Generative AI in an Educational Technology Course for Pre-Service Mechanical Engineering Educators: A Case Study

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***Abstract*—This study explores the integration of Generative Artificial Intelligence (GenAI) tools into an Educational Technology course designed for pre-service Mechanical Engineering educators. The course was redesigned to incorporate GenAI tools within the Learning by Design (LBD) framework, particularly centering around the development of a WebQuest project. Through a series of structured activities, the course introduced students to the applications of GenAI for ideation, instructional design, and content creation, fostering hands-on engagement with this emerging technology. A mixed-methods approach evaluated students' awareness, perceptions, and practical experiences pre- and post- intervention. Results indicated notable increases in students' familiarity with GenAI and a growing appreciation for its potential as teaching and learning tool. However, challenges were also identified, including overly generic outputs and contextual inaccuracies, underscoring the need for critical oversight and iterative refinement. This study contributes practical insights for teacher education programs seeking to prepare educators for the integration of GenAI technologies into diverse teaching and learning contexts.**

***Keywords*—generative AI, educational technology, teacher education, learning by design, webquests**

I. Introduction

Educational technology courses, offered in various contexts such as universities, teacher training programs, and professional development initiatives, are designed to equip future or in-service educators with the knowledge, skills, and confidence needed to effectively integrate digital tools into their teaching practices, preparing them to meet the demands of modern classrooms, where technology is increasingly central to fostering engagement, collaboration, and learning. In vocational and Science, Technology, Engineering, Mathematics (STEM)-focused contexts, this integration is not only beneficial but essential for modeling the technological practices students will encounter in their professional lives. To achieve effective technology integration, however, STEM educators must approach technology as a cognitive tool rather than merely a learning outcome. They need to focus equally on technology, pedagogy, and content, and possess the ability to combine these elements in their instructional designs [1].

Recently, Generative AI (GenAI) has emerged as a transformative technology with promising applications in education, including facilitating resource creation, supporting inquiry-based learning, and enhancing creativity in instructional design [2–4]. Recognizing its potential, researchers emphasize the importance of introducing GenAI into teacher education programs to help educators develop both technical skills and critical awareness of its affordances and limitations, better preparing them to utilize it as a teaching and learning tool in their classrooms [5–11].

In response to the growing call for incorporating GenAI into teacher education programs, this paper reports on an Educational Technology course for undergraduate pre-service Mechanical Engineering educators that was redesigned to include activities introducing students to GenAI tools. The course builds on the Learning by Design (LBD) approach [12], engaging students in collaborative problem-solving tasks that develop their Technological Pedagogical Content Knowledge (TPACK) [13]. A hallmark of the course is the WebQuest project, where student teams design authentic, vocationally relevant learning activities tailored to high school Mechanical Engineering students. Weekly lessons provide targeted instruction on educational technology concepts, guiding students as they address the multifaceted challenges of their WebQuest design.

Ahead of the 2023–2024 academic year, the course underwent a redesign to incorporate GenAI tools and activities, maintaining its LBD approach while introducing students to this emerging technology. The redesigned lessons aimed to foster technical proficiency and critical reflection on GenAI's applications and limitations in educational contexts. This integration provided students with opportunities to explore the relevance of GenAI for instructional practices and its broader implications for teaching and learning. By reflecting on students' experiences, this study seeks to contribute practical insights into the potential of GenAI for teacher preparation programs and its meaningful adoption in educational practices.

To achieve these goals, the study addresses two key research questions:

RQ1: How did the pre-service Mechanical Engineering educators' experience with the redesigned Educational Technology course shape their perceptions of GenAI's potential as a teaching and learning tool?

RQ2: How did pre-service Mechanical Engineering educators use and perceive the applications of GenAI tools for ideation, instructional design, and content creation during the redesigned Educational Technology course?

These questions provide a framework for examining both the broader impacts of the intervention on students' perceptions and their specific experiences using GenAI tools in an authentic educational context.

The remainder of the paper is organized as follows: Section II provides the theoretical foundation of the study, discussing the role of Educational Technology in teacher education (II.A) and the emerging significance of GenAI in this context (II.B). Section III outlines the study's methodology, describing the course context, participants, research tools, and data collection and analysis methods (III.A–III.B).

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Section IV presents the results of the intervention, detailing students' activities with GenAI tools (IV.A) and their responses to pre- and post-intervention questionnaires on awareness, perceptions, and future use of GenAI tools (IV.B). Section V discusses the research questions and concludes with implications for teacher education and the integration of GenAI into instructional practices. Finally, the limitations of the study along with suggestions for future research are presented in Section VI.

