Education in the Knowledge Society

journal homepage http://revistas.usal.es/index.php/eks/

Ediciones Universidad Salamanca

Generative Artificial Intelligence and Education: An Analysis from Multiple Perspectives

Inteligencia artificial generativa y educación: Un análisis desde múltiples perspectivas

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ARTICLE INFO

Keywords
chatGPT, artificial intelligence, education, academia.

ABSTRACT

At the crossroads of advanced technology and pedagogy, Generative Artificial Intelligence (GenAI) is, at the very least, prompting a reassessment of traditional educational paradigms. Following a frenetic year in the advancement of GenAI, particularly after the emergence of ChatGPT, there is an intent to explore the impact of GenAI on the educational sector, analysed from the perspectives of four key groups: teachers, students, decision-makers, and software engineers. Throughout 2023 and into 2024, literature reviews, interviews, surveys, training sessions, and direct observations have been conducted to gauge how GenAI is perceived by individuals representing these groups within the educational context. It is highlighted how GenAI offers unprecedented opportunities for, among other things, personalising learning, enhancing the quality of educational resources, and optimising administrative and assessment processes. However, the application of GenAI in education also has a less favourable aspect related to reservations and mistrust, often due to a lack of literacy in issues related to AI in general, but also well-founded in some cases due to gaps in legislative, ethical, security, or environmental impact aspects. This analysis reveals that, although GenAI has the potential to transform education significantly, its successful implementation requires a collaborative and cross-sectional approach involving all actors in the educational ecosystem. As we explore this new horizon, it is imperative to consider the ethical implications and ensure that technology is used to benefit society at large without overlooking the risks and challenges that already exist or will inevitably arise with the accelerated development of these extremely powerful technologies.

Palabras clave
chatGPT, inteligencia artificial, educación, academia.

RESUMEN

En la intersección entre la tecnología avanzada y la pedagogía, la Inteligencia Artificial Generativa (IAGen) está provocando, como poco, el replanteamiento de los paradigmas educativos tradicionales. Después de un año frenético en el avance de la IAGen, especialmente tras la aparición en escena de ChatGPT, se quiere explorar el impacto de la IAGen en el sector educativo, analizado desde las perspectivas de cuatro colectivos clave: profesorado, estudiantado, perfiles de toma de decisiones e ingenieros/as de software. Durante 2023 y lo que llevamos de 2024 se han realizado revisiones de literatura, entrevistas, encuestas, formaciones y observaciones directas de cómo se percibe la IAGen por personas que representan a los colectivos anteriormente mencionados dentro del contexto educativo. Se destaca cómo la IAGen ofrece oportunidades sin precedentes para, entre otros aspectos, personalizar el aprendizaje, mejorar la calidad de los recursos educativos u optimizar los procesos administrativos y de evaluación. Sin embargo, la IAGen aplicada a la educación tiene otra cara menos amable que se relaciona con recelos y desconfianzas, debidas, en muchas ocasiones a una falta de alfabetización en aspectos relacionados con la IA en general, pero bien fundamentados en otras ocasiones por las lagunas existentes en cuanto a aspectos legislativos, éticos, de seguridad o de influencia medioambiental. Este análisis revela que, aunque la IAGen tiene el potencial de transformar significativamente la educación, su implementación exitosa requiere un enfoque colaborativo y transversal que involucre a todos los actores del ecosistema educativo. A medida que exploramos este nuevo horizonte, es imperativo considerar las implicaciones éticas y garantizar que la tecnología se utilice de manera que signifique un beneficio para la sociedad en general, sin obviar los riesgos y retos que ya existen o que ineludiblemente aparecerán con el desarrollo acelerado de estas tecnologías tan extremadamente potentes.

