

APPLICATION OF ARTIFICIAL INTELLIGENCE IN INDUSTRIAL ENGINEERING DEGREES: A CASE STUDY

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Abstract

Integrating emerging Artificial Intelligence (AI) tools into the teaching of Industrial Engineering courses has become a crucial aspect of the university environment. This requires both the continuous training of faculty members and the integration of new AI-based tools into teaching, as well as careful consideration of the significant ethical and social impact of these technologies. To address these objectives, the University of Valladolid (Spain) has funded an Innovative Educational Project at the Industrial Engineering School, with the participation of five different technological departments involved in its engineering degrees.

This paper presents the main results and conclusions obtained during the initial phases of this project, which have primarily focused on training lecturers in the use of AI tools to effectively integrate them into their teaching methodologies and to develop new educational materials. Specifically, AI tools are being used to generate questionnaires for student self-assessment, based on the content covered in each session. A key finding is the necessity of encouraging students to develop a strong critical mindset when using AI tools, particularly in analysing the reasoning behind AI-generated solutions. It has been observed that AI-driven self-assessment is particularly beneficial for theoretical knowledge, although students are guided to critically evaluate the AI's output, especially in problem-solving, where errors in intermediate steps can occur. The paper also presents specific examples related to systems and automation engineering using different AI tools and analysing their responses collaboratively with students to identify their strengths and weaknesses, highlighting both the potential and the current limitations of AI tools in these practical domains.

To summarize the main conclusions derived from this study, it is essential to encourage students to develop a strong critical mindset when evaluating responses provided by AI-based tools. To achieve this, it is important to allow and encourage the use of such tools in the classroom, guiding students in identifying inconsistencies in AI-generated texts or results, and comparing them with other sources of knowledge. Moreover, it is a priority for lecturers to stay continuously updated on advancements in AI-based tools. Anticipating the impact of these tools on teaching is crucial, as their development and applications are constantly evolving and improving.

Furthermore, with the gradual integration of AI into teaching activities, future engineers will be well-positioned to adapt to and lead technological changes in their industrial careers. Initiatives and experiences like this study will help both lecturers and students in their daily activities, allowing them to adapt to constant technological changes and helping them become better professionals in the not-so-distant future.

Keywords: Artificial Intelligence Tools, Industrial Engineering Degrees, Innovative Educational Project.

1 INTRODUCTION

Artificial Intelligence (AI) is currently an umbrella term for disruptive technologies in constant expansion, continuously transforming the technological landscape that both university lecturers and students must navigate [1, 2]. Additionally, the entry into force of the European AI-Act [3] highlights the need to analyse the ethical and legal implications that the use of these new tools entails in the university environment. AI is transforming our daily lives, and it is crucial for society to learn how to move forward with it.

At the educational level, AI-based tools present both new opportunities and challenges that lecturers should leverage to enhance their teaching skills, encouraging a more productive and positive learning environment [4, 5, 6, 7]. Furthermore, in a society where Industrial Engineering students play a key role in work teams within companies and factories, their training in cutting-edge technologies such as AI and their application across different fields becomes crucial in transforming the way these activities are carried out. The development of plans for integrating AI into universities is essential in the teaching

environment, allowing lecturers not only to train themselves in managing and using these new technologies, both in terms of content and application, but also to transfer this knowledge to students, enhancing their education.

To achieve this, different departments of the School of Industrial Engineering (EII, <https://www.eii.uva.es/index.php>) at the University of Valladolid (Uva, <https://www.uva.es>) proposed the following activities for the 2024-2025 academic year:

- Developing new teaching material using the latest trends in AI technology, both to create new content and to update existing material. The focus will be primarily on the practical aspects of courses aimed at problem-solving.
- Encouraging students to self-assess their knowledge using AI tools: Allowing students to use AI for problem-solving and/or document analysis, followed by a personal presentation explaining how they used the tools and assessing the accuracy of the generated content (critical reasoning).

The project will therefore help to establish and sustain a collaborative working group across various EII departments, facilitating an enriching exchange of experiences for all teaching staff involved in this initiative.

