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The Delphi method as a consensus tool in the design of a framework for the application of Artificial Intelligence in Medical Education in Spain.

El método Delphi como herramienta de consenso en el diseño de un marco de aplicación de la Inteligencia Artificial en Educación Médica en España.

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Summary.

Introduction. The rapid integration of artificial intelligence (AI) into biomedical education has generated an urgent need for a framework to guide students and academic staff. In Spain, institutions are rapidly adopting AI, but without consistent regulatory or pedagogical guidance. Structured approaches are required to prioritize competencies and address emerging ethical, legal, and educational challenges. **Methods.** A Delphi study coordinated by the European University of Madrid (UEM) was conducted using REDCap to manage the iterative rounds. The project received financial support from the Spanish Society for Medical Education (SEDEM). Medical education experts, some with specific knowledge of AI, participated in a series of online questionnaires. Through anonymized feedback, participants assessed, refined, and prioritized a set of areas where the impact of AI is essential. **Results.** Experts agreed on the need for skills beyond technical literacy, highlighting critical thinking, the interpretation of AI-generated results, awareness of biases, and professional responsibility. Ethical and legal considerations, especially those related to privacy, transparency, and decision-making, were highly prioritized. They also underscored the cross-cutting nature of AI, suggesting that competencies should be integrated throughout the curriculum and not treated as isolated content. **Discussion.** Despite institutional heterogeneity, consensus converged on areas that balance innovation with ethical safeguards. The results support the development of a competency framework capable of guiding curriculum design, informing teacher training, and promoting the responsible and evidence-based use of AI, without compromising professional autonomy.

Keywords: Artificial Intelligence, Delphi, Medical Education.

Abstract.

Introduction. The rapid integration of artificial intelligence (AI) into biomedical education has created an urgent need for a framework that can guide both learners and academic staff. In Spain, where institutions are adopting AI at speed but without homogeneous regulatory or pedagogical guidance, structured approaches are required to prioritize competencies and address ethical, legal and educational challenges. **Methods.** A Delphi study was coordinated by the European University of Madrid, using the REDCap platform to manage iterative rounds. The project received financial support from the Spanish Society for Medical Education (SEDEM). Experts in medical education, including some with specific AI expertise, participated in a sequence of online questionnaires. Through anonymized feedback, participants evaluated, refined and prioritized a core of areas where the impact of AI seems essential. **Results.** Experts agreed on the need for skills extending beyond technical literacy, emphasizing critical thinking, interpretation of AI -generated outputs, bias awareness and professional responsibility. Ethical and legal considerations, particularly concerning privacy, transparency and decision -making, were strongly prioritized. Participants also highlighted the transversal nature of AI, suggesting that competencies should be embedded across curricula rather than treated as isolated content. **Discussion.** Despite institutional heterogeneity, consensus converged on areas that balance innovation with ethical safeguards. The results support the development of a competency -based framework capable of guiding curriculum design, informing faculty development and promoting responsible, evidence -informed use of AI while safeguarding professional autonomy.

Keywords: Artificial Intelligence, Delphi, Medical Education.

1. Introduction

The integration of Artificial Intelligence (AI) in the biomedical and health sciences is progressing rapidly, generating new opportunities in research, teaching, and clinical practice. These tools have become established in recent years as a transformative force, offering advanced capabilities to personalize learning, automate assessments, and analyze large volumes of educational data (1-2). Recent advances in generative AI (IAG)and multimodal systems have expanded these possibilities, enabling clínicasadaptive simulations (ASCE) (3), intelligent tutors (4) , and real-time feedback in clinical training environments (5). However, its integration into academic contexts raises significant ethical and pedagogical challenges related to data privacy, algorithmic bias, and academic integrity (6-7). Therefore, considering the current extent of its use, a framework is needed competencialto guide which use cases are relevant, how they should be implemented, and what best practices ensure their responsible adoption (8). Given the diversity of possible applications and the variability of institutional contexts, the need for a systematic and consensual approach becomes essential.

En países como Reino Unido o Australia disponen de marcos institucionales más desarrollados para el uso de IA en educación superior, incluyendo políticas claras sobre docencia, evaluación e integridad académica, así como orientaciones nacionales más consolidadas para su adopción (9-10).In this sense, the Delphi method emerges as an ideal methodological tool for gathering expert opinions and establishing agreements on priorities, appropriate uses, and quality guidelines for the application of AI in the biomedical field in Spain (11-12). The Delphi method, characterized by successive rounds of questionnaires and anonymous feedback, facilitates the convergence of opinions and reduces the influence of dominant voices, making it an ideal tool for emerging fields such as AI in education (13-14). The present study aims to describe the application of a Delphi process combined with a nominal virtual group to analyze the impact of AI tools on biomedical education in Spanish, combining methodological rigor with an experiential perspective from university professors with varying levels of experience (11). This framework seeks to address not only technical skills, but also ethical, legal and pedagogical dimensions, aligning with global recommendations on AI literacy and responsible innovation in health sciences education (15).

