Generative Artificial Intelligence. Open Challenges, Opportunities, and Risks in Higher Education

Francisco José García-Peñalvo

GRIAL Research Group, Computer Science Department, Research Institute for Educational Sciences (IUCE), Universidad de Salamanca, Salamanca, Spain

Abstract

In recent months, the intertwined narratives of education and artificial intelligence have gained remarkable momentum, framing dialogues on the future of learning and teaching. The potency of generative artificial intelligence, particularly in higher education, offers a rich tableau of both promises and perils. This paper delves into the challenges, opportunities, and risks of such technologies within the ambit of higher education. The confluence of generative artificial intelligence and higher education is undeniably transformative. It beckons an era where personalised, globally accessible, and highly efficient education might become the norm. In essence, while generative artificial intelligence stands as a formidable tool in the arsenal of higher education, its deployment must be thoughtful, ethical, and always in service of enhancing human-centric education, which must comply with universities' digital transformation strategies.

Keywords

Education, Artificial Intelligence, Generative Artificial Intelligence, Higher Education

1. Introduction

Before November 30, 2022, artificial intelligence (AI) was already beginning to permeate various facets of daily life, albeit in a more concealed manner. Smart devices, harnessing "soft intelligence", have become ubiquitous in many homes. These devices, while intelligent, were often perceived as mere tools or assistants, aiding in everyday tasks or streamlining processes [1]. Notwithstanding their widespread adoption, a cloud of ambiguity hovered over the term "intelligence" as many businesses employed it chiefly as a market label or as a "suitcase word", as described by Marvin Minsky [2]. Concurrently, the emergence of some AI applications, such as deepfakes, stoked both astonishment and trepidation [3]. These instances were emblematic of AI's duality: its potential to revolutionise and its capacity to destabilise. Consequently, discourse often revolved around AI's future implications—how it might reshape job markets, redefine educational paradigms, and pose ethical conundrums. The public's perception was a mosaic, composed of tangible soft smart applications, devices, and a looming shadow of potential future disruptions, much of which was fuelled by the AI Collective Imagination [4].

However, post-November 30, 2022, with the appearance of ChatGPT by OpenAI (https://openai.com/blog/chatgpt/), the abstractness of AI began to dissolve. The technology shifted from being a conceptual marvel of the future to a tangible reality of the present in every domain [5-8]. AI became entrenched in virtually every domain, heralding a wave of innovation and integration. Thousands of applications surfaced rapidly, each touting AI capabilities, reshaping industries and user experiences. Nevertheless, as with all disruptive technologies, AI's proliferation was accompanied by a duality of public sentiment [9].

Proceedings for the 14th International Conference on e-Learning 2023, September 28-19, 2023, Belgrade, Serbia
EMAIL: fgarcia@usal.es (A. 1)
ORCID: 0000-0001-9987-5584 (A. 1)

On one hand, the benefits—efficiency, personalisation, and accessibility—became more palpable than ever. On the other hand, fears were exacerbated by the potential misuse of the technology and the pervasive misunderstandings surrounding it.

The narrative around AI has evolved. Discussions were no longer confined to hypothetical scenarios but addressed tangible job, education, and ethics challenges. With AI no longer on the distant horizon but right at society's doorstep, the apprehensions borne out of the AI Collective Imagination took on a more urgent hue. The implications of this shift are profound, demanding a more nuanced understanding and navigation of the AI landscape in the present rather than as a distant future concern.

ChatGPT is an avant-garde chatbot designed to produce text in response to user queries articulated in natural language via an intuitive interface. Initial interactions with ChatGPT were remarkable for their adeptness, often likened to responses one might expect from a human expert. Its profound capability not only established it as a pivotal advancement in the AI sector but also caused ripples in the broader scientific community, leading many to perceive it as a significant stride towards the realisation of artificial general intelligence (AGI) [10]. Some have even begun speculating on its trajectory towards superintelligence [11], underscoring its transformative potential.

On 14 March 2023, ChatGPT witnessed a ground-breaking enhancement with the release of version 4.0. This iteration brought to the fore an array of sophisticated features, including the ability to manage an unprecedented 25,000 words simultaneously and showcase superior reasoning capabilities. Notably, it was tested on the bar examination, succeeded in passing, and achieved a score within the top 10%, highlighting its versatility and profound comprehension. May 2023 marked another seminal moment in ChatGPT's evolution as it was endowed with a real-time connection to the Internet, exponentially broadening its horizon of information access and response generation. A few months later, in September 2023, OpenAI further augmented ChatGPT by integrating voice and image processing capabilities, heralding a new era of multimodal interaction, indicating a commitment to refining and expanding the user experience.

ChatGPT's trajectory from its inception to its current state embodies a confluence of technological prowess and visionary innovation, setting new benchmarks in pursuing AGI. Its developments, both in terms of cognitive capabilities and interface improvements, underscore its prominence in the ongoing AI revolution.

Defining artificial intelligence is extremely difficult because there are different paradigms or approaches to developing [12]. According to John McCarthy, one of the fathers of Artificial Intelligence, it can be defined as "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable" [13].

The general term AI or specific types of AI, such as machine learning [14] or deep learning [15], for example, can be misleading for those unfamiliar with the subject, as no thinking is involved. In this context, learning means recognising patterns in data (such as a high correlation between frequency and complexity) and making predictions about new data, which implies that AI does not mean understanding or reasoning.

One of the AI types is the generative artificial intelligence (GenAI) [16]. This branch of AI has brought about the last real disruption in the field of information technology, considering a disruptive moment when the digitised product or service outperforms the analogue product or service in terms of efficiency or cost [17]. This disruption is due to GenAI's aim of generating digital content.