The following sections provide details on the development of the project. Section 2 outlines the methodology employed, including the objectives, techniques, and procedures used. Section 3 summarises the results obtained, highlighting the key findings and their potential implications, while Section 4 presents the conclusions. Finally, acknowledgements and references are included.

2 METHODOLOGY

This section introduces the objectives and describes the approaches and steps taken in the project.

The main objective of this Innovative Educational Project is to explore and analyse the various possibilities offered by current AI-based tools for university lecturers, evaluating their potential legal and ethical impacts, and enabling lecturers to innovate and transform the teaching of industrial engineering in multiple ways, facilitating teaching while also enriching the learning experience.

Moreover, three specific objectives were defined:

- 1 Training of faculty members in the field of AI: Helping lecturers understand AI tools and their potential at an educational level. This will significantly improve the quality of teaching. Learning to explore these techniques and transferring the acquired skills to students will be key for their future professional careers and the advancement of educational techniques in general.
- 2 Development of new educational materials and methodologies: Tools such as ChatGPT, DeepSeek, and Copilot can assist not only students but also lecturers, as they offer additional resources to answer frequently asked questions and generate new content, particularly at a practical level. The aim is to innovate by generating new and more up-to-date content adapted to the current real world, while being mindful of compliance with legal and ethical requirements, to be used in classroom and laboratory sessions of the subjects taught.
- 3 Student AI-based self-assessment: The aim is to search for and analyse new automated intelligent assessment techniques that can help students determine their educational level in a particular subject or topic. If the results of the analysis are promising, pilot tests will be launched with students to validate these new and innovative methods of self-assessment.

In this study, a qualitative approach has been followed to analyse and evaluate the integration of AI in Industrial Engineering degrees. The participants in the study are 14 faculty members from 5 different departments within the EII at UVa. These lecturers have varying levels of experience with AI tools, and they are responsible for analysing and deciding what to do, where, and how to implement it. That is, each lecturer selects the subject(s) under their responsibility that they consider could be best adapted to the use of AI tools and proposes an activity tailored to the subject, as well as evaluating the students' ability to use these tools. Students enrolled in different Industrial Engineering courses, in which these AI-based methodologies are implemented, are secondary participants.

The proposed work plan (a framework to ensure an evaluable approach) includes the following key phases:

- Faculty training sessions and AI tool exploration [Oct 24 - Dec 24]
 - Search and analysis of AI-based tools to support university teaching.

- Training sessions for university lecturers.
- Development of AI-enhanced teaching materials [Jan 25 - Mar 25]
 - Search and analysis of AI tools that assist university lecturers in generating and updating teaching materials.
 - Generation of teaching materials for the subjects.
- Implementation of AI-based student self-assessment activities [Apr 25 - Jun 25]
 - Search and analysis of AI tools to help students self-assess their knowledge in a given topic.
 - Proposal for self-assessment tasks for students.
- Analysis and evaluation of project outcomes [Jul 25 - Sep 25]
 - Evaluation of results: final documentation and conclusions.

So far, the first three activities described above have been completed, and the following four are currently underway. The next section presents the key results obtained up until April 2025.

3 RESULTS

The main results obtained from the initiatives launched during the first semester of the current academic year, as well as those started in the second semester, are presented below. Two main results were pursued during this period: training the teaching staff in AI tools for educational use and promoting student AI-driven self-assessment.

On the one hand, lecturers have acquired the skills needed to use AI tools in their teaching methodologies. Both the educational offering at universities and the large number of freely available online courses related to AI tools demonstrate that it is not necessary to design specific courses for this purpose. Once lecturers became accustomed to using AI tools throughout the project's implementation, the focus then shifted to the development of new educational materials using AI-powered tools to create and improve content for the next academic year.

Specifically, based on the slides used in class, AI tools are being employed to generate questionnaires (question tests) to be used at the end of each session. The aim is to allow students to self-assess and provide lecturers with feedback on the concepts students have assimilated during that session (see Table 1).

