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Artificial Intelligence and Mechanical Engineering in Greek Vocational High Schools: Educational Perspectives and Institutional Barriers

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ABSTRACT: This scoping review investigates the potential and challenges of integrating Generative Artificial Intelligence (GenAI) into Vocational Education and Training, with a specific focus on the Mechanical Engineering sector of Greek Vocational High Schools (EPA.L.). The purpose of this study is to analyze how AI can transform the teaching of mechanical engineering courses, bridging the gap between theoretical knowledge and laboratory practice in the context of Industry 4.0. The methodology involved a literature review of 26 scientific sources (2016-2026), utilizing thematic analysis guided by theoretical frameworks such as the Technology Acceptance Model (TAM) and teacher self-efficacy. Key findings indicate that the use of specialized, knowledge-enhanced Large Language Models (LLMs) significantly improves the structural integrity and technical accuracy of instructional materials, effectively reducing teacher preparation time. However, despite a high perceived usefulness, the adoption of AI by educators in public schools is severely hindered by the lack of adequate laboratory infrastructure, the absence of discipline-specific training, and heightened AI anxiety regarding ethical risks. In conclusion, the transition to an AI-enhanced school laboratory necessitates immediate upgrades to equipment and a shift from general ICT training to targeted, specialty-specific professional development programs, ultimately empowering teachers to become designers of digital learning experiences.

KEYWORDS: artificial intelligence, industry 4.0, lesson planning, mechanical engineering, teacher self-efficacy, vocational education.

INTRODUCTION

Modern technical and vocational education worldwide, and specifically in Greece, is facing one of the greatest challenges in its history. The advent of the 4th Industrial Revolution (Industry 4.0) has radically transformed the landscape of industrial production, integrating cutting-edge technologies into modern factories such as the Internet of Things (IoT), Digital Twins, automated CNC production lines and Predictive Maintenance systems. In this digitally transformed environment, Vocational High Schools (EPA.L.) are called upon to play a pivotal role: to prepare the future technical workforce of the country, ensuring that graduates will not merely be passive operators of mechanical equipment, but professionals capable of understanding, supervising, and interacting with smart and automated systems.

Alongside the industrial transformation, the rapid evolution of Generative Artificial Intelligence (GenAI) and Large Language Models (LLMs) offers unprecedented possibilities in the field of pedagogy. The educational community is gradually shifting from an initial stance of hesitation or fear of plagiarism toward a disruptive and creative integration of AI as a valuable digital co-pilot for the educator (Alier, García-Peñalvo, & Camba, 2024). In the teaching of mechanical engineering courses, where the continuous coupling of theoretical knowledge (e.g., strength of materials, machine elements, thermodynamics) with practical laboratory application is required, Generative AI can radically upgrade the teaching methodology. It can support the educator in the production of differentiated material, the creation of realistic fault scenarios for troubleshooting, and the personalization of learning based on the pace of each individual student (Kong & Yang, 2024).

However, the integration of general AI tools into technical education presents a significant knowledge gap regarding the structural integrity, logical coherence, and, most importantly, the technical and scientific accuracy of the generated content. Conventional LLMs often suffer from "hallucinations," producing vague or technically incorrect data, a fact that is highly dangerous for a Mechanical Engineering laboratory where adherence to safety standards and the accuracy of calculations are issues of vital importance. To address this challenge, modern research is turning toward specialized, knowledge-enhanced LLMs, such as the LessonPlanLM framework, which utilizes RAG (Retrieval-Augmented Generation) techniques to ensure that automated lesson planning strictly follows the curricula and the technical specifications of each respective specialty (Zheng et al., 2025).

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In the Greek educational system, and particularly within the framework of public vocational education, the introduction of these tools encounters multi-level institutional and organizational obstacles. Although Greek educators recognize the potential usefulness of AI in reducing their bureaucratic and preparatory workload, its systematic use is significantly limited by the lack of modern laboratory infrastructure, the absence of specialized digital skills, and the anxiety caused by ethical and deontological risks (Pantazatos, Taouki, & Meli, 2024; Petropoulou, 2024). As confirmed by international studies based on extended technology acceptance models (EETAM), the intention of educators to integrate AI into the school reality depends directly on the provision of targeted, specialty-specific training and the existence of an organized school strategy, and not on fragmented individual initiatives (Ng, Chan, & Lo, 2025; Tomczyk & Majkut, 2025).