II. Background

A. Educational Technology in Teacher Education

Educational technology has long been an integral component of teacher education programs, equipping both pre-service and in-service educators with the skills necessary to integrate technology effectively into their teaching practices. This is especially critical in vocational and STEM-focused contexts, where technological fluency is indispensable. Vocational educators must model practices their students will encounter in professional environments, while STEM educators are tasked with facilitating inquiry-driven, real-world problem-solving experiences [14]. These responsibilities demand that educators view technology as a cognitive tool that fosters critical thinking, collaboration, and creativity, rather than as an end in itself [1].

To address these demands, educational technology courses should aim at fostering TPACK, emphasizing the interplay between its knowledge domains—technology, pedagogy, and content—in effective instructional design [13]. Several approaches have been proposed for achieving this aim (e.g., [12, 15, 16]). Among these, the LBD approach [12] stands out as a widely adopted method. It encourages teachers to develop their TPACK in an integrated manner, treating it as a cohesive whole rather than as separate knowledge areas. This approach emphasizes hands-on, collaborative learning, with student-teachers working in groups to develop technology-enhanced solutions to authentic pedagogical problems. Instructors play the role of facilitators, offering guidance and support throughout the process.

Design tasks in the LBD approach may vary but typically involve the creation of technology-supported lessons and resources. These can be tailored to specific disciplinary learning needs using specialized digital tools or designed with more generic technologies [17]. One example of such design outcomes is a WebQuest, an inquiry-oriented activity where most or all of the information learners interact with is sourced from the web [18]. Since their introduction in 1995 by Bernie Dodge and Tom March, WebQuests have gained widespread adoption across grade levels worldwide [19].

Research highlights the impact of WebQuests on student learning, demonstrating their effectiveness in boosting motivation, promoting collaboration and critical thinking skills, facilitating knowledge acquisition, and improving learning outcomes (e.g., [20–23]). From a teacher's perspective, the WebQuest model offers a structured yet flexible framework for designing technology-enhanced, inquiry-driven learning activities [24]. However, designing WebQuests presents challenges related to all three TPACK components and their intersections. These challenges make WebQuests an ideal design task for cultivating teachers' technology integration skills, as they mirror the complexities of authentic educational contexts (e.g., [25–27]).

Building on these foundations, the Educational Technology course used in this case study has long adopted the LBD approach to develop pre-service teachers' TPACK [1]. Students, pre-service Mechanical Engineering educators, are engaged in group work over an extended period through the semester to solve an authentic design problem. Specifically, they are tasked with designing a WebQuest for their specific target group of future learners—students attending a vocational high school in the Mechanical Engineering specialty. Each of the 10 weekly lessons of the course focuses on a key aspect of educational technology, providing students with the necessary knowledge and skills to address the design challenges posed by the WebQuest project.

The course, as it was structured until the academic year 2023–2024, included the following lessons:

The Internet as a Source of Educational Resources. This lesson introduced students to the Internet as a tool for accessing and evaluating educational resources. It emphasized critical evaluation skills, teaching students to assess the quality, reliability, and relevance of online content. Using structured guidelines and checklists, students evaluated a variety of educational websites. This hands-on activity equipped them to select high-quality, appropriate resources for their WebQuest projects, aligning with inquiry-driven learning goals.

Exploring WebQuests. Students were introduced to the structure and pedagogical foundations of WebQuests, an inquiry-oriented learning strategy. Through analysis of sample WebQuests, students examined key components such as the introduction, task, process, resources, evaluation, and conclusion. Discussions focused on the strengths and adaptability of the WebQuest model. This foundational lesson enabled students to begin constructing their own WebQuests with a solid understanding of the framework and its potential for fostering critical thinking and collaboration.

Developing Interactive Educational Websites. This lesson provided students with the skills to create interactive educational websites to host their WebQuests. They explored website development tools focusing on features that enhance usability, interactivity, and learner engagement. Students began designing the structure and preliminary content for their WebQuest websites, ensuring alignment with pedagogical goals and inquiry-based principles.

Peer Review and Feedback. Students presented their WebQuest drafts to peers and instructors, receiving constructive feedback on structure, content, and usability. These sessions allowed students to refine their projects iteratively, addressing alignment with inquiry-based learning principles and improving their designs. The collaborative process fostered critical evaluation skills and exposed students to diverse approaches to WebQuest design.

Educational Video Creation. This lesson introduced students to the use of video as a medium for enhancing teaching and learning. The primary objective was to equip students with the technical skills and creative strategies needed to create engaging educational videos that align with instructional objectives. Students created short videos to serve as the introductory component of their WebQuests, orienting learners to the topic and sparking their curiosity. By producing these multimedia elements, students enhanced their ability to use video as a tool for promoting engagement and supporting inquiry-based learning.

Leveraging Web 2.0 Tools. Students explored the potential of Web 2.0 technologies –such as blogs and tools for creating comics, word clouds, and other multimedia objects– for enhancing interactivity, collaboration, and engagement in educational settings. Students brainstormed ways to incorporate these technologies into a hypothetical WebQuest design, considering how these tools could be used to support each stage of the WebQuest process. Outputs were shared in class discussions, providing students with feedback and inspiration for their final WebQuest projects.

