REVIEW PAPER

University Education Versus Artificial Intelligence Methodological Challenges And Approaches For Evidence-Based Teaching

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SUMMARY
The objective of this article is to carry out a critical review of the methodological frameworks applied in university education in relation to artificial intelligence. It seeks to integrate empirical evidence that addresses educational effectiveness, as well as ethical and equity aspects, in order to guide teaching practices. The methodology used includes an analysis of previous studies and the evaluation of practical cases that incorporate AI in the educational field. The results obtained highlight the need to adapt pedagogical strategies to face both the challenges and opportunities presented by artificial intelligence in higher education.
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1. INTRODUCTION

The emergence of generative artificial intelligence (AI) tools, such as ChatGPT and DALL-E, has attracted the world's attention and poses various challenges to education and university pedagogy. One of the main challenges is related to the validity and reliability of the assessments, which could be compromised due to the facilities offered by these technologies to perform tasks, assignments or even exams automatically and at a cost close to zero.

However, these tools could also drive progress towards more effective and efficient teaching. There is a growing interest in creating pedagogical architectures that integrate AI to promote deeper learning, and the combination of AI technologies with formative assessment offers new possibilities for formative interaction between students and teachers. On the other hand, the availability of data on students' use of AI tools can be useful for making decisions about teaching design and improving its effectiveness.

2. CONCEPTUAL FRAMEWORK

2.1. Artificial intelligence and higher education

Artificial intelligence is defined as computer systems that perform tasks that normally require human intelligence, such as reasoning, understanding language, perception, and producing creative outputs (Russell & Norvig, 2010). Higher education is a strategic application area for AI. On the one hand, the adoption of the technology in universities around the world is widespread and has a speed that is very difficult to control. On the other hand, AI learning and its practical activities linked to data have become the subjects in greatest demand. This includes use as a resource for the creation of texts, images, audio, and video, as well as education, question answering, and programming, among others. The adoption of AI models by companies and educational institutions is increasingly increasing concerns about privacy, bias and fairness of decisions, as well as equity in access.

The use of AI-based tools to facilitate learning and teaching and the use of AI technologies in educational environments to enrich the learning process constitute a fundamental component in AI training. However, for these approaches to be truly effective, whatever the tool, it is necessary to assess the impact they have on learning outcomes and equity. The design of the subject, the pedagogical architecture and the underlying dataset are fundamental aspects for the adoption of any technology, and especially AI, to generate positive results.

2.1. Artificial intelligence and higher education

Artificial intelligence (AI) is defined as a specialized field within computer science that integrates components, such as machine learning algorithms, natural language processing, data analysis, and neural networks. This field has allowed the development of tools that produce texts, images, audio sequences and video games from short requests. Among these tools, in the last year, Large

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Language Models (LLM) stand out, which are implemented in platforms such as ChatGPT, Bard and Bing Chat.

The emergence of these technologies poses a set of methodological challenges for higher education. First, the validity and reliability of educational assessments are compromised because generative models are capable of answering complex questions and writing essays or research papers at the university level. Consequently, the evaluation instances must be redesigned. Second, educational curricula must explicitly incorporate the competencies associated with the responsible and critical use of these tools. Likewise, initial teacher training should include these topics to allow for conscious integration into the classroom.

2.2. Evidence-based approaches to teaching

Effective teaching requires informed decisions about its design and implementation. The search for effective means to maximize learning has led education to experiment with many strategies, but, in many ways, education remains a low-risk activity. This is partly because, although the results of research in education have been systematically reviewed and synthesized, the information obtained has rarely been used to implement changes in pedagogical practice to a large extent. An evidence-based approach can help integrate machine learning and other AI tools into study designs.

An evidence-based approach involves any innovation used in the classroom being applied according to empirical findings that support its effectiveness, controlled testing according to a well-planned experimental design to assess its effectiveness, or using data managed and synthesized within an organization to guide its implementation. A/B testing elements of an instructional or evaluation design typically provides sufficient data to make an informed decision about maintaining or disposing of the item in question. An evidence-based approach also requires that the effectiveness of teaching in terms of learning gains be considered. If this is not measured, the use of a well-controlled experimental design may not be a priority.

3. METHODOLOGICAL CHALLENGES

The emergence of artificial intelligence applications, such as ChatGPT, has generated widespread attention, but research into their implications on learning and potential benefits should also be considered. Specifically, these challenges can be thought of as a set of research questions. Thus, the validity and reliability of evaluations in educational settings have been questioned, in addition to the fact that the curricular design and the competencies that must be developed by students are under review. Concerns about privacy and bias in AI tools, as well as equity in access to AI technologies, among other aspects, are also being studied.