GenAI has not begun with ChatGPT or similar tools. García-Peñalvo and Vázquez-Ingelmo analysed 631 articles published between January 2019 and May 2023, and obtained a curated set of real-world applications for AI-driven content generation. These solutions included generating various resources (images, tabular data, 3D models, videogame assets, etc.) to support different tasks in several domains. What they do have in common is that every solution employed generative, not discriminative, models, allowing to define GenAI as the "production of previously unseen synthetic content, in any form and to support any task, through generative modelling" [18].

Behind the GenAI tools are the large language models (LLM) [19]. The language models have evolved since the early 1990 statistical language models (SLM) [20], the neural language models (NLM) [21], and the pre-trained language models (PLM) [22] to the LLMs, which scale the PLMs (e.g., model size or data size) for improving the models' capability in downstream tasks.

Whenever a promisingly disruptive technology emerges, it is accompanied by both technophile and technophobe discourses and positions. Examples of these extremes might be the position of Chomsky et al.: "Generative Artificial Intelligence undermines our scientific pursuits and compromises our moral principles by integrating a fundamentally erroneous understanding of language and knowledge" [23] or Gates "The development of AI is as fundamental as the creation of the microprocessor, the personal computer, the Internet, and the mobile phone. It will change the way people work, learn, travel, get health care, and communicate with each other. Entire industries will reorient around it. Businesses will distinguish themselves by how well they use it. […] The world needs to make sure that everyone—and not just people who are well-off—benefits from artificial intelligence. Governments and philanthropy will need to play a major role in ensuring that it reduces inequity and doesn't contribute to it" [24].

The discourse surrounding integrating AI, particularly generative models like ChatGPT, into the educational milieu has been a source of profound contention. Analogous to the advent of calculators in pedagogical settings, generative AI has initiated recalibrations in curricular objectives [25]. Just as the calculator's omnipotent computational prowess rendered the emphasis on manual mathematical calculations in classrooms somewhat redundant, the capabilities of GenAI challenge the conventionally imparted skill sets. However, it is salient to note that the ubiquity of calculators did not culminate in the obsolescence of manual mathematical proficiencies. Similarly, while the potential of AI tools in education is undeniable, their mere presence should not presage the eradication of foundational learning. Historically, attempts at prohibition, rather than judicious integration, have yet to yield the intended results. Thus, the pedagogical community stands at a crossroads, tasked with harmonising AI's transformative capabilities with holistic education's imperatives.

The most widespread position is a mixture of enthusiasm and apprehension [26], avoiding the extremes of naïve technophiles, who defend technology without analysing the risks it entails, and recalcitrant technophobes, who reject technology simply because it is technology, without stopping to think about its benefits [27]. The goal of this paper is to present the real scenarios of the integration of GenAI into education.

The paper is organised as follows. Section 2 summarises the relationship between AI and education. Section 3 journeys through the potentials, the risks, and the challenges of AI and GenAI in education. Section 4 reflects some possible educational scenarios incorporating GenAI in the daily of teachers and students of all educational levels. Section 5 closes the paper with some open-reflections about AI in education.

2. Artificial intelligence in education: Navigating the trichotomy of integration

The landscape of education, historically resistant to change, has begun to undergo a transformative shift with the advent of AI. This metamorphosis is fundamentally anchored in three primary paradigms of AI's integration: learning from AI, learning about AI, and learning with AI [28]. Each approach offers distinct prospects and challenges, carving a unique niche in the vast expanse of pedagogy.

Firstly, the principle of learning from AI envisages AI as the central conduit for knowledge dissemination. The quintessential example of this approach is Intelligent Tutoring Systems (ITS) [29, 30]. Driven either by rule-based mechanisms or advanced machine learning algorithms, ITS platforms epitomise adaptability [31, 32]. They possess the acumen to tailor instructional content and delineate learning trajectories based on a student's behavioural patterns, interests, and inherent aptitudes [33]. This bespoke form of education promises a more personalised and efficacious learning experience, potentially mitigating the traditional 'one-size-fits-all' model of instruction.

Conversely, the imperative of learning about AI foregrounds the pedagogical need to equip students and educators with a foundational understanding of AI [34]. As we steer into a future where AI is no longer a mere augmentation but an integral facet of daily life, possessing the competencies to navigate, manage, and cohabit with various AI tools becomes non-negotiable. This paradigm emphasises AI's technicalities and accentuates the ethical, societal, and practical implications of living harmoniously with these intelligent entities [35].

The third approach, learning with AI, conceptualises AI as a collaborator rather than a tutor or a subject. This perspective is best exemplified by Learning Analytics (LA) [36, 37] and Academic Analytics (AA) [38, 39], wherein AI tools enhance learning and teaching practices. By meticulously

analysing vast swathes of academic data, these tools can offer insights into pedagogical efficacy, student engagement, and areas of improvement. This data-driven approach to education could catalyse more informed instructional strategies and foster an environment of continuous improvement.

Nevertheless, as we transition into this AI-augmented epoch, profound reflections on the essence and objectives of education become imperative. What role does education play in a world continually moulded by intelligent technologies? How do these AI applications recalibrate the fundamental triad of teaching, learning, and assessment? What new skills, knowledge, values, and competencies become paramount for life and vocation in this AI-dominated era? As we grapple with these questions, it becomes increasingly evident that education, in the age of AI, must adapt and envision, ensuring that it remains a beacon of holistic development amidst rapid technological advancements.

3. Generative AI in education: Navigating paradoxical perceptions

Integrating GenAI in educational spheres has elicited a broad spectrum of reactions, oscillating between fervent enthusiasm and discerning apprehension. This complex interplay of sentiments is succinctly encapsulated in the four paradoxes Lim et al. postulated [26]. Firstly, the notion that generative AI serves simultaneously as a “friend” and a “foe” underscores the duality of its potential: on the one hand, it can be a catalyst for personalised, efficient, and globally accessible education; on the other, it poses challenges related to data privacy, quality of content, and perhaps, an over-reliance that might eclipse critical human faculties.