Finalizing and Presenting WebQuest Projects. In the final sessions, students completed their WebQuest projects, ensuring all required components were included and aligned with inquiry-based learning principles. Groups presented their finished WebQuests to the class, reflecting on the design process and receiving final feedback from peers and instructors.

B. Generative AI and Teacher Education

GenAI represents a transformative branch of artificial intelligence that enables the creation of new content—such as text, images, videos, audio, and code—through advanced machine learning models trained to understand and replicate the structure and characteristics of specific types of data [28, 29]. These models, including Large Language Models (LLMs) like OpenAI's ChatGPT and Google's Gemini, rely on user input to generate outputs that resemble the original data. Beyond LLMs, other GenAI architectures, such as Generative Adversarial Networks (GANs) and diffusion models, underpin a wide range of applications designed to serve various purposes across industries. Depending on the intended application, GenAI tools can produce outputs in diverse formats, adapting their user interfaces to meet the needs of users seeking text-based, visual, or multimedia content [30].

The potential of GenAI to revolutionize education has been highlighted in numerous studies. For students, GenAI offers efficient and effective personalized learning opportunities, fosters creativity in tasks like writing or project development, increases their motivation, and supports them in inquiry-oriented activities [31–33]. For educators, GenAI tools hold promise for enhancing productivity, creativity, and instructional capacity. They may streamline tasks such as lesson and resource creation [2] and foster creativity by inspiring innovative instructional strategies and approaches to lesson planning [4]. Moundridou *et al*. [3] in their classification of GenAI tools for educator use imply that these tools may support educators in: (i) planning – assisting them in instructional design, (ii) content creation – generating materials in diverse formats like text, images, and videos, (iii) evaluation – facilitating assessment and feedback, and (iv) delivering instruction effectively – acting as teaching assistants to provide them with ideas and support for addressing the challenges of effective instruction.

While these potentials are promising, research highlights that their realization heavily depends on providing educators with the skills and training necessary to leverage these tools in practice. Chiu [5] advocates for reimagining pre-service teacher education programs to position AI literacy as a core component; likewise, Barrett and Pack [6] highlight the urgent need for professional development initiatives in these matters. However, for educators to effectively utilize these tools, they must not only familiarize themselves with their technical functionalities but also develop a nuanced understanding of how to integrate them appropriately and efficiently into their teaching practices [7, 8]. In this sense, Zhai [9] underscores that comprehensive training and support enable teachers to move beyond basic applications of GenAI, empowering them to use it for personalized learning, adaptive feedback, and co-creative educational experiences. Teacher education should therefore focus both on technical proficiency and pedagogical application to ensure that educators can leverage GenAI tools to enhance learning environments while fostering inquiry, creativity, and critical thinking among students.

In line with this approach, researchers have proposed specific frameworks to guide teacher training on GenAI. Alexandrowicz [10] suggests incorporating exemplar activities that combine traditional pedagogical methods with AI-based tools, emphasizing critical evaluation and ethical considerations alongside practical applications in instructional design. Similarly, Saimon *et al*. [11] advocate for the use of structured models, such as the 6E Learning by Design framework, which integrates phases like exploration, engineering, and evaluation to equip teachers with the skills to design and refine AI-supported instructional strategies. These proposals underscore the importance of professional development programs that not only introduce educators to the functionalities of GenAI tools but also provide comprehensive guidance on their integration into curriculum design and delivery. By addressing both technical and pedagogical dimensions, such initiatives prepare educators to navigate the complexities of GenAI while maximizing its potential to transform teaching and learning practices.

Building on the growing recognition of GenAI's potential in education and the need to prepare teachers to integrate it effectively, the Educational Technology course described in the previous Section (II.A) was redesigned before the spring semester of the 2023–2024 academic year to incorporate GenAI tools and activities. Retaining its foundational LBD framework, the redesign aimed to familiarize students with this emerging technology while fostering both technical competencies and critical awareness of its applications and limitations.

The course continued to center around the development of a WebQuest project, with the following lessons being modified or newly introduced to integrate GenAI into the learning process.

Generative AI in Education. This newly introduced session provided students with a foundational understanding of GenAI concepts, tools, and applications in education. Through a lecture and lab session, students explored how text- and image-generation tools could be used to support instructional design. Following the session, students worked in groups to experiment with these tools, developing inquiry-based lesson plans and creating multimedia components for their hypothetical lessons. These outputs were shared and discussed in an online forum, allowing students to reflect on their experiences and exchange feedback.