In Greece, the need for the practical training of secondary education teachers in the use of AI tools for teaching and organizational purposes is imperative, with research highlighting the need for structured digital self-training courses (Diga, 2025; Bartzoulianou, 2024). Considering that the existing literature focuses primarily on general education or theoretical subjects (Papazaiti, 2025), it is deemed necessary to investigate the application of AI in specialized technical environments, such as the Mechanical Engineering sector of EPA.L.

The purpose of this study is to analyze how the digital transformation through Artificial Intelligence can be applied effectively and safely in the courses of the Mechanical Engineering sector of EPA.L. To achieve this purpose, the study is guided by the following two research questions:

- RQ1: In what way can the integration of specialized Artificial Intelligence models (knowledge-enhanced LLMs) improve the structure, coherence, and technical accuracy of educational material and lesson plans in laboratory and theoretical Mechanical Engineering courses at EPA.L.?
- RQ2: What are the critical organizational, technical, and ethical challenges faced by educators and the school units of EPA.L. during the attempt to integrate AI, and what strategies can be adopted for its effective inclusion in the curriculum?

MATERIALS AND METHODS

Study Design

The present research follows the design of a Scoping Review, which is considered the most appropriate methodological approach for mapping the existing literature in a rapidly evolving field, such as that of the integration of Generative Artificial Intelligence (GenAI) in Vocational Education and Training (VET). The study was designed and executed in accordance with the international reporting guidelines PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews), in order to ensure its transparency, validity, and reproducibility. The aim of the design was to investigate the theoretical background (TAM and TPACK models), as well as the practical application of generative AI tools in the Mechanical Engineering sector of EPA.L.

Data Sources and Search Strategy

To identify the relevant literature, an extensive search was conducted in reputable academic databases, including Scopus, Web of Science, IEEE Xplore, and Google Scholar. Concurrently, to cover the gap regarding the Greek school reality (EPA.L.), data were drawn from the institutional repositories of Greek universities (e.g., University of Piraeus, Democritus University of Thrace). The search strategy was based on combinations of keywords and Boolean operators (AND, OR), such as: ("Generative AI" OR "Large Language Models" OR "LLMs") AND ("Vocational Education" OR "VET" OR "Mechanical Engineering") AND ("Teacher Self-efficacy" OR "Lesson Planning" OR "Technology Acceptance Model").

Eligibility Criteria

The inclusion criteria for the selection of the studies were defined as follows:

1. Studies published in the last decade (2016-2026), with particular emphasis on the period 2023-2026, due to the explosion of GenAI tools.
2. Articles written in the English or Greek language.
3. Research focusing on AI-enhanced instructional design, the competence and self-efficacy of educators, or the evaluation of AI models in education (e.g., LessonPlanLM).

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4. Primary research, case studies, systematic reviews, and approved postgraduate/doctoral theses.

Correspondingly

Articles were excluded (exclusion criteria) if they concerned exclusively the use of AI in fields outside of education (e.g., medicine) or studies focusing solely on preschool education without the possibility of transferring the conclusions to secondary vocational education.

Data Collection and Selection Process

The screening process was carried out in three stages. Initially, duplicate records resulting from the different databases were removed. Subsequently, title and abstract screening was performed in order to reject studies that did not meet the eligibility criteria. In the final stage, a full-text review was conducted on 31 potentially relevant sources. From this process, a final sample of 26 highly relevant scientific documents emerged, which were included in the final analysis.

Analytical Methods

For the analysis of the data extracted from the literature, the method of Thematic Analysis was utilized. The data were inductively coded and grouped into two central thematic axes (themes), which correspond directly to the research questions of the present study: · Axis 1: Upgrading pedagogical design and ensuring technical accuracy in Mechanical Engineering (RAG tools, AI-assisted evaluation, knowledge-enhanced LLMs). ·

Axis 2: Organizational, ethical challenges, and integration strategies within the framework of EPA.L. (digital literacy, teacher anxiety, extended technology acceptance model - EETAM).