Further delving into this ambivalence, the second paradox suggests that while GenAI is undeniably “capable”, boasting abilities to customise learning experiences and provide instantaneous feedback, it remains “dependent” on human input, guidance, and the quality of data it is fed. This emphasises the symbiotic relationship between AI and human oversight in educational settings, challenging the misconception that AI can be a standalone solution. The third conundrum, positing GenAI as both “accessible” and "restrictive", touches upon its democratising potential to bridge educational divides. However, it highlights concerns about equitable access, potential biases in algorithms, and the homogenisation of learning experiences.

The final paradox, observing that GenAI garners heightened “popularity” when “banned”, accentuates the human proclivity towards the allure of the prohibited. Such bans, often stemming from genuine concerns about misuse or ethical dilemmas, inadvertently pique curiosity, amplifying interest and engagement with the technology. As we pivot towards a discourse on the multifaceted benefits, risks, and challenges of GenAI in education, these paradoxes offer a nuanced foundation, urging stakeholders to tread the AI path with a balanced, informed, and critical perspective.

3.1. Generative AI in education: A panorama of potential benefits

Navigating the intricate tapestry of GenAI in education, as underscored by the aforementioned paradoxes, leads us naturally to a contemplative juncture: What does this technological marvel specifically offer to the realm of pedagogy? To truly harness the capabilities of GenAI, it becomes imperative to elucidate its potential benefits, casting light on the transformative prospects that could redefine educational landscapes. As we transition into this exploration, considering how these advantages might align with, or perhaps diverge from, traditional pedagogical practices and objectives are worth considering.

GenAI’s foray into the educational sector holds transformative promise, reshaping the pedagogical landscape through a series of potent advantages [40]. One of the most conspicuous benefits is its unparalleled ability to access, process, and succinctly summarise vast swathes of information in real-time, presenting it with a semblance of human touch [41]. This capability opens the floodgates to a vast reservoir of educational content, broadening the horizon for learners and educators alike.

Beyond mere information retrieval, GenAI is a supportive tool in the learning journey. It transcends traditional media’s limitations by adeptly summarising or elucidating intricate concepts, crafting an interactive pedagogical dialogue [42]. This nuanced understanding of context, allowing for dynamic interactions, aids in fostering an environment wherein critical thinking and creativity flourish [43]. Through AI’s feedback mechanisms, students can challenge and refine their preconceived beliefs,

instigating deeper introspection. Moreover, the technology's prowess in automating repetitive tasks ensures students focus on the quintessential aspects of their learning, honing a more analytical and critical mindset [44].

In the creative realm of ideation, GenAI emerges as a catalyst, facilitating the initial germination of ideas and fostering reflective contemplation upon them [45]. This is further enhanced by its capacity to offer bespoke, personalised learning experiences catering to individual student trajectories [46]. Particularly transformative is its role in aiding students with writing challenges, bestowing them augmented control over their writing prowess [47]. This metamorphoses into a broader application where GenAI assumes the role of a virtual learning assistant [9], perpetuating continuous and informal learning paradigms.

From a linguistic perspective, the tool proves invaluable in bolstering language skills, offering targeted feedback and practice avenues [48]. Teachers, the linchpins of the educational ecosystem, too, reap the dividends of GenAI. Educators can reclaim their time by automating myriad tasks, from repetitive query resolutions to assignment gradings, directing their energies towards nuanced pedagogical endeavours like personalised feedback provision and holistic student support [49]. This segues into automated assessment encapsulates the broader potential of GenAI, heralding a wave of innovative evaluation methodologies that promise to redefine educational assessment paradigms [47].

3.2. Generative AI in education: A cautionary perspective on challenges

While the allure of GenAI in education, with its myriad benefits, cannot be understated, a balanced discourse necessitates that we pivot our attention to the other side of the coin. As we delve deeper into the complexities of integrating such a potent technological tool into pedagogical settings, we must shed light on the potential pitfalls. Anticipating and understanding these risks will ensure a judicious application of GenAI and safeguard education's foundational ethos and objectives from unforeseen adversities [40].

One of the immediate concerns is the facilitation of rapid yet superficial learning [49]. Such an approach could deter students, hampering them from cultivating the critical and independent thinking skills instrumental to their long-term intellectual growth [50].

Further, the spontaneity and ease of AI-generated answers can sometimes stymie the organic development of creativity [44]. By consistently presenting ready-made solutions, there is the risk of depriving students of the struggle and iterative processes often vital for creative maturation. Moreover, tangible concerns regarding the information's veracity and completeness exist in [25]. Instances, where GenAI offers incomplete data can lead to misconceptions or a skewed understanding of intricate concepts. This is exacerbated when the AI, striving for coherence, furnishes seemingly plausible yet fundamentally incoherent responses, often termed "hallucinations" [51].

The opacity surrounding the provenance of the information, devoid of any authorship or evidentiary backing, further muddies the waters. Not only does this risk the propagation of misinformation, but it can also inadvertently breach copyright norms [52]. A more subtle yet profound impact is on the socio-emotional facet of learning. Over-reliance on AI tools could diminish interpersonal skills, potentially eroding the rich tapestry of peer-to-peer and student-teacher interactions, foundational for holistic learning [53].

Ethical ramifications, too, come to the fore, especially concerning academic integrity. The ease of obtaining AI-generated content presents the temptation of dishonest appropriation, blurring the lines of plagiarism [54]. Socio-economic disparities in accessing these tools, particularly the premium iterations, raise equity concerns, potentially exacerbating the digital divide [26]. Concurrently, the omnipresent spectre of privacy invasion looms large, given the vast data repositories these applications engage with [55].

