Fostering autonomous learning in higher education through AI: effectiveness and student satisfaction

Miguel Izquierdo-Díaz[a[0000-0003-2695-0779]], Bárbara Biosca[a[0000-0001-6736-3437]], Lucía Arévalo-Lomas[a[0000-0002-4073-5664]], Blanca Castells[a[0000-0002-5018-1298]], David Paredes-Palacios[a[0000-0003-3408-0726]] and Humberto Serrano[a[0000-0002-7777-0527]]
[a] School of Mining and Energy Engineering, Universidad Politécnica de Madrid, C/ Ríos Rosas 21, 28003 Madrid, Spain
*miguel.izquierdo@upm.es

Keywords: Artificial Intelligence, Autonomous Learning, e-Learning, Virtual Assistant.

EXTENDED ABSTRACT

INTRODUCTION: The integration of Artificial Intelligence (AI) into higher education is transforming traditional learning paradigms by offering personalized learning experiences, real-time feedback, and adaptive learning paths [1]. These tools play a crucial role in fostering autonomous learning, where students take control of their educational journeys—a key factor in developing critical thinking, problem-solving, and lifelong learning skills. Effective autonomy, however, requires structured support, which AI provides through tailored educational experiences and timely guidance. By personalizing learning paths and offering immediate feedback, AI tools have the potential to make learning more accessible and efficient [2], encouraging students to engage more deeply with the material.

This research investigates the effectiveness of AI in promoting autonomous learning across various subjects in higher education, focusing on AI applications such as intelligent tutoring systems and adaptive learning platforms. The study aims to uncover key factors that contribute to successful AI-enhanced self-directed learning environments. The hypothesis proposes that AI-driven tools can significantly improve student engagement and academic performance by providing real-time feedback and personalized support, thus helping students manage their studies more effectively.

To achieve these objectives, the study examines two main aspects: the effectiveness of AI in fostering autonomous learning and the level of student satisfaction with AI tools. It explores whether AI applications not only enhance performance but also lead to greater student satisfaction by providing accessible, accurate information and support. The research analyzes feedback from students to identify the strengths and limitations of AI in education, offering insights into how these technologies can be further optimized to support learning in higher education. Through this exploration, the study aims to contribute valuable knowledge on how AI can be integrated into academic settings to enhance both learning outcomes and student experiences.

METHODOLOGY: The study was conducted across multiple subjects within different engineering degree programs at the Universidad Politécnica de Madrid, involving over 180 students. Three key subjects were selected: Chemistry, Conventional and Renewable Energies, and Geophysics, each with distinct academic challenges. In Chemistry, students solved a series of progressively complex exercises that were also proposed to ChatGPT versions 3.5 and 4. The goal was to compare AI's accuracy and reasoning with student responses, particularly as the difficulty of the problems increased. This allowed researchers to observe patterns in how AI handled both theoretical and mathematical tasks.

In Conventional and Renewable Energies, students were encouraged to use AI applications like ChatGPT to assist in exam preparation. They were provided with a list of questions before exams and could compare AI-generated answers with those discussed in class. At the end of the course, students completed a survey on their AI usage and its perceived effectiveness. This assessment helped evaluate the role of AI in facilitating understanding and improving student performance, particularly regarding its reliability as a study tool.

Geophysics presented a more complex application of AI, where students used it to interpret resistivity sections in geophysical prospecting tasks. The process involved students creating prompts for ChatGPT to analyze specific geophysical data, followed by a comparison of AI's interpretation with the students' own. The evaluation focused on the accuracy of AI-generated analyses and the relationship between the quality of student prompts and AI responses, providing insight into the potential and limitations of AI in handling subjective, non-deterministic tasks.

ISBN: 978-84-09-63206-0

RESULTS AND DISCUSSION: In Chemistry, AI tools performed well when addressing theoretical questions, often providing accurate and detailed explanations similar to those produced by students. However, as the complexity of exercises increased, particularly those requiring mathematical calculations, AI's performance deteriorated. While ChatGPT 4 consistently achieved better results than ChatGPT 3.5, both versions struggled with more advanced concepts, leading to errors that were easier to distinguish from student-generated responses.

For Conventional and Renewable Energies subject, students reported mixed results regarding their use of AI tools to prepare for exams. Over 70% of students used AI applications, and of those, nearly 40% found them helpful in clarifying concepts and providing additional information that enhanced their understanding. However, around 54% noted that AI's responses were sometimes inaccurate or confusing, which led to skepticism about fully relying on these tools for study. Despite this, students who critically engaged with AI—by cross-referencing its answers with their own knowledge—tended to achieve higher exam scores compared to those who solely relied on traditional study methods.

Geophysics case presented unique challenges, as AI was tasked with interpreting resistivity sections, a complex, subjective process involving qualitative analysis. While students were able to generate prompts for ChatGPT to analyze geophysical data, the AI's responses often lacked the depth and accuracy required for valid interpretations. The AI sometimes misinterpreted the data, focusing on superficial elements like color scales rather than the underlying resistivity values. Despite this, the exercise proved valuable in encouraging students to critically evaluate the AI's outputs and refine their own geophysical reasoning.

Across all subjects, the correlation between the quality of student prompts and AI responses was evident. In general, better-structured prompts led to more coherent AI outputs, though discrepancies still arose, particularly in non-deterministic tasks like those in Geophysics. These findings highlight the importance of prompt engineering and suggest that AI tools, while useful, require careful oversight and human intervention to ensure the accuracy and relevance of their outputs.

Overall, results demonstrate that AI can be a valuable tool in supporting autonomous learning, particularly in tasks involving theoretical understanding and straightforward problem-solving. However, its limitations in handling complex calculations and subjective interpretations indicate that AI should be used as a complementary tool rather than a substitute for traditional learning methods. Moreover, the need for critical engagement with AI-generated content is crucial for students to maximize its educational benefits.

CONCLUSIONS: The study concludes that AI-driven tools can substantially enhance autonomous learning by providing immediate, personalized feedback, which helps students manage their study time and improves their understanding of complex concepts. Despite some limitations, such as errors in complex problem-solving and a lack of ability to generate qualitative insights in fields like Geophysics, AI has proven to be a valuable complementary tool in higher education.

Student satisfaction was generally high, with most students acknowledging the utility of AI in clarifying concepts and improving their study efficiency. However, the study highlights the need for students to critically engage with AI-generated content, as AI may not always provide accurate or contextually appropriate responses.

In conclusion, the integration of AI in higher education has the potential to transform learning, enhancing student autonomy and satisfaction. To maximize its benefits, careful implementation, along with ongoing training for both students and professors, is essential. While AI shows promise in reshaping educational practices, its limitations must be understood and mitigated to fully harness its potential in promoting autonomous learning in higher education.

ACKNOWLEDGMENTS: The authors would like to thank Universidad Politécnica de Madrid for supporting this research under project "EduIA Avanzada: Integrando la IA en la Docencia Universitaria" (code number IE24.0604), funded by 2024 call on "grants for educational innovation and improvement of the quality of teaching".

REFERENCES

1. Opara, E., Mfon-Ette Theresa, A., Aduke, T.C.: ChatGPT for teaching, learning and research: Prospects and challenges. Global Academic Journal of Humanities and Social Sciences 5 (2023).
2. Yun, J.J., Lee, D., Ahn, H., Park, K., Yigitcanlar, T.: Not deep learning but autonomous learning of open innovation for sustainable artificial intelligence. Sustainability 8(8), 797 (2016).

 ISBN: 978-84-09-63206-0