2. Methods

A longitudinal study was conducted, following the Delphi methodology combined with the virtual nominal method (11). The Delphi panel included 23 experts (approximately 60% men, approximately 40% women), aged between 34 and 72 years, with the majority of participants in their 40s and 60s. Teaching experience ranged from 10 to 40 years, estando representadas en el mismo disciplinas tanto básicas como clínicas.El tamaño del panel (n = 23) se considera adecuado según la literatura metodológica del método Delphi, que indica que la calidad del panel depende más de la experiencia y la diversidad de expertos que del número total de participantes, situándose los rangos habituales entre 10 y 30. La selección de participantes se realizó siguiendo criterios de inclusión y exclusión, incorporando únicamente a docentes en activo con experiencia previa en innovación docente o tecnologías aplicadas a la educación médica y la IA, por invitación directa como a través de redes profesionales como la Sociedad Española de Educación Médica (SEDEM).

The questionnaires were developed using the *Technology Acceptance Model* (TAM), proposed by Davis in 1985 (16-17), as a reference for the selection and prioritization of AI use cases in the biomedical field. This model provides a particularly useful theoretical framework for addressing the emergence of new technologies in a specific field. The TAM model explains how users adopt and accept these new technologies based on two key perceptions: their perceived usefulness, understood as the degree to which the technology improves performance or facilitates relevant tasks, and their perceived ease of use, which refers to the effort required to learn and integrate it into daily practice (18).

Existen otros marcos como la Teoría Unificada de Aceptación y Uso de Tecnología (UTAUT), marco ampliamente utilizado para entender cómo los usuarios aceptan y utilizan tecnologías. Aunque UTAUT es efectivo en muchos contextos, su aplicación puede requerir entornos de implantación tecnológica más consolidados, lo que puede limitar su uso en ciertos contextos exploratorios (19). En nuestro caso, el usoTAM estaría justificado al tratarse de un entorno reciente de Technological adoption, which contributes to selecting applications that are useful, accessible, and sustainable in clinical, educational, and research settings (16-17). Recientemente, se han publicado otros trabajos con usando el marco TAM y aplicados al uso de la IA en ámbito educativo lo que justifica su uso a pesar de no ser un marco de nueva adopción (20).

When formulating the questions, SWOT-type decision matrices were also applied (Debilidades, Amenazas, Fortalezas y Oportunidades) (21). Este enfoque, nos permitió explorar los to identify possible risks and difficulties that the implementation of new technologies may entail. Los cuestionariosThese were developed oby a group of 10 experts who did not participate in the subsequent iterative rounds (group CORE, figure 1).

Regarding the search for consensus, and given the considerable heterogeneity in the thresholds used in Delphi studies, our study considered consensus percentages, but adopted a flexible criterion based on the qualitative interpretation of expert contributions in anonymous questionnaires and virtual meetings, as noted by Schifano and Niederberger (22). In this study, the disciplinary diversity and convergence observed between rounds support the panel's conceptual sufficiency and saturation.

All questionnaires were implemented using the REDCap tool (23). Se utilizó la plataforma REDCap por su diseño específicamente orientado a proyectos académicos y de investigación que requieren altos estándares de seguridad, trazabilidad y protección de datos, incluyendo el cumplimiento de normativas como HIPAA (*Health Insurance Portability and Accountability Act*) o GDPR (*General Data Protection Regulation*, o *Reglamento General de Protección de Datos*) (23). Data analysis was performed using JASP software.

3. Results

The Delphi study was structured in 3 phases, represented in Figure 1. The questionnaires, developed using the REDCap data collection and management tool, as well as the responses to them, are available here: https://zenodo.org/records/17876108

In Phase 0, the questionnaire was designed using a SWOT analysis framework (CORE group). Its objective was to gather the expert group's perceptions of the weaknesses, threats, strengths, and opportunities related to the integration of Artificial Intelligence (AI) in the university context within the health sciences. The aspects analyzed included academic integrity, the digital skills gap among faculty, governance and regulation, security in accessing technology, and the effects of AI on science teaching and learning. The surveys were distributed to a closed group of experts, whose experience in the field had been verified, through REDCap.