More insidiously, biases entrenched in data used to train these AI tools can perpetuate racial and socio-economic prejudices, subtly influencing learner outcomes [56]. Lastly, an often-overlooked facet is the environmental cost. The prodigious processing power and energy required for these AI functionalities can have significant environmental implications [42].

3.3. Generative AI in educational institutions: Navigating the uncharted waters of open challenges

Having illuminated the potential benefits and risks associated with implementing GenAI, it is crucial to distil this conversation further to focus on the specific challenges educational institutions might face. As these establishments form the bedrock of the educational system, understanding their unique predicaments and constraints becomes paramount. Before we delve into detailed considerations, it is pivotal to recognise that while GenAI might offer transformative capabilities, its incorporation has intricate hurdles for institutions aiming to preserve the essence of pedagogical excellence [40].

At the forefront of these challenges lies the dynamic and ceaselessly evolving digital ecosystem [57] propelled by GenAI. Educational institutions face the formidable task of ensuring the seamless adaptation of all stakeholders – from teachers and administrative staff to students and parents – to this digital metamorphosis [26].

Central to this adaptation is the upskilling of educators. A paramount concern is equipping teachers with the requisite competencies in GenAI, not merely from a functional standpoint but with a more profound understanding of its pedagogical implications [58]. This necessitates the cultivation of robust communities of practice [41], fostering collaborative spaces where educators can exchange experiences, strategies, and insights on the judicious incorporation of AI in their teaching paradigms.

Further complicating the landscape is the pressing need to inculcate students with a robust foundation in GenAI. Beyond mere operational proficiency, it is vital to instil critical thinking aptitudes that empower students to discern the capabilities and constraints of AI, ensuring its ethical utilisation [9]. This, in turn, dovetails into the broader challenge of curriculum revitalisation [59]. In an age where information is in flux, educational institutions must overhaul outdated curriculum content and pedagogical methodologies. This endeavour is not solely academic but requires fostering a culture that embraces change, mitigating resistance and stimulating reflective contemplation among students.

Assessment paradigms, too, beckon a reimagining. Traditional evaluative metrics may no longer suffice in a world augmented by AI. Institutions are thus prompted to explore a spectrum of assessment modalities [9]. This could range from integrating oral evaluations, which lend a personal touch, to fostering open-ended evaluations and championing originality and creativity. Visual tools and a pronounced emphasis on the learning journey, rather than a myopic focus on the end product, are becoming pivotal.

Lastly, but perhaps most critically, resides the ethical dimension [60]. The onus is on educational institutions to craft and implement rigorous ethical codes, establishing unambiguous guidelines concerning GenAI. Such guidelines should be enshrined with responsible and ethical AI usage principles, serving as a beacon for all educational endeavours in this brave new world.

4. Emerging scenarios for the application of generative AI in education

GenAI, with its capacity to dynamically craft responses and offer personalised content, makes possible new approaches in education. The question should not be how to prevent students from cheating us by using these technological tools but how we should use them [61]. The integration of these AI tools into various educational paradigms has paved the way for a myriad of innovative scenarios and practices [62-64]:

1. Possibility engine. The AI serves as a tool for diversifying expression. Upon formulating queries in platforms like ChatGPT, students can utilise the 'Regenerate response' feature, delving into a spectrum of ways a singular idea can be articulated, thereby broadening their linguistic and cognitive horizons.

2. Socratic opponent. By simulating an adversarial setting, the AI aids students in honing their argumentative prowess. Students can structure a dialogue or debate within ChatGPT, and in preparation for classroom discussions, they can anticipate counterarguments and sharpen their rhetoric.

3. Collaboration coach. This scenario envisages AI as a conduit for collective problem-solving and research. In their collaborative endeavours, students can employ ChatGPT as a repository of information, thus facilitating their group assignments.

4. Guide on the side. Rather than being at the forefront, AI is a supportive guide in this role. Educators can harness the power of ChatGPT to conjure content for their courses, be it framing thought-provoking discussion questions or devising strategies to elucidate intricate concepts.

5. Personal Tutor. This paradigm encapsulates AI's potential for bespoke pedagogy. ChatGPT, armed with data from students or educators, can furnish tailored feedback, providing real-time insights into a student's progress.

6. Co-designer. AI is involved in pedagogical design. Educators seeking to craft or revamp a curriculum can solicit ideas from ChatGPT, emphasising aligning the content with overarching academic goals.

7. Exploratorium. AI can stimulate exploration by serving as a nexus of information. Students, equipped with foundational data, can probe deeper using ChatGPT, making it primarily instrumental in language acquisition endeavours.

8. Study buddy. Beyond mere information dissemination, AI acts as a reflective companion. Students can elucidate their comprehension levels to ChatGPT, which can proffer study strategies or even assist in preparations for extracurricular pursuits as a virtual assistant.

9. Motivator. AI can conceptualise games and pedagogical challenges to invigorate the learning process. After receiving a summary of learners' current knowledge, ChatGPT can suggest ways to increase their understanding through interactive means.

10. Dynamic Assessor. This scenario underscores AI's potential in evaluative paradigms. Students can engage in tutorial dialogues with ChatGPT, a post where the platform can generate a comprehensive profile of their knowledge spectrum for educators to peruse.

In sum, these emerging scenarios underscore the transformative potential of generative AI in education. AI can potentially revolutionise teaching and learning in contemporary educational landscapes by tailoring its capabilities to diverse pedagogical needs.