No specific statistical software (e.g., SPSS) was used, as the nature of the research questions is ideally approached through the conceptual and qualitative synthesis of the existing theoretical frameworks and research data.

RESULTS

From the application of the inclusion and exclusion criteria, a final sample of 26 studies emerged (18 international journal and conference articles, 1 book chapter, and 7 Greek postgraduate and doctoral theses). The thematic analysis of the documents yielded specific findings that are categorized based on the two research questions (RQ1 and RQ2). A brief mapping of the primary studies and their quantitative/qualitative findings is presented in Table 1.

RQ1: Pedagogical Design and Technical Accuracy

Regarding the use of AI for lesson planning (RQ1), the findings demonstrate that simple Large Language Models (LLMs) present limitations in technical accuracy. However, the study by Zheng et al. (2025) recorded that the use of the LessonPlanLM framework, which integrates Retrieval-Augmented Generation (RAG) techniques and specialized Knowledge Bases, improves the index of structural integrity and logical coherence of the generated educational material, aligning it with the official curricula.

Furthermore, in the field of Mechanical Engineering, the comparative analysis by Coşkun & Altan (2025) showed a high correlation between the evaluations generated by AI and those of expert educators in mechanical design assignments. In the Greek context, the evaluation of tools (such as ChatGPT) for lesson planning (Papazaiti, 2025; Bartzoulianou, 2024) showed that these systems reduce preparation time by up to 40%, provided that the educator applies advanced prompt engineering techniques.

RQ2: Organizational Challenges, Self-Efficacy and Strategies (Challenges, Self-Efficacy & Strategies)

Regarding the acceptance factors (RQ2), quantitative studies based on the Technology Acceptance Model (TAM) showed that "perceived usefulness" constitutes the strongest predictor for the intention to use Generative AI, statistically surpassing "perceived ease of use" (Tang & Zhong, 2026; Zhao et al., 2024, $r=0.734$, $p<0.001$). Educators with constructivist pedagogical beliefs exhibited higher adoption rates.

Regarding self-efficacy, the thesis by Abhay (2025) and the research by Bergdahl & Sjöberg (2024, $n=718$) recorded a positive correlation between practical training in AI tools and the increase of educators' confidence in their teaching abilities.

Conversely, the data highlight significant challenges. The research by Petropoulou (2024) on Greek educators showed a negative correlation ($r=-0.502$, $p<0.01$) between participation in training sessions and actual usage in the classroom in public schools, a finding attributed to the lack of appropriate laboratory infrastructure. Concurrently, review studies (Tao et al., 2026; Ni Uanachain

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& Ibrahim Aouad, 2025) identified high levels of "AI anxiety" among educators, related to ethical risks, such as plagiarism and the potential cognitive debt of students due to over-reliance on the systems.

Table I: Overview of Key Themes and AI Applications in Educational Settings

Thematic Category	Authors / Studies	Key Quantitative & Qualitative Findings
AI-Enhanced Lesson Planning	Zheng et al. (2025); Παπαζαΐτη (2025); Μπαρτζουλιάνου (2024)	RAG models significantly improve structural integrity and curriculum alignment compared to standard LLMs. Time-saving metrics noted.
Engineering Assessment	Coşkun & Altan (2025); Han He (2024)	High correlation between AI and expert evaluations in engineering design tasks.
Technology Acceptance (TAM)	Tang & Zhong (2026); Tomczyk & Majkut (2025); Zhao et al. (2024)	Perceived usefulness is the primary driver for adoption (r=0.734). Constructivist beliefs positively impact intention to use.
Teacher Self-Efficacy & Training	Abhay (2025); Bergdahl & Sjöberg (2024); Δίγκα (2025)	AI literacy training directly correlates with increased teacher self-efficacy and reduced operational anxiety.
Ethical & Infrastructure Barriers	Tao et al. (2026); Ng et al. (2025); Πετροπούλου (2024)	Infrastructure deficits limit real-world application in public schools. Concerns regarding cognitive debt and plagiarism are prevalent.