Table 1 Sample test questions generated by ChatGPT

<p><i>User prompt:</i></p> <p>I need to generate multiple-choice questions from the content of the robots.docx file. The questions must have three possible answers, where only one of them is true. I need at least 5 multiple-choice questions.</p>
<p><i>AI response:</i></p> <p>Below, I have generated 5 multiple-choice questions based on the content of the provided document on industrial robots. Each question has three possible answers, of which only one is correct.</p> <p>What is an industrial robot?</p> <ul style="list-style-type: none"> a) A single-use automatic machine. b) An automatic, reprogrammable, multi-functional handling machine. c) A mechanical device that cannot be reprogrammed. <p>Correct answer: b) An automatic, reprogrammable, multi-functional handling machine.</p> <p>What determines the number of degrees of freedom (DOF) in a robot?</p> <ul style="list-style-type: none"> a) The size of the robot. b) The number of sensors. c) The number of independent movements that each joint can perform. <p>Correct answer: c) The number of independent movements that each joint can perform.</p> <p>What is the main function of the wrist in a robot?</p> <ul style="list-style-type: none"> a) To provide linear motion. b) To orient the terminal element. c) To support the weight of the robot.

Correct answer: b) To orient the terminal element.

What is a characteristic of hydraulic drive systems in robots?

- a) They use electric motors.
- b) They stand out for their great power and load capacity.
- c) They are ideal for high-speed applications.

Correct answer: b) They stand out for their great power and load capacity.

What is the advantage of off-line robot programming?

- a) It allows the robot to be programmed without stopping production.
- b) It requires the physical presence of the robot.
- c) It is more expensive than online programming.

Correct answer: a) It allows the robot to be programmed without stopping production.

These questions cover various fundamental aspects of industrial robots, depending on the content of the document provided.

On the other hand, students have been encouraged to use AI tools to assess their knowledge and understanding. It has been observed that the self-assessment processes for theoretical knowledge have been the most beneficial, as AI tools tend to make mistakes in problem-solving. Although the result provided by the AI may be correct, errors often occur in the intermediate steps, particularly when more advanced mathematical knowledge is required. Therefore, students must focus not only on whether the result is correct, but also on the formulas used to obtain it.

Furthermore, when it comes to automation programming and the generation of simulations using graphical languages (such as Ladder, <https://webstore.iec.ch/en/publication/4552>, or Simulink, <https://es.mathworks.com/products/simulink.html>), AI tools are not yet sufficiently developed to provide accurate solutions (see Table 2 and

Table 3). In general, while the descriptions and steps produced by the AI are correct, the generated diagrams often do not align with the description, though in some cases they come close (see Figure 1 vs Figure 2 and Figure 3 vs Figure 4). This is understandable, given that these AI tools are based on Large Language Models (LLMs), which are more suitable for generating text.

Therefore, it is essential to encourage students to develop a critical mindset that enables them to analyse the results provided by AI tools, particularly in developing mathematical reasoning or graph-based programming problems, which are common in engineering disciplines.

Table 2 Ladder problem

User prompt:

A conveyor belt must be started (by turning on the motor M), either by activating a local start button (LA) or by activating a remote switch (RA). The belt must not operate if the motor is overheated. For this purpose, it has a thermal relay (TM) that is activated when there is overheating. Automate this process using a ladder diagram.

Possible correct answer:



Figure 1 Correct ladder diagram

AI responses:

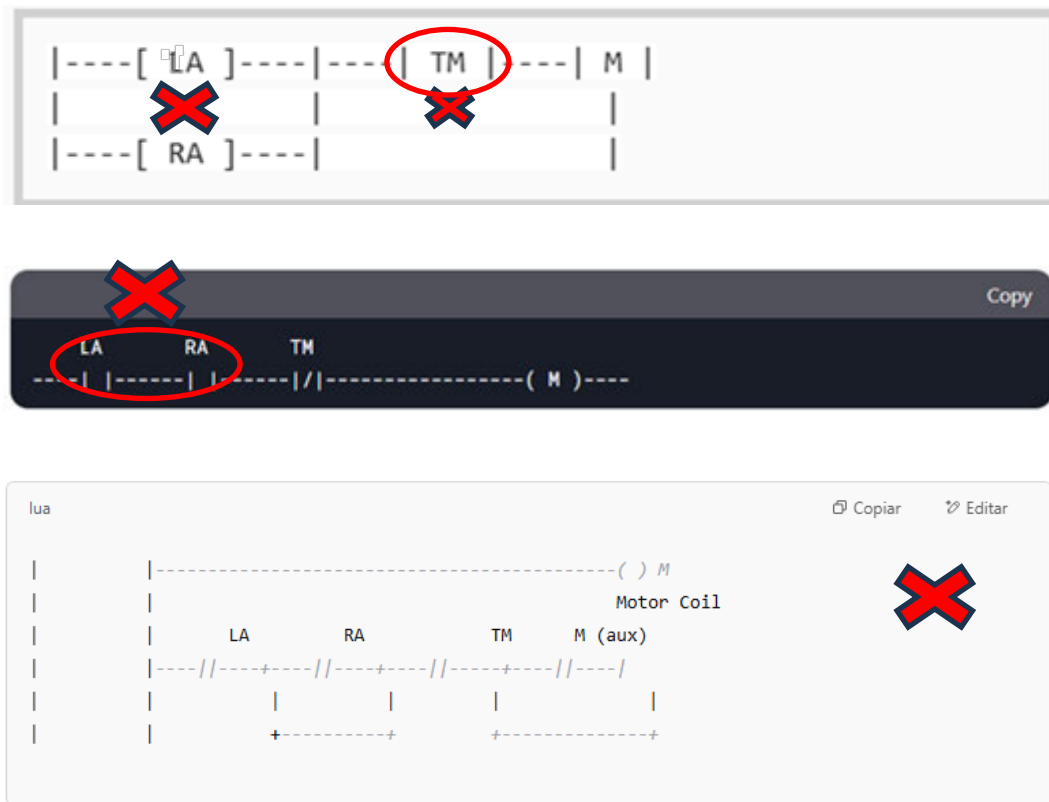


Figure 2 Some Ladder diagrams generated by Copilot, DeepSeek, and ChatGPT

Table 3 Simulink problem

User prompt:

Build the model in Simulink from ODE $y''(t) + ay'(t) + 50y(t) = 100u(t)$
 The input $u(t)$ must be a step of amplitude 1 in two cases: $a=5$, $a=50$

Possible correct answer:

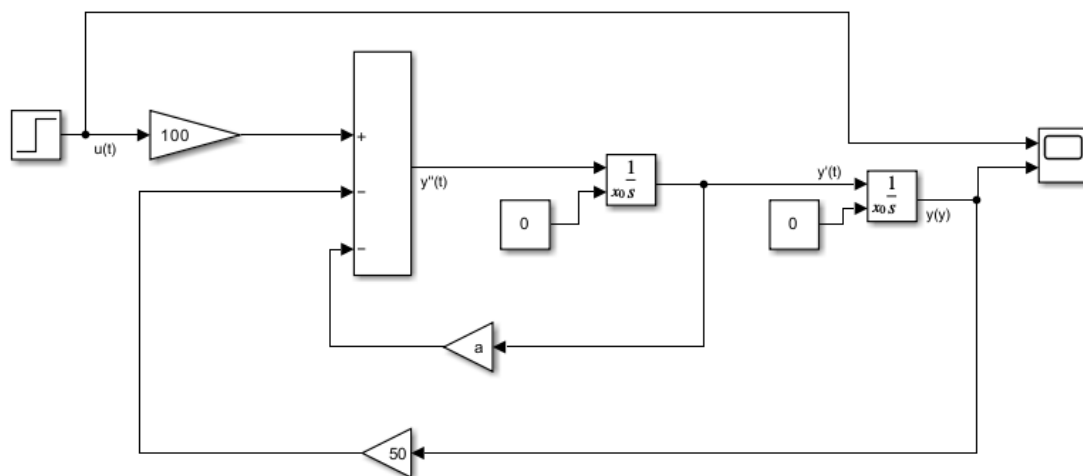


Figure 3 Correct Simulink diagram

AI responses:

