

01. Title: Impact Of Ai-Based Educational Interventions On Academic Performance And Learning Of Medical Students: A Meta-Analysis

CESARIO, G. S¹; Samyra Fernanda Santos Silva¹; Gabriela Gabriel da Fonseca¹; Danilo De Amorim Simões; Emily Shiu Takahashi; Giovanna Antunes Pereira¹; Beatriz Lopes; Amanda Arcifa Ferreira; Matheus Trolezi Silva; Gustavo Morgado da Fonte Marino; Kim Karl Silva; Thomas Moreno Camargo; Giovanna Camillo Leite Pereira Pinto; Lauren Lee Schuster Biallowons; Rafaela Andrade Costa; Sofia Mei Hirata; Luisa Vieira Causin Alves; Nicole Camillo de Oliveira Amaral; Lais de Alvarenga Santa Barbara; Anny Elisa Costa Borges; Letícia Pastana De Mello; Marina Lobo Carvalho; Herakles Antonio Garcia Perez.

¹ Universidade de Santo Amaro. Brasil.

Introduction: Contemporary medical education demands educational approaches capable of adapting to the individual needs of students, something still limited by traditional teaching models. In this context, educational interventions based on Artificial Intelligence, including intelligent tutors, adaptive platforms, virtual patients, language models, and chatbots, have emerged as promising strategies to personalize learning paths, increase the availability of formative feedback, and reduce the extrinsic cognitive load associated with conventional instructional methods. Despite this potential, the magnitude of the benefit provided by these technologies, when compared to traditional or non-AI-based pedagogical strategies, still lacked robust and quantitative systematic evaluation. The objective of this study was to evaluate and quantify the impact of AI-mediated educational interventions on the academic performance and learning of medical students in relation to non-AI-based methods.

Methods: A systematic review with meta-analysis was conducted according to the PRISMA 2020 guidelines. Searches were conducted in the PubMed, LILACS, and SciELO databases and included studies published between 2015 and 2025, in Portuguese, English, and Spanish. Eligible studies were experimental or quasi-experimental studies involving undergraduate medical students that implemented an AI-based educational intervention, presented a comparator group, and reported objective learning outcomes or academic performance (e.g., test scores, OSCE performance, knowledge retention).

The methodological quality assessment used the RoB 2 and ROBINS-I tools. Quantitative synthesis was conducted using a random-effects model, with effect size estimation using Hedges' g. Results: The search identified 231 records, of which 81 studies were included in the qualitative synthesis and 10 randomized clinical trials comprised the meta-analysis. Educational interventions based on Artificial Intelligence have demonstrated a positive and significant impact on the learning of medical students. AI-based strategies showed superiority over traditional methods, with a robust effect size ($g = 1.07$; 95% CI: 0.90–1.24; $I^2 = 48\%$). This effect size corresponds to a high educational impact, indicating substantial superiority of AI-based interventions. The greatest benefits occurred among pre-clinical students and in interventions using adaptive platforms, while chatbots and virtual patients also promoted relevant gains in clinical reasoning, communication, OSCE performance, and knowledge acquisition. Meta-regression indicated that students with lower baseline performance showed proportionally greater gains, suggesting an equalizing effect of AI,

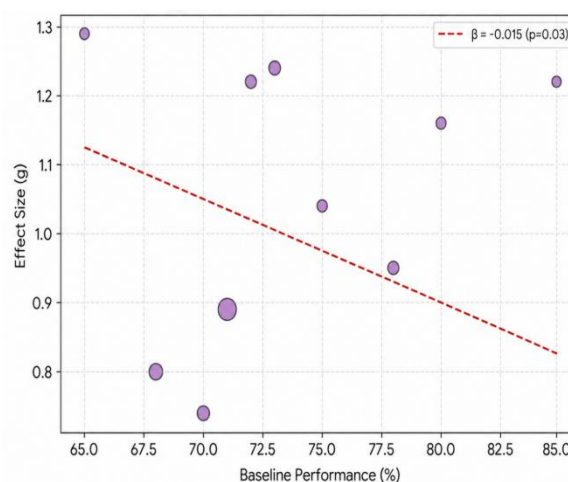
and that systems with complex and adaptive feedback were associated with better academic results. However, moderate heterogeneity was observed among the studies, especially regarding the types of intervention and methods of outcome assessment.

Conclusion: Educational interventions based on Artificial Intelligence promote consistent and significant improvement in academic performance and learning outcomes of medical students. These effects are more pronounced when technologies are integrated into structured pedagogical models, anchored in adaptive feedback and aligned with curricular objectives. AI is configured as a high-value complementary tool, without replacing teachers or face-to-face clinical experiences, but enhancing the personalization of learning, reducing cognitive load, strengthening self-efficacy, and promoting educational equity. Its curricular incorporation must occur with teacher supervision, critical digital literacy, and attention to the ethical and responsible use of these technologies.

Key Words: Artificial Intelligence (AI); Learning curve; Education, Medical; Learning Strategies; Computer-Assisted Instruction.

Figure or Table:

Figure 1: Meta-regression: Intervention Duration



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