In Phase 1, new elements were added for prioritization by the expert group, such as the financial sustainability of institutions, the development of critical thinking, personal learning environments, and opportunities for educational innovation. Responses were systematically collected and analyzed for further analysis. In Phase 2, the prioritization phase, the CORE group reviewed the data, identified common patterns, and prioritized the most relevant elements. A working meeting (online format) was held to discuss the results with the experts, compare perspectives, and reach a consensus on the key points. Phase 3, or the validation phase, consisted of developing a new questionnaire with the prioritized items, on which the experts indicated their level of agreement, with the aim of achieving greater consensus. This phase concluded with a virtual meeting to consolidate the findings. The results of this phase, including the prioritized areas, are shown in table 1.

Figure 1. Creation of a Delphi study protocol combined with a nominal virtual group.

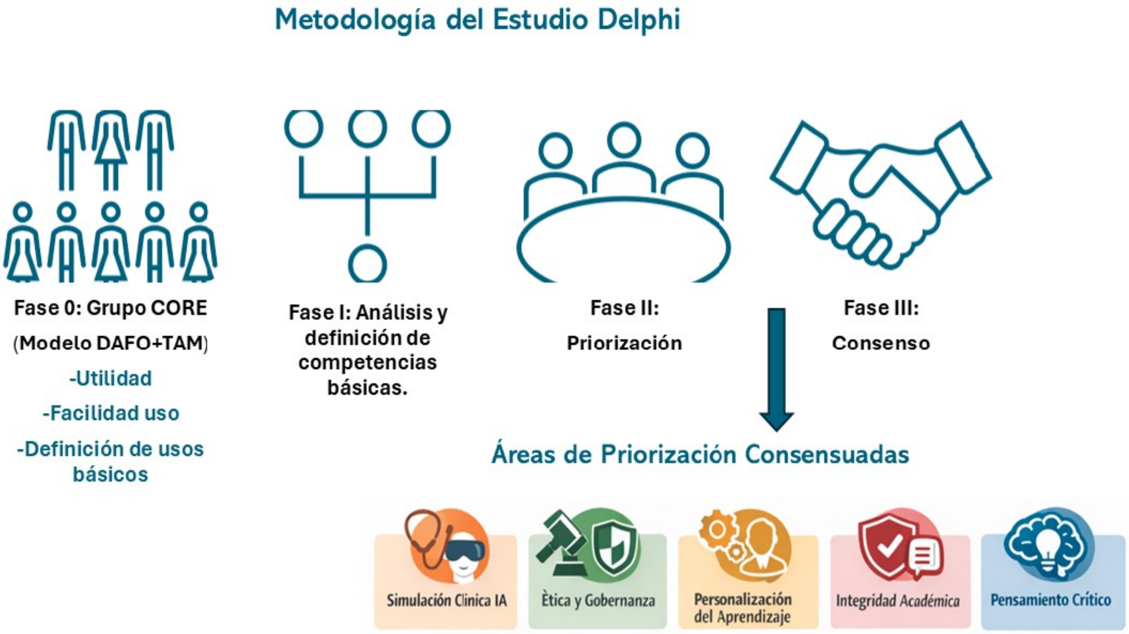

Table 1. Summary table showing the prioritization areas resulting from the Delphi study.

Prioritization Area	Delphi Consensus	Implications	Proposed solution
Clinical simulation with AI	58%	Develop clinical skills in a safe environment.	Implement adaptive generative simulation (ASCE) (24).
Ethics and Governance	43%	It requires data control, transparency, and bias reduction.	Governance framework aligned with EU and WHO regulations. (25-26)
Personalization	57%	Content adaptation, intelligent feedback.	Modular design system, learning analytics, cultural adaptation (27).
Academic integrity	71%	Risk of plagiarism and ambiguous authorship.	Authentic evaluation and declaration of use AI (28).
Critical thinking	57%	Promoting clinical reasoning and metacognitive reflection.	Argumentative simulation and AI-human comparison (29-30).

The Delphi study identified five key areas for integrating artificial intelligence into biomedical education. First, **AI-based clinical simulation** was prioritized by 58% of the panel as the most valuable training strategy, highlighting its ability to strengthen clinical skills in safe and reproducible environments. Second, 43% indicated that **ethics and governance** constitute the main challenge, especially due to the implications for privacy, transparency, and mitigating algorithmic bias—aspects that require regulatory frameworks aligned with international standards. Similarly, **personalized learning** emerged as a key opportunity for 57% of the experts, who emphasized AI's potential to adapt content and provide intelligent, real-time feedback. The area of **academic integrity** garnered the greatest consensus (71%), given the growing concern about plagiarism, ambiguous authorship, and the non-transparent use of generative tools, underscoring the need to redesign assessment strategies toward more authentic and traceable formats. Finally, 57% highlighted the importance of

critical thinking, recognizing that interactive simulations and AI-assisted decision-making are effective tools for promoting deep clinical reasoning and metacognitive reflection in health science students.