5. Reflections and conclusions

AI in education (and in all business sectors) is not a future promise; it is a reality after the ChatGPT emergence at the end of 2022. For those teachers who do not believe in or are ignorant of GenAI tools, there is one absolute maxim these days: students at all educational levels are using tools like ChatGPT or similar [65]. It means there is an indelible imprint of GenAI in educational paradigms.

GenAI can be unsettling and, in some cases, frightening. It has its strengths and limitations, but it is crucial to remember that it will improve over time, and many of its limitations may disappear in the very short term [66]. For this reason, The extensive and widespread use of AI applications leads to the need to consider an ethical AI [67] and/or eXplainable AI (XIA) [68].

The advent of GenAI tools in the educational sphere marks a transformative phase that embodies unprecedented opportunities and potential challenges. To dismiss, resist, or deny the burgeoning influence of these technologies would be tantamount to eschewing the digital tide sweeping global pedagogical terrains [54]. Moreover, the impetus to outrightly prohibit these tools within educational precincts, often rooted in apprehensions about misuse or oversimplification of the learning process, can be myopic in its vision.

At the core of this debate lies a more nuanced perspective: the need to comprehend the manifold contributions of GenAI to pedagogical paradigms. Instead of erecting barriers to their use, the emphasis should be on harnessing their capabilities to elevate teaching and learning outcomes. For instance, these tools can serve as instrumental aids in fostering critical analysis. By presenting students with diverse responses, GenAI prompts them to discern, evaluate, and critically appraise the information, honing their analytical acumen in the process.

Furthermore, in an era inundated with information, the ability to compare sources becomes paramount. GenAI platforms can assist learners in juxtaposing diverse viewpoints, discerning biases, recognising credible sources, and developing an informed perspective. Moreover, these tools can be invaluable in guiding students in formulating pertinent and incisive questions. Students can refine their inquiry skills by engaging with AI-driven platforms, making their questions more precise, contextually relevant, and conducive to deeper exploration.

It means the final product should not be the only assessment element; the process to achieve the outcome gains great relevance in the learning process and, especially, in the evaluation stages.

Many of the problems and dangers identified in the educational context do not arise from the appearance of ChatGPT or other similar applications. They exist, have been addressed from many perspectives, and have remained unresolved (for example, the assessment issues during the COVID-19 Campo pandemic [69]). However, the potential of these technologies and the effect of their rapid penetration are magnifying some of them more than ever before.

In the ever-evolving landscape of modern education, the incorporation of AI represents more than just the adoption of a new technological tool; it signifies the vanguard of digital disruption, which has long been anticipated yet remains not fully realised [70]. As educational institutions globally are immersed in digital transformation [71], reflecting broader societal shifts towards a digitised future, the conspicuous absence of a complete educational upheaval driven by AI might appear paradoxical. However, this absence can be attributed to the complexities of integrating such transformative technologies into deeply entrenched pedagogical frameworks.

A crucial element of this transformation revolves around capacity-building, notably the imperative to equip educators and students with the requisite competencies for adeptly navigating AI-enhanced educational landscapes [41]. There is an undeniable urgency to cultivate a holistic understanding of AI, ensuring its deployment is guided by robust ethical considerations. The narrative should not merely focus on technological proficiency but should emphasise cultivating an ethos of critical thinking. This dual-pronged approach – marrying technological fluency with ethical and critical pedagogy – is pivotal to harnessing AI's transformative potential in education.

Institutions must transcend mere infrastructural adaptations to realise the zenith of AI's promise in redefining educational paradigms. They should champion comprehensive training programmes tailored for both educators and learners. Such initiatives should underscore the ethical dimensions of AI, fostering an environment where technology is viewed not as an unequivocal panacea but as a tool whose efficacy is contingent upon its judicious and enlightened use, conforming to real learning ecosystems [72, 73].

While the tidal wave of AI-driven disruption in education might seem imminent yet elusive, its eventual ascendency is inexorable. The key lies in preparation: equipping stakeholders with the knowledge, ethics, and critical acumen to ensure that when the wave does crest, it brings forth an era of enriched, empowered, and ethically grounded educational experiences.

GenAI applications can do astonishing things, but they are just in their infancy. They will continue to evolve, growing in their capabilities and in their "intelligence", with the help of users who provide feedback on the responses they generate [74].

AI, especially with the capability to create content indistinguishable from human production and to interact with users using natural language, represents one of the most disruptive technological means at the social level of our time. We are still just beginning to imagine the possibilities, risks, and challenges opened by this technology. However, it must be noted that the future we can build upon this foundation should not, and must not, be in the hands of technologists alone. There must be spaces for inter- and trans-disciplinary co-creation [75, 76] to ensure the ethical, safe, and inclusive development of a technology we would have deemed science fiction not so long ago.

In conclusion, the question is not whether educational institutions should embrace GenAI but how they can judiciously incorporate these tools to enrich, empower, and elevate the learning journey. Embracing an integrative stance that melds technological prowess with pedagogical objectives can pave the way for a more enlightened and informed educational future.

Acknowledgements

This research was partially funded by the Ministry of Science and Innovation through the AvisSA project grant number (PID2020-118345RB-I00).