Developing Interactive Educational Websites. This lesson, while retaining its focus on website creation, encouraged students to consider how GenAI could enhance the design process. Students reflected on how features embedded in website-building tools could support personalization and interactivity. In addition to creating the initial structure and content of their WebQuest websites, students discussed ways to leverage these capabilities to engage learners and align with inquiry-driven principles.

Leveraging Web 2.0 Tools. This redesigned session built on the original lesson's exploration of Web 2.0 technologies—such as blogs, comic creators, word clouds, and other online tools—by integrating GenAI as a teaching assistant. Students used GenAI to brainstorm creative and practical ways to incorporate Web 2.0 tools into their WebQuest designs, exploring how they could support different stages of inquiry-driven activities. This activity introduced students to GenAI's potential to assist in instructional planning and ideation. Outputs were shared in an online discussion forum, where students received peer and instructor feedback and critically reflected on the role of GenAI in supporting their instructional strategies.

Finalizing and Presenting WebQuest Projects. In the redesigned course, the final sessions retained their original structure, with students completing their WebQuest projects to ensure all required components were included and aligned with inquiry-based learning principles. Groups presented their finished WebQuests to the class, reflecting on the design process and receiving final feedback from peers and instructors. Additionally, however, students were asked to reflect on their use of GenAI during the project. They shared insights into how AI tools supported their instructional design efforts, providing valuable perspectives on the practical application of GenAI in educational contexts and contributing to the broader evaluation of the intervention.

Other lessons, such as *Educational Video Creation*, remained largely unchanged but included brief discussions about the potential of GenAI to support instructional design, including multimedia content development. In Fig. 1, the overall structure of the course is presented, along with the enriched sections featuring GenAI tools.

III. Methodology of the Study

A. Context and Participants

This study was conducted during the spring semester of the 2023–2024 academic year as part of the Educational Technology course, offered to pre-service Mechanical Engineering educators in their sixth semester at the School of Pedagogical and Technological Education (ASPETE), a higher education institution in Athens, Greece, specializing in engineering education. The course enrolled 31 students, all of whom had previously completed a foundational course on educational technology during their third semester, which introduced them to a range of digital tools and inquiry-based learning principles.

The primary objective of the Educational Technology course was to further develop students' TPACK, equipping them to integrate educational technologies into constructivist, inquiry-driven instructional designs. Following an LBD approach, the course engaged students in collaborative, project-based learning as they developed WebQuests tailored to vocational high school learners in the Mechanical Engineering specialty (see Section II.A).

For the purposes of this study, the course was redesigned to integrate GenAI tools and activities, familiarizing students with these emerging technologies while fostering critical awareness of their affordances and limitations. These additions provided students with hands-on experience in leveraging GenAI tools for instructional planning, content creation, and multimedia design, enhancing their technical competencies and instructional creativity (see section II.B).

B. Research Tools, Data Collection and Analysis

A mixed-methods approach was used to evaluate the impact of the intervention, combining quantitative and qualitative data sources.

The research tools designed for this study included:

1) Structured questionnaires (see Appendix A) were adapted from a tool used in prior research [34] and included a combination of open- and closed-ended questions as well as Likert-scale items, facilitating efficient data management, coding, and detailed analysis of responses. Quantitative data analysis was conducted using R [35]. The questionnaires were completed digitally and were accessible only to authorized students through the university's LMS platform. Specifically, the two questionnaires and their respective sections were as follows:
   - A pre-intervention questionnaire with 18 questions:
     Section A: 10 questions addressing the demographic characteristics of the participants.
     Section B: 6 questions assessing students' awareness and perceptions of AI.
   - A post-intervention questionnaire with 20 questions:
     Section A: 10 questions addressing the demographic characteristics of the participants.
     Section B: 9 questions exploring students' perceived impact and future use of LLMs.
2) All activities (see Appendix B), including the final WebQuest project, were delivered to students and submitted by them on the LMS platform. In particular,
   - In the 'Generative AI in Education' lesson activity, students were tasked with using LLMs and Image GenAI tools to create inquiry-based lesson plans and relevant multimedia content, respectively. In addition to these outputs, they were asked to provide a shareable link to their conversations with the tools, along with reflections on the tools' effectiveness, challenges, and limitations. Each group submitted the completed activity as a post in a discussion forum on the LMS platform.
   - In the activity of the 'Leveraging Web 2.0 Tools' lesson, students should use an LLM to brainstorm creative and practical ways to incorporate Web 2.0 tools into their WebQuest designs. They submitted their results by posting in a discussion forum on the LMS platform both the share link of their conversation and their reflections on the effectiveness of GenAI as an ideation tool for instructional design.
   - Students submitted their finished group projects as an assignment on the LMS platform and presented them to the class, receiving final feedback on their

WebQuests from peers and instructors. They were also asked to reflect on their use of GenAI during the project and shared insights into how these tools supported their instructional design efforts.