Received, 14/04/2024. Reviewed, 14/04/2024. Acepted, 14/04/2024. Published, 29/04/2024.
e-ISSN: 2444-8729

The 2023 volume of EKS opened with an article that echoed the launch of ChatGPT and its initial repercussions in the educational context (García-Peñalvo, 2023c). Now, as we approach the 2024 volume, approximately a year later, we can retrospectively view a year of dizzying advances that we could hardly have predicted, which have caused significant changes and implications across many business domains due to what we generally refer to as Generative Artificial Intelligence (GenAI). GenAI is the "production of unprecedented synthetic content, in any form and to support any task, through generative modelling" (García-Peñalvo & Vázquez-Ingelmo, 2023).

Given the events of this period, 2023 is already being referred to as the year of artificial intelligence (AI) disruption (Casal-Otero et al., 2023), primarily because AI has become a reality across virtually all business domains, integrated into the daily lives of citizens, effected changes in the perception of professional activities, and, most notably, popularised the automatic generation of content of all types with sufficient quality for use in real-world contexts.

At the time of writing the EKS editorial article in 2023, the focus of GenAI was primarily on the emergence of the ChatGPT application, which is seen as a disruptive element. It offers a freely accessible chatbot through a straightforward interface that enhances user experience by providing valuable and plausible responses to queries made in natural language. The acceptance of ChatGPT was so great that it surpassed one million users within five days, and by the end of January 2023, it had reached 100 million users (Mahajan, 2023).

Technically, ChatGPT is based on GPT-3.5 (Brown et al., 2020), a Large Language Model (LLM) (Zhao et al., 2023) with an architecture of 175 billion parameters capable of handling a context window of 4,096 tokens (approximately equivalent to about 2,500 words).

The emergence of ChatGPT has resulted in extremist attitudes ranging from enthusiasm to undue fear (Lim et al., 2023), from the most naive position of absolute trust to the most stubborn disdain (Llorens-Largo, 2019).

Approximately one year later, the advances in the world of GenAI and Large Language Models (LLMs) have been remarkable in terms of quantity, quality, and capabilities, all within a very short period of time, leading us to think of Ray Kurzweil's Law of Accelerating Returns (2001). Thus, by early 2024, ChatGPT is considered the leading artificial intelligence application, with about 14 billion views (Sarkar, 2023) (approximately 1.5 billion monthly visits) and 180 million users (Duarte, 2024). There is a paid version of ChatGPT (ChatGPT Plus) and a free access version, which already creates a gap in access to knowledge and the possibilities these tools offer. From a technical perspective, ChatGPT Plus is based on GPT-4.0 (OpenAI, 2023a), with a context window that varies between different model versions but ranges from 32K to 128K tokens. Information about GPT-4.0 has not been opened to the community. It is estimated to be a model of about 1.8 trillion parameters organised as a Mixture of Experts (MoE) (Shen et al., 2023), with 16 experts of 111 billion parameters, plus a backbone of 55 billion parameters, activating only two experts for each inference (280 billion parameters) (Patel & Wong, 2023; Santana, 2023).

A significant advancement since January 2023 is that ChatGPT, and GPT in general, are not alone; there is a multitude of models competing to provide the best results, which are utilised through chat applications, web browsers, integrated into various applications, or tools embedded in mobile devices. The list of tools and technologies would be lengthy. Still, notably, Google's offering through Bard and its potent family of LLMs called Gemini (McIntosh et al., 2023; Pichai & Hassabis, 2024) and Microsoft's Copilot tool (Grush, 2023) are discussed for their relevance. The range of LLMs is constantly expanding, now being augmented by Large Multimodal Models (LMMs) (Yang et al., 2023) that exhibit multimodal capabilities, such as visual understanding, exemplified by Gemini or GPT-4V (OpenAI, 2023b). However, most of these LLMs focus on English as the language for interaction and task execution (Held et al., 2023), rendering them somewhat limited for multilingual environments, especially in resource-scarce scenarios. To enable LLMs to be effective in various languages, thus extending their benefits to a more significant portion of the global population, Multilingual Large Language Models (MLLMs) have been defined, which have the advantage of comprehensively managing multiple languages (Qin et al., 2024).