One of the keys for AI to have a positive impact on education is to support its integration into the teaching-learning process through the development of pedagogical tools and architectures. Formative assessment systems that generate automated feedback and the use of student interaction data for pedagogical decision-making are approaches that have proven to be effective and require AI for scalability. The automation of laboratory and simulation practices has also been proposed as a path towards improving learning.

3.1. Validity and reliability of assessments in AI-enabled environments

An aspect of crucial importance in university education is the validity and reliability of the learning acquired by students, as well as the evidence that demonstrates such learning through assessment instruments. Both validity and reliability depend on the quality of assessments, and in this sense, the emergence of generative AI tools, which can generate textual and even visual content that resembles a student's work, represents a challenge for higher education. There are some general recommendations for the use of these tools, such as those reviewed by Kherwa and Ram (2023), but they are not evidence based on controlled experiments.

On the other hand, researchers at Stanford University suggest that in the future, generative AI tools will be able to evaluate and grade tasks (Dale & Tiru, 2023). Using a generative AI model for assessment makes a lot of sense, because it's possible to use data from students' interactions with the interface, such as the questions they ask or the mistakes they make, to create a formative assessment that not only grades, but also explains incorrect answers and provides redirects that indicate how to discover the correct answer. Consequently, the challenge faced is how to validate these new assessment tools in an environment where students can use generative AI tools to their advantage or against them.

3.2. Curriculum design and AI competencies

Curriculum design and student competencies should promote the development of AI-related skills and their conscious, ethical and responsible use rather than being an obstacle. New pedagogical architectures, which integrate AI as a learning support or assistant, or explicitly include it as a topic of study, can mitigate the risk that the use of AI degrades the quality of education.

Through the use of AI, fundamental aspects of the nature of intelligence and learning can be explored, while analyzing the philosophical premises and their relationship with what AI systems actually achieve. By integrating AI as an active component of the teaching and learning process, rather than considering it as a peripheral element, the potential of technology can be harnessed to meet the goal of preparing students for its responsible and ethical use. Thus, the use of AI in higher education can be perceived not only as a challenge, but also as an opportunity.

3.3. Privacy, bias, and ethics in AI tools

Incorporating AI tools into the educational process raises concerns related to privacy, bias, and ethics. Data collection to train AI models involves the use of large volumes of data. However, users' privacy is not always guaranteed. It is important that users read the terms and conditions of the services, since, in many cases, the data is used to improve the service or shared with third parties. Often, the only option they have is to accept. If data is used to improve a free service, users are generally willing to lose their privacy. However, transparency in the use of data is essential. In this sense, the integration of AI tools in institutional environments controlled by the institution, where privacy and data transfer are guaranteed, is a valid alternative. In this area, the debate revolves around how and to what extent it is possible, convenient and/or desirable to transfer or use data for other purposes, including in the field of educational research.

On the other hand, it has been observed that AI models can amplify existing biases. This effect occurs based on the decisions made by those who designed the model or training dataset. Training an AI model with biased data can lead to the model coming up with values, images, or even songs that are socially unacceptable. Therefore, it is essential to carry out an audit of bias and discrimination on the AI tool before applying it in the educational field. In addition, developers must ensure that the proposed system is secure and free of bias and discrimination. However, this does not completely eliminate the need for ethical intervention for the use of AI tools, even in those cases where the proper audit has been conducted.

3.4. Fairness and access to AI technologies

The digital divide and access to artificial intelligence technologies represent one of the most complex problems in education, as there are still differences in infrastructure, connectivity and devices, which result in unequal access to AI tools, both by students and teachers. Although the gap has narrowed in recent years, there are still scenarios where neither connectivity nor devices are adequate. However, in environments where access to AI appears to be adequate, this access has a positive impact on both learning and other outcomes of interest. Even so, the use of these tools still needs to have a positive impact on the development of students' skills. Therefore, its use must be supervised and guided by teachers.

Although connectivity and access to devices are not yet definitively established in most places, access to these tools is massive and often avoids teacher intervention. The results are still uncertain and research is needed on how to guide students so that the use of these tools generates a positive effect on teaching and learning. The current situation and the extensive use of AI generate the need to test whether it is possible to prevent AI from becoming a shortcut that harms the learning to be achieved and not a tool that enhances the capabilities of students.