Fig. 1 illustrates the redesigned Educational Technology course and its alignment with the study's research framework. Course sections modified or newly introduced to integrate GenAI are highlighted in blue, while unchanged sections are shown in gray. The yellow boxes represent the research tools and processes used for data collection, including the Pre- and Post-Intervention Questionnaires, Activity 1, Activity 2, and the Final WebQuest Project. Each of these processes is linked to specific aspects of the research questions (RQ1 and RQ2), which focus on students' perceptions of GenAI as a teaching and learning tool, as well as its applications for ideation, instructional design, and content creation.

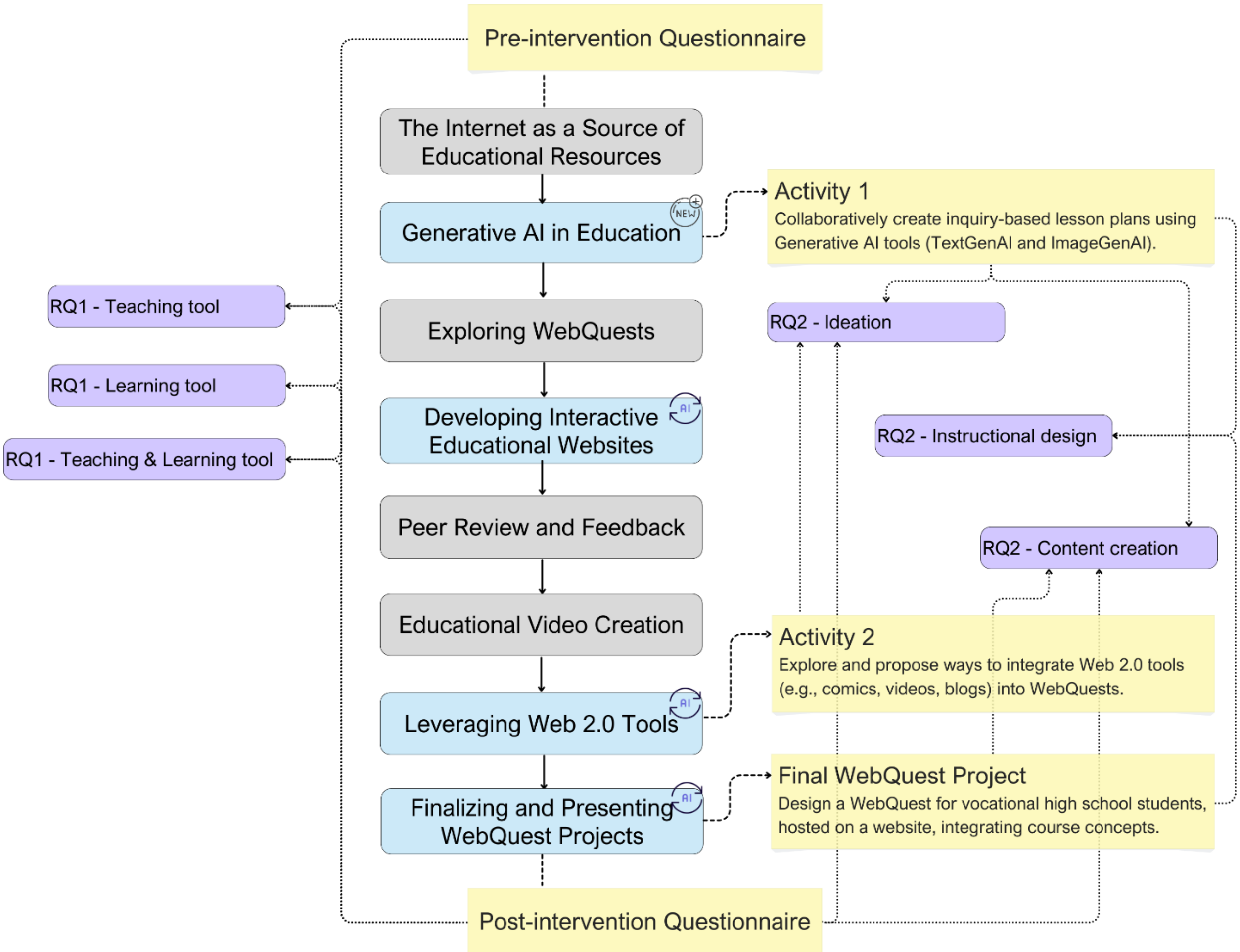

Fig. 1. Overview of the redesigned course structure and research framework.

The study was conducted in accordance with ethical research practices to ensure the protection of participants' rights and well-being. Prior to data collection, informed consent was obtained from all participants, who were assured that their participation was voluntary and that they could withdraw at any time without any negative consequences. Confidentiality and anonymity were maintained throughout the study, with all data being de-identified and securely stored to prevent unauthorized access. The intervention and data collection methods were designed to minimize any potential risks to participants, focusing solely on their perceptions and learning experiences. Approval for the study was obtained from the relevant institutional ethics committee, ensuring compliance with ethical standards for educational research.