4. Discussion

El estudio Delphi que aquí se describe permitió recoger, depurar y estructurar de forma iterativa las aportaciones del panel de expertos en un contexto de alta incertidumbre respecto al uso de la inteligencia artificial. Este diseño metodológico facilitó la identificación de patrones compartidos y áreas de convergencia necesarias para fundamentar el análisis posterior. En coherencia con ello, se adoptó un enfoque combinado basado en el análisis DAFO y el *Technology Acceptance Model* (TAM) (16, 17, 21) , marcos especialmente adecuados para examinar percepciones, barreras y facilitadores en etapas tempranas de adopción tecnológica. The results of this study show that the Delphi method is a solid tool for achieving a structured consensus on the integration of AI in biomedical education, even though there is heterogeneity of institutions and contexts.

In Spain, there has been an accelerated adoption of AI tools in teaching and research, despite the lack of a uniform regulatory and training framework. This multi-institutional approach allows for the prioritization of needs and reduces the existing conceptual fragmentation among institutions and professionals. The consensus reached also reflects a shared concern about balancing the pedagogical potential of these technologies with the ethical, legal, and educational risks associated with their use.

El consenso alcanzado en simulación clínica coincide con la proliferación de simuladores basados en modelos generativos y pacientes virtuales inteligentes, que han demostrado mejorar la adquisición de habilidades clínicas y la toma de decisiones en entornos seguros. Estudios recientes muestran que los simuladores impulsados por IA pueden igualar o incluso superar la efectividad de actores clínicos en tareas como la anamnesis o la resolución de casos clínicos, reforzando su papel en la formación médica de pregrado y posgrado (3, 31).Notably, the emphasis placed on skills related to critical thinking, the interpretation of AI-generated results, and professional responsibility suggests an educational approach that goes beyond mere technical mastery. This orientation is consistent with the current needs of the Spanish university and healthcare systems, where clinical decision-making continues to rest with professionals, regardless of the level of technological support used.

However, integrating these competencies into curricula presents significant challenges. The heterogeneity among Spanish universities in terms of resources, teaching load, and access to AI technologies hinders a uniform implementation. Furthermore, the lack of specific accreditation or AI training requirements for biomedical faculty limits their ability to apply pedagogical strategies aligned with the agreed-upon framework. Considering AI as a cross-cutting competency in biomedical education, rather than as an isolated subject, requires a thorough curricular review, which, within the Spanish regulatory context, tends to be slow and dependent on multiple levels of institutional decision-making.

In this context, recent advances associated with Large-Scale Language Models (LLMs) and conversational agents are introducing remarkable transformations in medical education. These technologies enable personalized learning, adapting content to the pace, level, and needs of each student. According to Kloos et al., LLMs facilitate student-centered education by offering adaptive resources and dynamic learning pathways (32). Furthermore, the automation of assessment and feedback through AI-based systems streamlines the educational process and improves the immediacy and quality of feedback from instructors. Razzak et al. also highlight that automated feedback helps students improve their skills in real time and with greater continuity of learning (33).

Furthermore, recent literature suggests that the combination of personalization and automation has a positive impact on academic outcomes. Fernández Cerero emphasizes that AI contributes to improving knowledge retention and the preparation of healthcare students to face real clinical situations, providing more efficient practice environments tailored to individual needs (34).

All these studies and opinions reinforce the idea that AI should be strategically, cross-cuttingly, and evidence-basedly integrated into biomedical training, ensuring that technologies serve educational quality and not the other way around. This integrated framework of quality, evidence, and professional autonomy forms the basis for moving toward more robust, coherent, and future-oriented training ecosystems.

5. Conclusions

- The results of this Delphi study show that AI tools can significantly transform teaching and learning, provided that their implementation is supported by robust supervisory structures, common policies, and adequate training for teachers and students.
- This integrated approach makes it possible to harmonize innovation and responsibility in a Spanish context characterized by uneven growth in digital capabilities and a regulatory framework that is still being consolidated.
- The future of higher health education will depend on combining intelligent use, ethical governance, and authentic assessment, ensuring that technology amplifies, and does not replace, professional judgment and meaningful learning.

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AI usage statement: M365 Copilot was used exclusively to support text restructuring, idea organization, and writing improvement. Copilot was also used to design some of the icons in Figure 1. The tool did not intervene in the generation of substantive content, the interpretation of results, or the panel consensus process, which were carried out entirely by the authors.

Ethical statement: This study was approved by the Research Committee of the Doctoral and Research School of the European University, with code CI 2023-414.

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