4. APPROACHES TO EVIDENCE-BASED TEACHING

The approaches that can contribute to evidence-based teaching are diverse, four stand out: the use of pedagogical architectures that integrate artificial intelligence (AI), the implementation of formative assessment systems that incorporate automated feedback, as well as the exploitation of databases to guide decision-making in the classroom, and the use of AI in laboratory and simulation practices. Each one is presented with a brief description, its relationship with the methodological challenges posed and examples of works that offer relevant findings.

Pedagogical architectures are structural blocks configured by a sequence of cognitive activities in learning environments. They integrate various resources, processes and roles of the participants in the process and promote the development of specific competencies, as well as the transfer of knowledge. Work along these lines, as well as others in the field of educational artificial intelligence, suggest that the combination of multiple technologies can be more effective than their application alone. Architectures are a tool that can also contribute to the validation of courses and assessments in AI-powered environments. Its design considering the capabilities of these technologies allows its use without fear that the results will be based on responses generated by an AI model.

4.1. Pedagogical architectures integrating AI

Generative AI systems can be designed for pedagogical purposes, although there is still no evidence to suggest that these designs are more effective than other approaches to teaching and learning. Aristotle proposed one of the first pedagogical systems. His work "Nicomachean Ethics" suggests that the practice of learning is designed as a three-step cycle. In the first step, the student hears his teacher give a verbal lesson on a sphere in which the teacher has knowledge and the student has a low level of knowledge. In the second step, the student performs an action. In the third step, the student listens to his teacher give a verbal lesson about the action he has just performed. The cycle repeats with the inclusion of new topics and levels of difficulty.

AI learning architectures can be implemented in generative AI systems such as ChatGPT, in which learning resources are created and provided by AI. Such applications can replicate the first step of the cycle, and practice can be supported by passages from AI response tools. The inclusion of a learning architecture designated for the second step could allow the learning cycle proposed by Aristotle to be automated. The second step is based on practice and practice-based learning. In this phase, students put their ideas into action, and the system assesses the quality of the action and provides feedback on performance.

4.2. Formative assessment and automated feedback

Digital tools can facilitate student feedback, but the challenge is to find ways that are effective and do not encourage superficial learning. Automated multiple-choice tests, especially those using the three-parameter item response model, can contribute to feedback by both providing performance insights and indicating areas for improvement. An additional approach to instant feedback is adaptive assessment, which adjusts the difficulty of the test based on the student's performance. For the use of multiple-choice questions to be valid and useful, it is important to follow guidelines for item writing and ensure that the higher levels of Bloom's taxonomy are addressed (Benjamin and his colleagues classified it into six categories: remembering, understanding, applying, analyzing, evaluating, and creating). Instead of penalizing students for making mistakes in questions whose answer they do not know or are not sure they know, multiple choice designs can be used, in which the student has to indicate the certainty he or she has regarding the chosen answer.

Formative assessment is fundamentally based on obtaining information about the learning process so that the teacher can adjust their educational interventions and, in this way, improve this experience for students. However, in university education, the number of students can make it difficult to implement this practice. In this sense, generative AI tools can analyze the performance of a group and offer suggestions for improvement to the teacher. It is expected that, in the coming years, these tools can also be used for the creation of formative assessment items.

4.3. Use of data for pedagogical decision-making

The data generated on digital platforms provides valuable information about student learning and behavior, and its analysis can be used for pedagogical decision-making at three levels: the classroom, the course, and the institution. Universities should explore the implementation of data design and analysis systems that generate useful information for the continuous improvement of teaching and learning.

At the classroom level, the information generated through student interactions in virtual spaces can be analyzed to identify patterns that influence the educational process. For example, the use of Artificial Neural Networks to analyze data from the Moodle system and predict the performance in an education subject of a group of students. On the other hand, the course level is related to the evaluation of the effectiveness of a virtual classroom in the teaching-learning of a subject, and the institutional level is oriented to the comparison of student performance in a subject in different faculties.

The amount of data generated by the interactions of students on digital platforms during the learning process in the different subjects can be evaluated, to determine if these data allow predicting the academic performance of students who finished the aras.

4.4. Laboratory practices and simulation with AI

AI tools can be integrated into teaching in the laboratory and in simulation environments. AI technologies can create virtual laboratory environments that allow students to perform risky, expensive, or hard-to-achieve practices in real-world conditions. This type of technology can be applied in areas such as biology, civil engineering, medicine, aeronautics, astronautics, and physics. Using automated AI simulations in the lab or simulation environments allows experimental design, data collection, and analysis to be automated.

Through the use of virtual laboratory environments, the student can perform experiments without the need for a physical laboratory. These tools allow experimenting with materials and processes that are impossible in real life or performing complex experiments that require a large number of repetitions. The data generated by a virtual lab environment can be used for learning concepts, theories, and relationships.