However, from an educational perspective, the summary of this intense period could focus on the fact that the generation of educational content in digital formats (text, image, video, presentations, audio, etc.) is now a reality. Additionally, these contents possess sufficient quality to be used as teaching materials or outcomes of teaching activities (Fonseca-Escudero et al., 2023). In most cases, it is impossible to ascertain their origin with sufficient certainty (Biderman & Raff, 2022; Sadasivan et al., 2024).

Nevertheless, the debate on the application of AI in education has shifted its focus. From traditional perspectives – that concentrated on (Wang & Cheng, 2021) **learning from AI**, where AI is the primary means of learning for students (e.g., intelligent tutors [Zhong & Zhan, 2024], adaptive or personalised learning [Huang et al., 2023], robotics [Conde et al., 2021], etc.); **learning about AI**, where the goal is to equip both students (future citizens and professionals) and teachers with the right competencies to interact symbiotically with various AIs (Long &

Magerko, 2020); and **learning with AI**, where AI tools are used to enhance teaching and learning practices (e.g., learning analytics [Yan el tal., 2024], academic analytics [Gampis et al., 2022], etc.) – to how to teach and learn in the era of AI. This scenario involves reflecting on how to prepare the population for a constantly changing world, how AI influences teaching/learning processes, and how the new knowledge, skills, competencies, and values impact life and work in the AI era. This leads us to a situation that does not replicate the clichéd battle between humans and intelligent machines typical of science fiction imagination but instead presents a competition for jobs between those who have had access to and training in AI and those who have not, defining a new technological divide in society.

In this new universe of possibilities, individuals must educate themselves and become technologically literate to augment their natural intelligence with the opportunities derived from artificial intelligence, thus becoming digital centaurs who will need to make their decisions with the support of AI (Marina, 2020).

Generative AI: A 360° view of its benefits, risks, and educational challenges

Learning can be understood as an ecology (García-Peñalvo, 2018) where the components of the underlying ecosystem reflect a mix of technological elements that are increasingly intelligent and capable of providing services, and people occupy various roles.

Throughout 2023, there was an opportunity to engage in various activities (training courses and workshops (García-Peñalvo, 2023a), keynote lectures (García-Peñalvo, 2023b), literature reviews (García-Peñalvo et al., 2024), studies (Amo-Filva et al., 2023), communities of practice (García-Peñalvo, 2023d), editing special issues in academic journals (Alier, García-Peñalvo, & Camba, 2024), that have allowed the observation, training, and interviewing of the different actors that would make up a learning ecosystem, with particular attention to higher education but not exclusively, regarding their perceptions and uses of GenAI. With the experience gained, work has been carried out on defining a reference framework that explains how key groups (teachers, students, decision-makers, and software engineers) view GenAI, distinguishing elements of potential positive impact, harmful and risky aspects, good practices, and the main open challenges in the short, medium, and long term (García-Peñalvo, 2024b, 2024c). This paradoxical view between the positive and the negative, between possible benefits but at the cost of significant efforts and not ignoring significant risks, is explained by Griffiths et al. (2024) as the result of the clash between the paradigms of communication transmission and coordination that occurs in teaching/learning processes, primarily because the core of educational action consists of communication between people, that is, conversations among the actors, where the roles previously identified are included.

The latest revision of this reference framework is presented below.

