10.5281/ZENODO.10615337

Posso-Pacheco, R. J., Gutiérrez-Ramos, E. A., Chica-Montero, N. J., Alemán-Aguay, J. A., Rondal-Guanotasig, M. D. C., & Mullo-Cóndor, K. S. (2024). Evaluation of Artificial Intelligence Technologies and the Metaverse in Adapting Pedagogical Strategies. *Metaverse Basic and Applied Research, 3,* 68. https://doi.org/10.56294/mr202468

Richards, B., Lillicrap, T., Beaudoin, P., Bengio, Y., Bogacz, R., Christensen, A., Clopath, C., Costa, R., Berker, A., Ganguli, S., Gillon, C., Hafner, D., Kepecs, A., Kriegeskorte, N., Latham, P., Lindsay, G., Miller, K., Naud, R., Pack, C., Poirazi, P., Roelfsema, P., Sacramento, J., Saxe, A., Scellier, B., Schapiro, A., Senn, W., Wayne, G., Yamins, D., Zenke, F., Zylberberg, J., Thérien, D., & Kording, K. (2019). A deep learning framework for neuroscience. *Nature Neuroscience, 22,* 1761 - 1770. https://doi.org/10.1038/s41593-019-0520-2

Rozov, K. (2020). About the need to change the content of professional training of a future informatics teacher in artificial intelligence. *Informatics in education,* 12-26. https://doi.org/10.32517/0234-0453-2020-35-4-12-26

Ruiz Díaz De Salvioni, V. V. (2023). Estrategias innovadoras para un aprendizaje continuo y efectivo durante emergencias sanitarias en Ciudad del Este. *Región Científica, 2*(1), 202338. https://doi.org/10.58763/rc202338

Sahlgren, O. (2021). The politics and reciprocal (re)configuration of accountability and fairness in data-driven education. *Learning, Media and Technology, 48,* 95 - 108. https://doi.org/10.1080/17439884.2021.1986065

Salas-Pilco, S., Xiao, K., & Oshima, J. (2022). Artificial Intelligence and New Technologies in Inclusive Education for Minority Students: A Systematic *Review. Sustainability, 14*(20), 13572. https://doi.org/10.3390/su142013572

Sánchez Cabezas, P., Amaiquema Márquez, F. A., & Ruíz Porras, M. C. (2024). Orientación educativa y formación continua del profesor universitario. Reflexiones de una experiencia en Ecuador. *Región Científica, 3*(1), 2024240. https://doi.org/10.58763/rc2024240

Schwartz, M., Hinesley, V., Chang, Z., & Dubinsky, J. (2019). Neuroscience knowledge enriches pedagogical choices. *Teaching and Teacher Education, 83,* 87-98. https://doi.org/10.1016/J.TATE.2019.04.002

Siddaway, A., Wood, A., & Hedges, L. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. *Annual review of psychology, 70,* 747-770. https://doi.org/10.1146/annurev-psych-010418-102803

Srivastava, S., Varshney, A., Katyal, S., Kaur, R., & Gaur, V. (2021). A smart learning assistance tool for inclusive education. *Journal of Intelligent & Fuzzy Systems., 40,* 11981-11994. https://doi.org/10.3233/JIFS-210075

Tapalova, O., Zhiyenbayeva, N., & Gura, D. (2022). Artificial Intelligence in Education: AIEd for Personalised Learning Pathways. *Electronic Journal of e-Learning, 20*(5). https://doi.org/10.34190/ejel.20.5.2597

Tymoshenko, N., Gordiichuk, G., Davydova, Z., Sirenko, P., & Dorozhko, Y. (2024). Utilising artificial intelligence in education: Current trends, challenges, and future directions. *Salud, Ciencia y Tecnología - Serie de Conferencias, 3*. https://doi.org/10.56294/sctconf2024.1134

Valencia Celis, A. U., Rosas Patiño, G., & Sánchez Castillo, V. (2023). La gestión del conocimiento ambiental: Propuestas en sistemas de educación. Bibliotecas. *Anales de Investigación, 19*(2), 7. http://revistas.bnjm.sld.cu/index.php/BAI/article/view/654

Velásquez Castro, L. A., & Paredes-Águila, J. A. (2024). Revisión sistemática sobre los desafíos que enfrenta el desarrollo e integración de las tecnologías digitales en el contexto escolar chileno, desde la docencia. *Región Científica, 3*(1), 2024226. https://doi.org/10.58763/rc2024226

Wei,X.,Sun,S.,Wu,D.,&Zhou,L.(2021).Personalized Online Learning Resource Recommendation Based on Artificial Intelligence and Educational Psychology. *Frontiers in Psychology, 12.* https://doi.org/10.3389/fpsyg.2021.767837

Wilson, S., & Anagnostopoulos, D. (2021). Methodological Guidance Paper: The Craft of Conducting a Qualitative Review. *Review of Educational Research, 91,* 651 - 670. https://doi.org/10.3102/00346543211012755

Xuan, D., Zhu, D., & Xu, W. (2021). The Teaching Pattern of Law Majors Using Artificial Intelligence and Deep Neural Network Under Educational Psychology. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.711520

Yi, P., & Li, Z. (2022). Construction and Management of Intelligent Campus Based on Student Privacy Protection under the Background of Artificial Intelligence and Internet of Things. *Mobile Information Systems, 22*(1), 2154577. https://doi.org/10.1155/2022/2154577

Yin, W. (2022). Personalized Hybrid Education Framework Based on Neuroevolution Methodologies. *Computational Intelligence and Neuroscience*, 2022. https://doi.org/10.1155/2022/6925668

Yue, M., Jong, M., & Dai, Y. (2022). Pedagogical Design of K-12 Artificial Intelligence Education: A Systematic Review. *Sustainability, 14*(23), 15620. https://doi.org/10.3390/su142315620

Zafari, M., Bazargani, J., Sadeghi-Niaraki, A., & Choi, S. (2022). Artificial Intelligence Applications in K-12 Education: A Systematic Literature Review. *IEEE Access,* PP, 1-1. https://doi.org/10.1109/ACCESS.2022.3179356

Zapata Muriel, F. A., Montoya Zapata, S., & Montoya-Zapata, D. (2024). Dilemas éticos planteados por el auge de la inteligencia artificial: Una mirada desde el transhumanismo. *Región Científica, 3*(1), 2024225. https://doi.org/10.58763/rc2024225

Zhan, Z., Shen, W., & Lin, W. (2022). Effect of product-based pedagogy on students' project management skills, learning achievement, creativity, and innovative thinking in a high-school artificial intelligence course. *Frontiers in Psychology, 13.* https://doi.org/10.3389/fpsyg.2022.849842

Zhang, Y., Yun, Y., An, R., Cui, J., Dai, H., & Shang, X. (2021). Educational Data Mining Techniques for Student Performance Prediction: Method Review and Comparison Analysis. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.698490