5. INSTITUTIONAL IMPLEMENTATION

Implementing evidence-based university education in AI environments requires change management that prioritizes educational research and teacher development. Data governance, privacy and regulatory compliance are necessary conditions to ensure trust and ethical use of technologies and tools to support teaching and learning.

AI's ability to create and analyze large volumes of information opens up avenues of research that increase the amount of data on the teaching and learning process and its relationship to outcomes. However, the use of this data for pedagogical decision-making faces ethical and privacy challenges that must be managed with transparency and rigor. Likewise, their potential for improvement is diminished by the lack of formal education architectures that integrate these tools, the scarcity of experience in their use and in the design of training experiences that integrate the results of their use as a support for practice.

5.1. Change management and teacher development

Teaching approaches in higher education must evolve to add value in the face of artificial intelligence (AI). Preparing for this change requires a sense of urgency, transition plans, and awareness and development of the academic body. For teachers, the challenge of integrating AI into their practice translates into changes in the preparation, teaching, and use of data. The implementation of AI in teaching must be an ongoing process of capacity building. This implies having a change management policy that begins with the development of an institutional vision in higher education for the incorporation of AI in the teaching-learning process; prioritize the use of AI in the classroom; identify and develop teacher skills needed for the use of AI in the classroom; and bring institutions closer to a use of AI that generates value during learning.

Incorporating AI is not only a challenge for students, but also for the academic body, who, in addition to their role as teachers, must be researchers with expertise in the use of AI. These new capabilities are necessary for AI to be implemented in a safe way and to really add value to the training process. Institutions should think about creating an environment that favors development on the use of AI in higher education, in particular in the use of AI that not only allows teachers to be more efficient and effective, but actually improves student learning.

5.2. Data governance and regulatory compliance

The implementation of AI in teaching and evaluation processes generates new challenges for data governance in institutions. On the one hand, the conditions of privacy and data protection of students, necessary in all evidence services, must be clearly defined. Moreover, institutions must be able to manage the data generated in their interactions with students, as well as the data collected in an automated way by AI tools. Special attention should be paid to the data of underage students or those who are in jurisdictions with stricter data protection conditions. The review of AI platforms that use training data that is not always well defined allows many of them to be classified as without risk of use, so exposure to these platforms during the development of competences should be part of the curriculum of the subjects.

The speed of incorporation of these tools, as well as the possibility of access from any computer connected to the Internet, also invites the data generated to be used by institutions in order to direct pedagogical decision-making. These processes must be addressed based on a review of the data protection laws or regulations of each jurisdiction, as well as the contracts for the use of the platforms by the educational centers.

5.3. Inter-institutional collaborations and prioritisation of research

Educational research on the influence of artificial intelligence on learning should be prioritized and supported through collaborations between institutions. The design of pedagogical interventions that integrate AI is complex and requires the constitution of working groups in which teachers and researchers from different specialties (education, psychology, engineering, computer science, artificial intelligence) and levels (undergraduate and graduate) participate. The scarcity and high workload of teachers limit the ability to design, implement and evaluate large-scale experiments that allow providing evidence on teaching proposals related to AI. Collaboration between institutions facilitates the constitution of larger, more distributed research teams, which can address more complex research questions and use more sophisticated experimental designs, thus contributing to the advancement of knowledge.

Inter-institutional collaboration is essential to produce and share collections of educational resources that integrate AI and are aimed at teaching different disciplines. The creation of resource collections using AI requires the establishment of inter-institutional working groups, consisting of teachers who specialize in the use of AI and who understand the specific methodologies of different teaching disciplines. Inter-institutional collaboration should also prioritise research on software tools and teaching infrastructures that implement AI and facilitate its use in teaching and learning practices in higher education.

6. IMPLICATIONS FOR EDUCATIONAL RESEARCH

Recent developments in the field of AI offer unique opportunities for both educational research and education in general. By using AI to develop models that simultaneously integrate different types of data, such as academic backgrounds, student characteristics, and teaching practices, patterns can be identified that indicate which pedagogical strategies are most effective for different groups of students, even in situations where there are interactions of multiple variables. These models can be particularly useful in contexts where the number of observations is low. AI also allows the detection of patterns in student behavior that may be related to dropout or dropout, and the analysis of data from natural language analysis and sentiment analysis techniques. On the other hand, the potential of tools that generate text and images from natural language descriptions can be exploited in the design of low-cost intervention programs.