Teachers

- *Positive impact*:
  - Enrichment of educational content (Cooper, 2023).
  - Enhancement of teachers' creativity (Nerantzi et al., 2023).
  - Improvement of teachers' productivity (Cotton et al., 2024).
  - Assessment support (Khan et al., 2023).
  - Facilitation of personalised learning (Sallam, 2023).
  - Improvement of digital teaching competencies (García San Martín, 2024).
- *Negative aspects and risks:*
  - Reluctance to allow students to use GenAI tools (Johinke et al., 2023).
  - Overvaluation of GenAI (Zapata-Ros, 2023).
  - Inappropriate use of GenAI tools (Sabzalieva & Valentini, 2023).
  - Excessive technological dependency (Llorens-Largo et al., 2023).
  - Loss of authorship of academic materials (Gašević et al., 2023).
  - Depersonalisation of the teaching/learning process (Lee, 2023).
  - Attacks on personal privacy (Iskender, 2023).
- *Good practices:*
  - Need for continuous teacher training (Choi et al., 2023).
  - Balanced integration of GenAI in instructional design (García-Peñalvo et al., 2024).
  - Promotion of ethical behaviour and data protection (Flores-Vivar & García-Peñalvo, 2023).

    - Development of supplementary educational content (Sabzalieva & Valentini, 2023).
    - Use of GenAI tools as virtual assistants for teachers (Crawford et al., 2023).
    - Exploration of new assessment forms and support in the evaluation process (García-Peñalvo, 2024a).
- *Future challenges:*
    - Digital transformation and educational innovation in the classroom require the natural integration of Artificial Intelligence into teaching spaces (Martínez-Arboleda, 2024).
    - Collaborative development of more specific and economically sustainable language models, such as Small Language Models (SLM) (Ghosh, 2023).

Students

- *Positive impact:*
    - Enhancement of their critical thinking and creativity (Vartiainen & Tedre, 2023).
    - Facilitation of idea prototyping (Iskender, 2023).
    - Enabling personalised learning (Gilson et al., 2023).
    - Improvement in student productivity (Crawford et al., 2023).
    - Access to more educational resources that can also be more innovative (Denny et al., 2024).
    - Enhancement of digital competence among students (Kartal, 2023).
- *Negative aspects and risks:*
    - Dishonest use (Gallent-Torres & Comas-Forgas, 2024).
    - Superficial learning (Mustak et al., 2023).
    - Content generated with errors (Mustak et al., 2023) or fabricated (hallucinations) (Li et al., 2024), coupled with students' potential lack of knowledge to curate received information (Llorens-Largo et al., 2023).
    - Barriers to developing students' critical thinking and creativity (Thurzo et al., 2023).
    - Depersonalisation of the teaching/learning process (Lee, 2023).
    - Inequitable access to such technologies (Evans et al., 2023).
- *Good practices:*
    - Support and development of linguistic competencies (Cotton et al., 2024) and writing skills (Crawford et al., 2023).
    - Ability to summarise information in different formats (text, mind maps, etc.) (Pavlik, 2023).
    - Use of GenAI tools as virtual assistants for students (García-Peñalvo, 2023c).
    - Using GenAI tools as a Socratic opponent (Choi et al., 2023).
    - Ethical awareness among students (Tlili et al., 2023).
- *Future challenges:*
    - Preparation for the future workforce in the AI era (Aoun, 2018).
    - Need for ongoing training and informal learning (Choi et al., 2023).

Decision-makers

- *Positive impact:*
    - Improvement in administrative efficiency (Llorens-Largo & García-Peñalvo, 2023).
    - Enhancement of academic analytics (de Souza Zanirato Maia et al., 2023).
    - Enrichment of the educational process (Llorens-Largo et al., 2023).
    - Increase in competitiveness (Hannan & Liu, 2023).
- *Negative aspects and risks:*
    - Inequality in access to these technologies (Leal Filho et al., 2024).
    - Issues arising from data security and privacy (Pedreño Muñoz et al., 2024).
    - Technological dependency on private companies (Alier, García-Peñalvo, & Camba, 2024).
    - Biases in training sources are reproduced in the synthetic data generated (Bartlett & Camba, 2024).
    - Environmental impact (Cooper, 2023).
- *Good practices:*
    - Training of students, service personnel, and faculty (Pedreño Muñoz et al., 2024).
    - Review of teaching methods (Denny et al., 2024).