References

1. Moh, P., Datta, P., Warford, N., Bates, A., Malkin, N., Mazurek, M.L.: Characterizing Everyday Misuse of Smart Home Devices. 2023 IEEE Symposium on Security and Privacy (SP), San Francisco, CA, USA, 2023, pp. 2835-2849. IEEE, USA (2023)
2. Minsky, M.: Consciousness is a big suitcase. A talk with Marvin Minsky. Conversations at Edge (1998)
3. Mustak, M., Salminen, J., Mäntymäki, M., Rahman, A., Dwivedi, Y.K.: Deepfakes: Deceptions, mitigations, and opportunities. Journal of Business Research 154, (2023)
4. Russell, S., Bohannon, J.: Artificial intelligence. Fears of an AI pioneer. Science 349, 252 (2015)
5. García-Peñalvo, F.J., Vázquez-Ingelmo, A., García-Holgado, A., Sampedro-Gómez, J., Sánchez-Puente, A., Vicente-Palacios, V., Dorado-Díaz, P.I., Sánchez, P.L.: Application of Artificial Intelligence Algorithms Within the Medical Context for Non-Specialized Users: the CARTIER-IA Platform. International Journal of Interactive Multimedia and Artificial Intelligence 6, 46-53 (2021)
6. Zhang, C., Vinodhini, B., Muthu, B.A.: Deep Learning Assisted Medical Insurance Data Analytics With Multimedia System. International Journal of Interactive Multimedia and Artificial Intelligence 8, 69-80 (2023)
7. Governatori, G., Bench-Capon, T., Verheij, B., Araszkiewicz, M., Francesconi, E., Grabmair, M.: Thirty years of Artificial Intelligence and Law: the first decade. Artificial Intelligence and Law 30, 481-519 (2022)
8. Pallathadka, H., Ramirez-Asis, E.H., Loli-Poma, T.P., Kaliyaperumal, K., Ventayen, R.J.M., Naved, M.: Applications of artificial intelligence in business management, e-commerce and finance. Materials Today: Proceedings 80, 2610-2613 (2023)
9. García-Peñalvo, F.J.: The perception of Artificial Intelligence in educational contexts after the launch of ChatGPT: Disruption or Panic? Education in the Knowledge Society 24, (2023)
10. Bubeck, S., Chandrasekaran, V., Eldan, R., Gehrke, J., Horvitz, E., Kamar, E., Lee, P., Lee, Y.T., Li, Y., Lundberg, S., Nori, H., Palangi, H., Ribeiro, M.T., Zhang, Y.: Sparks of Artificial General Intelligence: Early experiments with GPT-4. arXiv (2023)
11. Altman, S.: Planning for AGI and beyond. OpenAI. OpenAI, USA (2023)
12. Nilsson, N.J.: Principles of Artificial Intelligence. Springer-Verlag, Berlin (1982)
13. McCarthy, J.: What is Artificial Intelligence? , Computer Science Department. Stanford University (2007)
14. Bishop, C.M.: Pattern Recognition and Machine Learning. Springer Science+Business Media, New York, NY, USA (2006)
15. LeCun, Y., Bengio, Y., Hinton, G.: Deep learning. Nature 521, 436-444 (2015)
16. van der Zant, T., Kouw, M., Schomaker, L.: Generative artificial intelligence. In: Müller, V.C. (ed.) Philosophy and Theory of Artificial Intelligence, pp. 107-120. Springer-Verlag, Berlin (2013)
17. Diamandis, P.H., Kotler, S.: Bold: How to go big, create wealth and impact the world. Simon and Schuster, New York, NY, USA (2015)
18. García-Peñalvo, F.J., Vázquez-Ingelmo, A.: What do we mean by GenAI? A systematic mapping of the evolution, trends, and techniques involved in Generative AI. International Journal of Interactive Multimedia and Artificial Intelligence In Press, (2023)
19. Zhao, W.X., Zhou, K., Li, J., Tang, T., Wang, X., Hou, Y., Min, Y., Zhang, B., Zhang, J., Dong, Z., Du, Y., Yang, C., Chen, Y., Chen, Z., Jiang, J., Ren, R., Li, Y., Tang, X., Liu, Z., Liu, P., Nie, J.-Y., Wen, J.-R.: A Survey of Large Language Models. arXiv (2023)
20. Rosenfeld, R.: Two decades of statistical language modeling: where do we go from here? Proceedings of the IEEE 88, 1270-1278 (2000)
21. Collobert, R., Weston, J., Bottou, L., Karlen, M., Kavukcuoglu, K., Kuksa, P.: Natural Language Processing (Almost) from Scratch. The Journal of Machine Learning Research 12, 2493–2537 (2011)
22. Devlin, J., Chang, M., Lee, K., Toutanova, K.: BERT: pre-training of deep bidirectional transformers for language understanding. In: Burstein, J., Doran, C., Solorio, T. (eds.) Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, NAACL-HLT 2019, Minneapolis, MN, USA, June 2-7, 2019, Volume 1 (Long and Short Papers), pp. 4171–4186. Association for Computational Linguistics, USA (2019)