IV. Results

In this section, we present the results from the activities conducted by the student groups, along with an analysis of the data collected from the pre- and post-intervention questionnaires. The results are organized by data collection tools to reflect how each source contributes to different aspects of the research questions. The connections between the findings and RQ1 and RQ2 are synthesized in the Discussion and Conclusion section.

A. *Student activities*

In the activity of the 'Generative AI in Education' lesson, students utilized LLMs and Image GenAI tools to create inquiry-based lesson plans and accompanying multimedia content. The completed outputs were posted by the 11 student groups in a discussion forum on the LMS platform. An analysis of these discussions revealed that the groups selected a wide range of topics for their lesson plans, including titles such as "How Refrigerators Work: The Compression Cycle", "Applications of Screws and Fasteners in Mechanical Assemblies", "Basics of Metal Welding Techniques", "The Refrigeration Cycle in Everyday Appliances," "Introduction to Gearbox Mechanisms" and "Understanding the Basics of Internal Combustion Engines."

Students' reflections were categorized into themes, providing insight into their experiences of using GenAI in this activity.

Concerning the first part of the activity, the themes that emerged (Table 1) included:

Table 1. Students' reflections on using LLMs to generate lesson plans during the 'Generative AI in Education' lesson activity

Thematic Category	Example students' reflections	Comments
Accuracy and Output Quality	"The final result was not satisfactory because AI has problems with translation."	The tool does not perform well with different languages.
	"The results were almost always inaccurate or seemed 'fake'."	Verification and user intervention are required.
	"The lesson plan seemed correct but too simplistic."	Needs more specialized analysis.
	"It could be more detailed with more specialized questions."	The tool can improve with additional information.
	"Gemini analyzed all phases of the exploratory lesson plan and continuously improved it based on our suggestions."	Shows a good ability to improve based on feedback.
	"ChatGPT understood what we were asking, and the final result [lesson plan] was quite satisfactory."	Shows good understanding and satisfactory results.
Prompt Adaptation	"I believe we would get better answers if we were more detailed in the prompt."	Details in the prompt affect the quality of the responses.
	"If we were more descriptive in what we were asking, perhaps the result would have been better."	Guiding AI requires clarity and detail.
	"The more specific the questions you ask, the more specific and detailed the responses you receive."	A basic principle of effective use of LLMs.
	"To incorporate everything we needed into the lesson plan, several rounds of Q&A were required."	Improvements require multiple iterations.
	"All one needs to do is ask simple and clear questions."	The tool is effective with simple and well-structured questions.
Usability and User Experience	"Sometimes the response generation was interrupted."	Stability issue during usage.
	"ChatGPT is very user-friendly, and we liked the interface for natural language communication."	Positive characteristic for users.
	"Gemini provides significant assistance to teachers by designing the lesson for them."	Useful tool for educators.
	"The ability to provide feedback directly on outputs made the tool feel more interactive and responsive."	Shows the value of feedback mechanisms in enhancing user experience.
	"Natural language communication made it easy to interact, but understanding how to phrase prompts effectively took practice."	Highlights the accessibility of the interface but notes a learning curve for optimal usage.
	"It was easy to get started, but understanding how to fine-tune the prompts took some trial and error."	Reflects a balance between initial ease of use and the learning curve for optimal usage.
Time and Performance	"ChatGPT produced a correct lesson plan extremely quickly."	Speed is a major advantage.
	"The result was impressive at first glance, especially considering how quickly it was created."	Highlights the value of speed in content creation.
	"The tool saved a lot of preparation time, allowing us to focus on improving the overall content quality."	Reflects the time-saving potential while emphasizing the need for human intervention.
	"Even though the initial output was fast, evaluating and correcting the inaccuracies consumed more time than expected."	Highlights the trade-off between speed and the time required for review and adjustments.
Reliability and Supervision	"At any time, [the LLM] can make mistakes, so you need to have knowledge of the subject to make interventions and ensure the final result is reliable."	Highlights the need for professional judgment by the user.
	"What we realized is that the result you get [from the LLM] should be used as a starting point for generating ideas, and the final lesson plan should come from your own interventions."	The tool is more useful as a creative idea generator rather than a fully automated solution.

Accuracy and Output Quality: Students highlighted varying levels of satisfaction with the quality of the AI-generated lesson plans. Some noted issues such as translation problems, inaccuracies, or overly simplistic outputs, while others found the results to be satisfactory for general tasks. They also observed that iterative feedback improved the quality of the outputs.

Prompt Adaptation: Crafting detailed and specific prompts emerged as a key factor in generating meaningful AI outputs. Students reflected on how clearer, more descriptive prompts led to improved responses, emphasizing the importance of precise input to achieve the desired outcomes.