- Exploration of new assessment formats (Pearce & Chiavaroli, 2023).
- Development of ethical codes and general guidelines (Masters, 2023).
- Collaboration and strategy development with other educational institutions (Llorens-Largo & García-Peñalvo, 2023).
- *Future challenges:*
- Review of curricular content (Johinke et al., 2023).
- Integration of AI in the institutional digital transformation strategy (Llorens-Largo & García-Peñalvo, 2023).
- Improvement in change management (Pedreño Muñoz et al., 2024).
- Ensuring equity and access to GenAI (Verma et al., 2023).

Software Engineers (for the development of new educational technologies)

- *Positive impact:*
  - Innovation and creativity in learning technologies (Bozkurt, 2023).
  - Evolution of technological ecosystems for learning (Vázquez-Ingelmo et al., 2022).
- *Negative aspects and risks:*
  - Biases in training sources (Vardi, 2023).
  - Complexity in developing, deploying, and maintaining intelligent educational applications (Bandi et al., 2023).
  - Dependency on third-party APIs (Llorens-Largo & García-Peñalvo, 2023).
  - Data security and privacy issues (Gupta et al., 2023).
  - Environmental impact (Berthelot et al., 2023).
- *Good practices:*
  - Enhancement of the user experience in learning technologies (Hyun Baek & Kim, 2023).
  - Development of ethical (Prem, 2023) and explainable AI (Khosravi et al., 2022).
- *Future challenges:*
  - Definition of a new generation of educational applications (Lytras, 2023) (smart apps (Alier, Casañ, & Amo, 2024; Alier, García-Peñalvo, & Camba, 2024)).
  - Interdisciplinarity to ensure effective learning (Hodges & Kirschner, 2024).
  - Continuous technological updating (wael Al-khatib, 2023).
  - Reduction of environmental impact (Chien et al., 2023).

Reflections

Technology, in its essence, is neither inherently good nor bad, but it is also not neutral (Kranzberg, 1986); its impact derives from how it is applied and integrated into existing systems. The adoption of GenAI tools, such as ChatGPT, by students at all educational levels reflects their penetration into everyday life. Studies in the United States already show a 49% adoption of GenAI by university students in the last semester of 2023, encompassing academic activities and other domains performed by regular and occasional users of these technologies (Tyton Partners, 2023). This suggests that we are facing the first generation of teachers confronted with students equipped with cutting-edge technological devices and instant access to AI (Álvarez, 2023).

The rapid advancement of AI in education arouses both excitement and concern. While the potential to radically transform teaching and learning processes is undeniable, so is the need to approach new possibilities with caution yet audacity (Fernández Enguita, 2024). The temptation to ban these tools in educational contexts should give way to a concerted effort to understand what they can offer, especially in critical analysis and formulating relevant questions.

Beyond the imminent digital disruption, AI offers the opportunity to move toward a more profound transformation of the educational system. However, this transformation is still in process and has yet to be fully realised. Both teachers and students must be trained to use AI ethically, emphasising the importance of critical thinking to maximise its potential.

Furthermore, it is essential to generate communities of practice where teachers can share experiences and support each other, fostering innovation. It is crucial to recognise that many of the problems identified in the educational context are not new or caused exclusively by emerging technologies like ChatGPT; however, the impact and speed of adopting these technologies exacerbate some of these challenges.

AI, especially with its ability to create content indistinguishable from that produced by humans and to interact in natural language, represents one of the most disruptive technological advances of our time. We are still exploring the possibilities, risks, and challenges that this technology opens up. The future built on this foundation must not be shaped solely by technologists but in spaces of inter and transdisciplinary co-creation that ensure these technologies' ethical, secure, and inclusive development, which until recently might have been considered science fiction.

As we navigate this new technological landscape, we must balance bold exploration with a solid commitment to ethics and equity, ensuring that the education of the future leverages the best of AI without falling into its potential pitfalls.

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