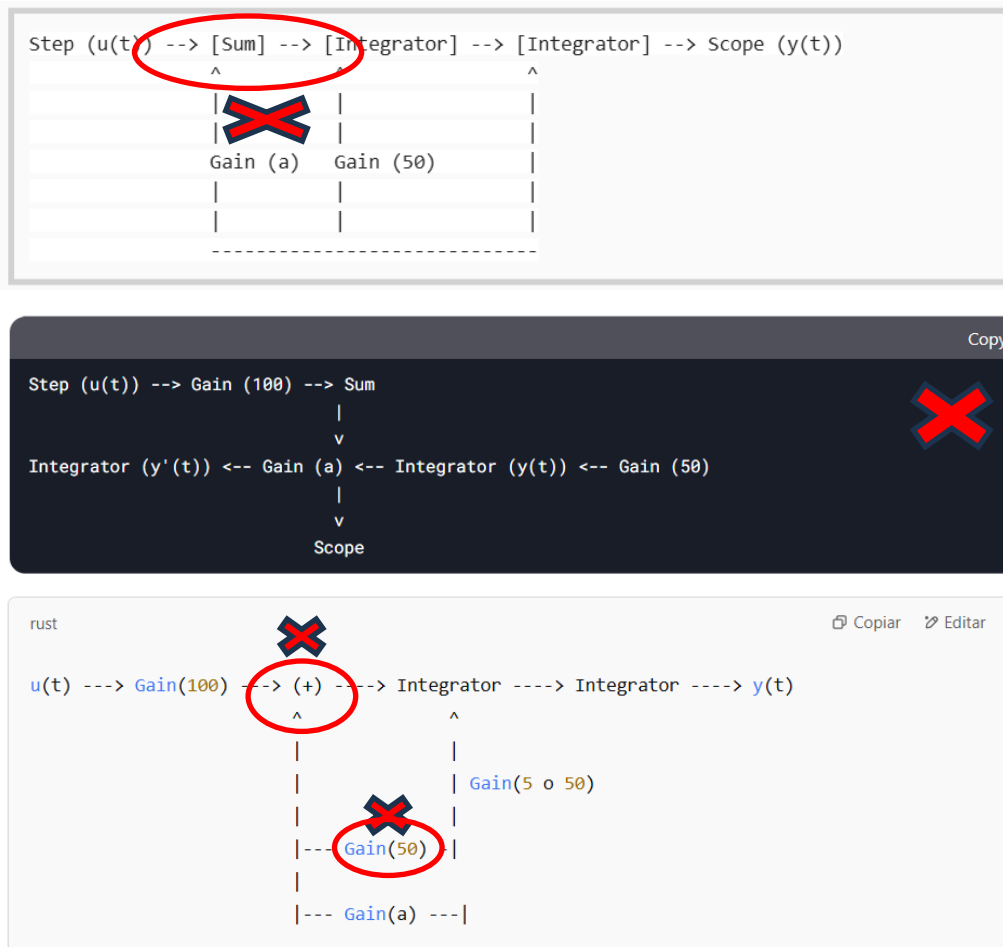


Figure 4 Some Simulink diagrams generated by Copilot, DeepSeek, and ChatGPT

4 CONCLUSIONS

The main conclusions derived from this study, based on interviews with faculty members to understand their perceptions of AI's role in teaching, as well as feedback from students regarding their experiences with AI tools, are as follows:

- AI tools are in continuous evolution and improvement, which means that providing necessary training for lecturers is crucial, while also addressing the ethical and social implications of these technologies.
- Long-term working groups focused on AI-based educational innovation within relevant courses, such as industrial engineering studies, are key. These groups help transform teaching and enrich the learning experience throughout the entire degree programme.
- Students must be encouraged to use AI tools for self-evaluation, which will improve learning outcomes, especially for theoretical concepts.
- It is necessary to help students develop a critical mindset regarding AI tools and their answers. To achieve this, it is necessary to allow and encourage the use of such tools in class, guiding students to detect inconsistencies in AI-generated texts and compare them with other knowledge sources.

AI-based tools will undoubtedly revolutionize the way teaching is carried out at all levels from now on, including at university. Therefore, initiatives and experiences like the one presented here will become increasingly common. This type of project will assist both lecturers and students in their daily activities, enabling them to adapt to the constant technological changes occurring and helping them become better

professionals in the not-so-distant future. Moreover, disseminating the results obtained to date and sharing specific experiences with the broader teaching community is essential for advancing within a technological landscape that continues to evolve.

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