Usability and User Experience: The tools were generally regarded as user-friendly, with students appreciating their ability to simplify the lesson planning process. However, technical interruptions, such as response generation failures, occasionally disrupted their workflow.

Time and Performance: The speed at which lesson plans were generated was a major advantage, with students noting the efficiency of the tools in producing initial drafts. However, creating a fully refined and complete lesson plan required multiple iterations and ongoing adjustments.

Reliability and Supervision: Students stressed the importance of professional judgment and oversight when working with GenAI tools. While these tools were seen as valuable for generating ideas and providing a starting point, students emphasized the need for user intervention to ensure accuracy, reliability, and alignment with instructional objectives.

These reflections demonstrate how students navigated the balance between leveraging the efficiency and creativity of GenAI tools and applying their own critical thinking and instructional expertise to refine the outcomes.

Concerning the second part of the activity, which involved using Image GenAI tools to generate images relevant to their lesson plans, students' reflections revealed the following themes (Table 2):

Table 2. Students' reflections on using Image GenAI tools to generate images relevant to their lesson plans during the 'Generative AI in Education' lesson activity

Thematic Category	Example students' reflections	Comments
Accuracy and Output Quality	"It was not what I expected because the program showed an air compressor and not a refrigeration compressor as I requested."	Highlights a mismatch between user expectations and the tool's output.
	"The result was what I expected, as the image shows all the tools needed for welding."	Positive feedback on the tool's outputs.
	"The images Firefly generated were not satisfactory for educational use."	Indicates a limitation in the tool's quality or relevance for educational purposes.
	"Craiyon produced a variety of high-quality images, but it struggled with creating specific technical illustrations."	Indicates strong creative capabilities but limited precision for specialized content.
	"The photo created was quite impressive and met my expectations… I believe it would definitely attract students' interest."	Points out the potential for AI-generated content to engage students.
	"Although the generated content was accurate, it required significant editing to align with my lesson objectives."	Shows that while the tool is useful, it still requires human oversight for fine-tuning.
Prompt Adaptation	"I had to be more specific to get the result I wanted."	Reflects the importance of prompt engineering.
	The result wasn't exactly what I expected, as I had to use several different prompts to achieve the desired outcome."	Demonstrates a trial-and-error approach in prompt formulation.
	"Good knowledge of English is required… The results are less satisfactory when the prompt is in Greek."	Highlights a language barrier in tool functionality.
	"When I added context to the prompt, the response became much more relevant to my lesson plan."	Shows how providing additional context in prompts enhances the relevance of AI outputs.
User Experience	"The tool I used was Craiyon. The results lacked variety and took a long time to generate the images."	Indicates repetitive results and slower performance.
	"Deep Dream Generator created the image we requested very quickly… It's convenient when a teacher wants to create an original, 'custom' image quickly."	Positive acknowledgment of efficiency and usefulness for instructional materials.
Reliability and Supervision	"At any time, [the tool] can make mistakes, so you need to have knowledge of the subject to ensure the final result is reliable."	Reflects the need for human oversight in using these tools.
	"The results were not always reliable; refinements and adjustments were needed to get closer to the desired outcome."	Indicates the necessity for user intervention to improve or adapt outputs.
	"Some outputs contained factual errors that could mislead students, so careful verification was required before use."	Highlights the importance of fact-checking AI-generated content for educational purposes.

Accuracy and Output Quality: Students reported varied levels of satisfaction with the quality of the generated images. While some outputs met expectations, accurately reflecting their prompts and aligning with educational needs, others fell short, producing results that were irrelevant or unsuitable for instructional use. This variation underscores the need for refinement to ensure outputs meet specific educational requirements.

Prompt Adaptation: The importance of crafting precise and specific prompts was a recurring theme. Students observed that better-defined prompts often led to improved results, while vague or overly general inputs produced suboptimal outputs. Some noted the additional challenge of working in languages other than English, which affected the quality and relevance of generated images.

User Experience: Students reflected on their experiences using the tools, emphasizing their subjective perceptions of ease of use and efficiency. While some appreciated the convenience of generating custom visuals quickly, others remarked on a perceived lack of variety in the generated outputs or the time required to achieve satisfactory results.

Reliability and Supervision: Students highlighted the necessity of human oversight when using GenAI tools. They noted that the generated images occasionally required significant refinement and that subject-matter expertise was essential to validate the reliability of the outputs. This theme underscores the tools' role as a starting point for creative and instructional efforts, rather than a fully autonomous solution.

This analysis highlights both the potential and limitations of Image GenAI tools, demonstrating their ability to support teachers in creating engaging visual content while emphasizing the importance of effective prompting, user expertise, and critical evaluation.