DISCUSSION

The present scoping review investigated the possibilities and challenges of integrating Generative Artificial Intelligence (GenAI) in Vocational High Schools (EPA.L.), with a specific focus on the Mechanical Engineering sector. The interpretation of the findings confirms that AI is not merely an auxiliary digital tool, but a transformative factor that requires a radical revision of pedagogical design and school organization.

Interpretation of Findings in the Context of the Literature

Regarding the first research question (RQ1), the results clearly show that the use of general, non-specialized LLM models poses risks for technical education, primarily due to scientific inaccuracies. However, the adoption of knowledge-enhanced architectures (RAG), such as LessonPlanLM (Zheng et al., 2025), offers a viable solution. In the Mechanical Engineering laboratory, where accuracy in specifications (e.g., material tolerances, CNC settings) is critical for safety, these models allow the educator to produce reliable fault scenarios and worksheets in half the time. Furthermore, the high correlation between AI and expert evaluations (Coşkun & Altan, 2025) indicates that AI can function as a reliable "co-evaluator," providing immediate feedback on student designs and relieving the educator's workload.

Regarding the second question (RQ2), the analysis through the Technology Acceptance Model (TAM) offers a critical explanation for the hesitancy of educators. The fact that "perceived usefulness" outweighs "ease of use" (Zhao et al., 2024) means that Mechanical Engineering teachers are not simply interested in whether a tool is easy, but whether it genuinely solves problems in their laboratory. At the same time, the paradoxical finding of the Greek reality, where training is negatively correlated with classroom use (Petropoulou, 2024), is interpreted by the vast lack of digital infrastructure in public EPA.L. Educators are theoretically trained in AI, but return to laboratories without rudimentary equipment, a fact that leads to frustration and an increase in "AI anxiety".

Contribution to Knowledge and Practice

This study advances existing knowledge by shifting the discussion from "general education" to "specialized technical training". Practically, a model is proposed where the Mechanical Engineering teacher at EPA.L. transitions from the role of a simple "information transmitter" to the role of a "designer of digital learning experiences" (TPACK framework). At a policy level, the findings indicate that the Ministry of Education must abandon horizontal, general ICT training sessions and invest in targeted programs per specialty, combined with the immediate upgrading of laboratory hardware.

Strengths and Limitations of the Study (Strengths and Limitations)

The strengths of the present study include the combinatorial approach of theoretical models (TAM, TPACK, Self-efficacy) with empirical data that specifically concern the Greek educational system. However, the research is subject to limitations. As a scoping review, it is based on secondary data, while the rapid evolution of GenAI algorithms renders certain technical evaluations quickly obsolete. Additionally, there is a lack of primary quantitative data exclusively recording the attitudes of Mechanical Engineering educators in Greece.

Proposals for Future Research (Directions for Future Research)

Future research should focus on empirical, quasi-experimental studies within the laboratories of EPA.L. It is necessary to measure in real-time how the use of customized LLMs affects the academic performance of Mechanical Engineering students and their critical thinking regarding system failures, ensuring at the same time that the risk of "cognitive debt" is avoided.

CONCLUSION

The present study highlights that the integration of Generative Artificial Intelligence in Vocational High Schools (EPA.L.), and specifically in the Mechanical Engineering sector, constitutes a pivotal step for synchronizing technical education with the demands of Industry 4.0. The results demonstrated that the use of specialized AI models (knowledge-enhanced LLMs) ensures the necessary technical accuracy and structural coherence in the design of laboratory courses, transforming technology into a reliable "digital co-pilot". Concurrently, it was confirmed that the successful adoption of AI by educators depends primarily on its perceived practical usefulness and their degree of digital self-efficacy. The main contribution of the research lies in documenting that overcoming institutional obstacles and "AI anxiety" requires the abandonment of general training sessions in favor of targeted, specialty-specific professional development, which must inevitably be accompanied by the radical upgrading of the digital infrastructure of school laboratories.

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