The emergence of generative AI and other language models offers new opportunities for formative assessment of students, using AI that can provide instant feedback on tasks such as essay writing, as long as the tasks are well-defined and do not require the use of a specific voice in the text. However, the inclusion of generative AI tools in the classroom will require greater rigor in the design of the activities, as well as a paradigm shift in assessment and how students demonstrate their learning, in order to continue to meet the essential properties of good assessment. The satisfaction of the equity property in the evaluation processes must be considered in the decision-making on the use of generative AI tools in the classroom.

6.1. Experimental designs and mixed methods

Experimental designs are at the heart of evidence-based teaching. To analyze the role of different methodological approaches and to collect the limited amount of high-quality evidence in education, experimental designs are especially valuable. They allow for cause-and-effect relationships and can be used to adjust variables and enablers that are difficult to control. However, in higher education studies, randomized experimentation is complicated and rare. Some of the reasons that make it difficult to implement these experiments include the scale of the groups, the complexity of the environments, and the ethics of randomization. The difficulties of non-experimental designs drive the use of mixed methods. The combination of methods provides a valuable solution to the question of whether writing revision papers,

personalized education, or using multiple-choice exams contribute to learning.

6.2. Measuring educational outcomes and equity

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The validity of educational impact models requires measuring results. AI technologies, such as large language models, are capable of generating texts that can pass a typical university course assessment, raising doubts about the validity of such assessments. Given its ability to generate content, AI could help disguise plagiarism if it is used by students with less preparation and skills. On the other hand, quality education should minimize these asymmetries of preparation in the use of AI technologies. Therefore, it is key to have learning measures that are robust and used to measure equity in results.

AI technologies can also be used to support the assessment of student learning, through formative assessment and personalized feedback. In these cases, AI can be used by educators forming pedagogical architecture that, by integrating different types of digital technologies, enhances learning. Experimental designs could assess whether the use of architectures that include AI outperforms other architectures that do not.

6.3. Review of literature and state of the art

Literature review, state of the art, and meta-analysis development are crucial to understanding how to leverage AI in education. In the short term, a comprehensive map is needed that allows researchers, decision-makers, and teachers to identify research opportunities that generate useful solutions and evidence. In the medium and long term, the incorporation of experiments and mixed methods in the evaluation of pedagogical interventions and practices will form the basis for the formulation of design principles applicable to AI and non-AI education and, therefore, to the development of a new pedagogical framework.

Experimental designs and mixed methods are the most effective way to test cause-effect relationships in educational interventions, as well as the most comprehensive way to integrate qualitative and quantitative results. In the same way, in the context of the use of AI in education and its implications to reduce learning inequalities, a systematic use of data is needed to verify whether the results are effectively achieved, depending on the design and the context.

7. PRACTICAL RECOMMENDATIONS FOR TEACHERS AND INSTITUTIONS

Research on the use of AI technologies in education should be taken into account by educators and their institutions to inspire pedagogical decision-making. The following recommendations are primarily aimed at educators, but institutions should support them. Regarding the design of pedagogical architectures, the integration of generative AI technologies in teaching, assessment, tutoring, support, and educational management can be considered. For evaluation and feedback, generative AI technologies can be used to allow the evaluation of learning and the generation of feedback on tasks. Learning data, including responses from students and generative AI interpreters and their assessments, can be used to support pedagogical decision-making to guide educators in designing learning experiences and improving their materials. For laboratory and simulation practices, the use of generative AI technologies that simulate complex scenarios and integrate stakeholder decisions into the simulation can be enhanced.

Educational institutions should support educators in integrating generative AI technologies into teaching. To do this, they must put in place change management processes that promote their acceptance, justify investment in teacher development and create centres of excellence that support research and development of these technologies. In addition, they must effectively manage the data generated in educational environments and be proactive in ensuring its protection, regulatory compliance and the prevention of bias. They must also collaborate with other institutions in the definition of implementation policies and prioritize research on the educational impact and the improvement of equity that these technologies make possible.

8. CONCLUSION

Despite long-held expectations that AI would automate lower-skilled jobs, its increasing accessibility and power is allowing people with little or no experience to produce quality university papers. These tools present opportunities and challenges for university education, and evidence-based teaching can help to take advantage of the former and mitigate the latter.

Evidence-based teaching can leverage pedagogical architectures that integrate AI tools into open-ended tasks, formative assessments and automated feedback, learning data analysis to inform decision-making, and laboratory and simulation practices using AI applications. Implementing these opportunities requires change management that supports faculty development, governance that ensures privacy, equity, and regulatory compliance in the use of data, and research-first inter-institutional collaborations.

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