23. Chomsky, N., Roberts, I., Watumull, J.: The False Promise of ChatGPT. The New York Times, New York, USA (2023)
24. Gates, B.: The Age of AI has begun. GatesNotes, USA (2023)
25. Johinke, R., Cummings, R., Di Lauro, F.: Reclaiming the technology of higher education for teaching digital writing in a post—pandemic world. Journal of University Teaching and Learning Practice 20, (2023)
26. Lim, W.M., Gunasekara, A., Pallant, J.L., Pallant, J.I., Pechenkina, E.: Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators. International Journal of Management Education 21, (2023)
27. Llorens-Largo, F.: Las tecnologías en la educación: características deseables, efectos perversos. Universídad. Studia XXI, España (2019)
28. Wang, T., Cheng, E.C.K.: An investigation of barriers to Hong Kong K-12 schools incorporating Artificial Intelligence in education. Computers and Education: Artificial Intelligence 2, (2021)
29. Ma, W., Adesope, O.O., Nesbit, J.C., Liu, Q.: Intelligent tutoring systems and learning outcomes: A meta-analysis. Journal of Educational Psychology 106, 901-918 (2014)
30. Yilmaz, R., Yurdugül, H., Karaoğlan Yilmaz, F.G., Şahin, M., Sulak, S., Aydin, F., Tepgeç, M., Müftüoğlu, C.T., Ömer, O.: Smart MOOC integrated with intelligent tutoring: A system architecture and framework model proposal. Computers and Education: Artificial Intelligence 3, (2022)
31. Bhutoria, A.: Personalized education and Artificial Intelligence in the United States, China, and India: A systematic review using a Human-In-The-Loop model. Computers and Education: Artificial Intelligence 3, (2022)
32. Real-Fernández, A., Molina-Carmona, R., Pertegal-Felices, M.L., Llorens-Largo, F.: Definition of a Feature Vector to Characterise Learners in Adaptive Learning Systems. In: Visvizi, A., Lytras, M.D. (eds.) Research & Innovation Forum 2019, pp. 75-89. Springer International Publishing, Cham (2019)
33. Berlanga, A.J., García-Peñalvo, F.J.: IMS LD reusable elements for adaptive learning designs. Journal of Interactive Media in Education 11, (2005)
34. Su, J., Ng, D.T.K., Chu, S.K.W.: Artificial Intelligence (AI) Literacy in Early Childhood Education: The Challenges and Opportunities. Computers and Education: Artificial Intelligence 4, (2023)
35. Hornberger, M., Bewersdorff, A., Nerdel, C.: What do university students know about Artificial Intelligence? Development and validation of an AI literacy test. Computers and Education: Artificial Intelligence 5, (2023)
36. García-Peñalvo, F.J.: Learning Analytics as a Breakthrough in Educational Improvement. In: Burgos, D. (ed.) Radical Solutions and Learning Analytics: Personalised Learning and Teaching Through Big Data, pp. 1-15. Springer Singapore, Singapore (2020)
37. Lang, C., Siemens, G., Wise, A.F., Gašević, D., Merceron, A. (eds.): The Handbook of Learning Analytics. SoLAR, Vancouver, BC, Canada (2022)
38. Baepler, P., Murdoch, C.J.: Academic Analytics and Data Mining in Higher Education. International Journal for the Scholarship of Teaching and Learning 4, (2010)
39. Campbell, J.P., DeBlois, P.B., Oblinger, D.G.: Academic Analytics. A new tool for a new era. Educause Review 42, 40-42,44,46,48,50,52,54,56-57 (2007)
40. García-Peñalvo, F.J., Llorens-Largo, F., Vidal, J.: The new reality of education in the face of advances in generative artificial intelligence. RIED: Revista Iberoamericana de Educación a Distancia 27, (2024)
41. Choi, E.P.H., Lee, J.J., Ho, M.H., Kwok, J.Y.Y., Lok, K.Y.W.: Chatting or cheating? The impacts of ChatGPT and other artificial intelligence language models on nurse education. Nurse Education Today 125, (2023)
42. Cooper, G.: Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. Journal of Science Education and Technology 32, 444–452 (2023)
43. Vartiainen, H., Tedre, M.: Using artificial intelligence in craft education: crafting with text-to-image generative models. Digital Creativity 34, 1-21 (2023)
44. Iskender, A.: Holy or Unholy? Interview with Open AI's ChatGPT. European Journal of Tourism Research 34, (2023)

45. Crawford, J., Cowling, M., Allen, K.A.: Leadership is needed for ethical ChatGPT: Character, assessment, and learning using artifiicial intelligence (AI). Journal of University Teaching and Learning Practice 20, (2023)
46. Gilson, A., Safranek, C.W., Huang, T., Socrates, V., Chi, L., Taylor, R.A., Chartash, D.: How Does ChatGPT Perform on the United States Medical Licensing Examination? The Implications of Large Language Models for Medical Education and Knowledge Assessment. JMIR Medical Education 9, (2023)
47. Cotton, D.R.E., Cotton, P.A., Shipway, J.R.: Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. Innovations in Education and Teaching International In Press, (2023)
48. Khan, R.A., Jawaid, M., Khan, A.R., Sajjad, M.: ChatGPT-Reshaping medical education and clinical management. Pakistan Journal of Medical Sciences 39, 605-607 (2023)
49. Dwivedi, Y.K., Kshetri, N., Hughes, L., Slade, E.L., Jeyaraj, A., Kar, A.K., Baabdullah, A.M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M.A., Al-Busaidi, A.S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., Carter, L., Chowdhury, S., Crick, T., Cunningham, S.W., Davies, G.H., Davison, R.M., Dé, R., Dennehy, D., Duan, Y., Dubey, R., Dwivedi, R., Edwards, J.S., Flavián, C., Gauld, R., Grover, V., Hu, M.C., Janssen, M., Jones, P., Junglas, I., Khorana, S., Kraus, S., Larsen, K.R., Latreille, P., Laumer, S., Malik, F.T., Mardani, A., Mariani, M., Mithas, S., Mogaji, E., Nord, J.H., O'Connor, S., Okumus, F., Pagani, M., Pandey, N., Papagiannidis, S., Pappas, I.O., Pathak, N., Pries-Heje, J., Raman, R., Rana, N.P., Rehm, S.V., Ribeiro-Navarrete, S., Richter, A., Rowe, F., Sarker, S., Stahl, B.C., Tiwari, M.K., van der Aalst, W., Venkatesh, V., Viglia, G., Wade, M., Walton, P., Wirtz, J., Wright, R.: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. International Journal of Information Management 71, (2023)
50. Finnie-Ansley, J., Denny, P., Luxton-Reilly, A., Santos, E.A., Prather, J., Becker, B.A.: My AI Wants to Know if This Will Be on the Exam: Testing OpenAI's Codex on CS2 Programming Exercises. ACE '23: Proceedings of the 25th Australasian Computing Education Conference, pp. 97-104. ACM, New York, NY, USA (2023)
51. Šlapeta, J.: Are ChatGPT and other pretrained language models good parasitologists? Trends in Parasitology 39, 314-316 (2023)
52. Gašević, D., Siemens, G., Sadiq, S.: Empowering learners for the age of artificial intelligence. Computers and Education: Artificial Intelligence 4, (2023)
53. Lee, E.: Is ChatGPT a False Promise? Berkeley Blog, USA (2023)
54. Perkins, M.: Academic Integrity considerations of AI Large Language Models in the post-pandemic era: ChatGPT and beyond. Journal of University Teaching and Learning Practice 20, (2023)
55. Lee, H.: The rise of ChatGPT: Exploring its potential in medical education. Anatomical Sciences Education In Press, (2023)
56. Thurzo, A., Strunga, M., Urban, R., Surovková, J., Afrashtehfar, K.I.: Impact of Artificial Intelligence on Dental Education: A Review and Guide for Curriculum Update. Education Sciences 13, (2023)
57. García-Holgado, A., García-Peñalvo, F.J.: Validation of the learning ecosystem metamodel using transformation rules. Future Generation Computer Systems 91, 300-310 (2019)
58. Tlili, A., Shehata, B., Adarkwah, M.A., Bozkurt, A., Hickey, D.T., Huang, R., Agyemang, B.: What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. Smart Learning Environments 10, (2023)
59. Mbakwe, A.B., Lourentzou, I., Celi, L.A., Mechanic, O.J., Dagan, A.: ChatGPT passing USMLE shines a spotlight on the flaws of medical education. PLOS Digital Health 2, (2023)
60. Masters, K.: Ethical use of artificial intelligence in health professions education: AMEE Guide No.158. Medical Teacher 45, 574-584 (2023)
61. Barro, S.: La pregunta equivocada sobre el uso de ChatGPT en la educación. Universídad. Studia XXI, España (2023)
62. Sabzalieva, E., Valentini, A.: ChatGPT and artificial intelligence in higher education: Quick start guide. UNESCO and UNESCO International Institute for Higher Education in Latin America and the Caribbean (IESALC) (2023)

63. Herft, A.: A Teacher's Prompt Guide to ChatGPT aligned with 'What Works Best'. (2023)
64. Nerantzi, C., Abegglen, S., Karatsiori, M., Arboleda, A.M. (eds.): 101 creative ideas to use AI in education, A crowdsourced collection (2023)
65. Amo-Filva, D., Fonseca, D., Vernet, D., Torres, E., Muñoz Pastor, P., Caballero, V., Fernandez, E., Alier-Forment, M., García-Peñalvo, F.J., García-Holgado, A., Llorens-Largo, F., Molina-Carmona, R., Conde, M.Á., Hernández-García, Á.: Usos y desusos del modelo GPT-3 entre estudiantes de grados de ingeniería. In: Cruz Lemus, J.A., Medina Medina, N., Rodríguez Fórtiz, M.J. (eds.) Actas de las XXIX Jornadas sobre la Enseñanza Universitaria de la Informática - JENUI 2023 (Granada, España, 5-7 de julio de 2023), vol. 8, pp. 415-418, Granada, España (2023)
66. Bozkurt, A.: Generative artificial intelligence (AI) powered conversational educational agents: The inevitable paradigm shift. Asian Journal of Distance Education 18, 198-204 (2023)
67. Flores-Vivar, J.M., García-Peñalvo, F.J.: Reflections on the ethics, potential, and challenges of artificial intelligence in the framework of quality education (SDG4). Comunicar 31, 35-44 (2023)
68. Khosravi, H., Shum, S.B., Chen, G., Conati, C., Tsai, Y.-S., Kay, J., Knight, S., Martinez-Maldonado, R., Sadiq, S., Gašević, D.: Explainable Artificial Intelligence in education. Computers and Education: Artificial Intelligence 3, (2022)
69. García-Peñalvo, F.J., Corell, A., Abella-García, V., Grande-de-Prado, M.: Online Assessment in Higher Education in the Time of COVID-19. Education in the Knowledge Society 21, (2020)
70. García-Peñalvo, F.J.: Digital Transformation in the Universities: Implications of the COVID-19 Pandemic. Education in the Knowledge Society 22, (2021)
71. García-Peñalvo, F.J.: Avoiding the Dark Side of Digital Transformation in Teaching. An Institutional Reference Framework for eLearning in Higher Education. Sustainability 13, (2021)
72. García-Peñalvo, F.J.: Ecosistemas tecnológicos universitarios. In: Gómez, J. (ed.) UNIVERSITIC 2017. Análisis de las TIC en las Universidades Españolas, pp. 164-170. Crue Universidades Españolas, Madrid, España (2018)
73. García-Peñalvo, F.J., Hernández-García, Á., Conde, M.Á., Fidalgo-Blanco, Á., Sein-Echaluce, M.L., Alier-Forment, M., Llorens-Largo, F., Iglesias-Pradas, S.: Enhancing Education for the Knowledge Society Era with Learning Ecosystems. In: García-Peñalvo, F.J., García-Holgado, A. (eds.) Open Source Solutions for Knowledge Management and Technological Ecosystems, pp. 1-24. IGI Global, Hershey PA, USA (2017)
74. Trust, T.: ChatGPT & Education. University of Massachusetts Amherst (2023)
75. García-Peñalvo, F.J., Conde, M.Á., Johnson, M., Alier, M.: Knowledge co-creation process based on informal learning competences tagging and recognition. International Journal of Human Capital and Information Technology Professionals (IJHCITP) 4, 18-30 (2013)
76. Ramírez-Montoya, M.S., García-Peñalvo, F.J.: Co-creation and open innovation: Systematic literature review. Comunicar 26, 9-18 (2018)