The student activity of the 'Leveraging Web 2.0 Tools' lesson involved using an LLM as a teaching assistant to provide ideas for integrating Web 2.0 tools into a WebQuest. Across the responses, all student groups acknowledged the potential of the LLM to generate "…many great ideas." Several groups further appreciated that "…[the LLM] fully justified everything it proposed," "…its suggestions were easily comprehensible," and "…was there to help us when we were stuck." However, the analysis of students' interactions with the LLM revealed that most groups engaged with the tool in a limited manner, typically submitting a single request prompt and not engaging in iterative dialogue. This pattern of usage may have influenced the nature of their responses, which lacked diversity and thematic variation. While the activity demonstrated the LLM's ability to support ideation effectively, it also highlighted a tendency among students to approach the tool as a static resource rather than an interactive assistant.

Students submitted their completed group projects as an assignment on the LMS platform and presented their WebQuests to the class, receiving final feedback from peers and instructors. Additionally, they were asked to reflect on their use of GenAI throughout the project and to share insights into how these tools supported their instructional design efforts. Among the 11 groups, 4 (36%) reported utilizing GenAI, specifically ChatGPT, during the development of their WebQuests. The reflections provided by these groups revealed mixed experiences. While GenAI was applied across several sections of the WebQuest, its perceived effectiveness varied. One group shared a positive experience, noting that "ChatGPT helped us design the rubric for the evaluation section." Another highlighted its dual usefulness, stating, "We asked ChatGPT initially to explain how to design the WebQuest," and further noting its support in designing the process section: "It also helped us divide the students into groups and assign roles to each." However, other groups expressed dissatisfaction with the tool's output. For instance, one group attempted to use ChatGPT for the Task component but ultimately rejected its suggestions: "We attempted to use ChatGPT to give us ideas for what task to assign to students in the WebQuest. The results were unsatisfactory, so we didn't use them." Another group reported only limited use of ChatGPT, stating, "We used ChatGPT sparingly… mainly to draft the introduction of the WebQuest." These reflections highlight both the potential and the limitations of GenAI in supporting instructional design. While some groups found ChatGPT useful for tasks such as creating rubrics or structuring the WebQuest process, others encountered challenges in obtaining contextually relevant or satisfactory outputs, leading them to either refine the tool's suggestions or abandon them altogether.

B. Pre and post-intervention questionnaires: Students' awareness, perceptions, and future use of GenAI tools

From the 31 students enrolled in the course, a total of 20 completed both the pre- and post-intervention questionnaires. The remaining 11 students may have been absent on the day of administration of either the pre- or post-intervention questionnaire or chose not to participate, as the questionnaire was optional. While no demographic or academic data were collected from non-respondents, their absence may have introduced selection bias, as they could represent a subset of the population with differing levels of engagement, interest in GenAI tools, or availability. As the study was conducted within the constraints of a semester-long course, follow-up with non-respondents to understand their reasons for non-participation was not feasible. Ethical considerations related to the voluntary nature of participation further restricted the ability to obtain responses from all enrolled students.

To evaluate the implications of the limited sample size ($N = 20$), a post-hoc power analysis was conducted to determine whether it was sufficient to detect statistically significant differences in pre- and post-intervention responses. The analysis was based on the calculated effect sizes (d) from the data, which ranged from 0.39 (small effect size) to 1.02 (large effect size) across the selected questions. Using the mean effect size ($d = 0.62$), representing a medium effect size according to Cohen's guidelines, and assuming a significance level of $\alpha = 0.05$ and a statistical power of $1 - \beta = 0.8$, the analysis indicated that a minimum sample size of approximately 42 participants would have been required. Consequently, the sample size in the present study was insufficient to achieve the desired power, and the results should be interpreted with caution.

Most respondents were third-year students, predominantly male, and graduates of vocational high schools. Nearly all participants reported owning personal computers and having reliable internet access at home, reflecting a high level of technological readiness. Quantitative data from the pre- and post-intervention questionnaires was collected to assess changes in students' awareness and perceptions of GenAI tools. Heatmaps (Fig. 2) illustrate the frequency distribution of students' responses to selected questions before and after the intervention, with darker shades representing higher response frequencies. In the pre-intervention heatmap, most students rated their familiarity with AI (Q11) and GenAI (Q12) at moderate levels, with fewer responses in the highest categories (4 and 5). Similarly, their belief in the utility of GenAI tools in their studies (Q14–Q16) was modest, with responses predominantly clustered in the middle categories (2 and 3). The post-intervention heatmap reveals a distinct upward shift, with higher frequencies observed in Likert scale categories 4 and 5 across most questions, particularly for Q12 ("I know what GenAI is"). Responses to New Q14 ("I believe that using GenAI tools supported me in the Educational Technology course") were similarly concentrated in the higher categories, indicating increased confidence in GenAI's relevance and utility.

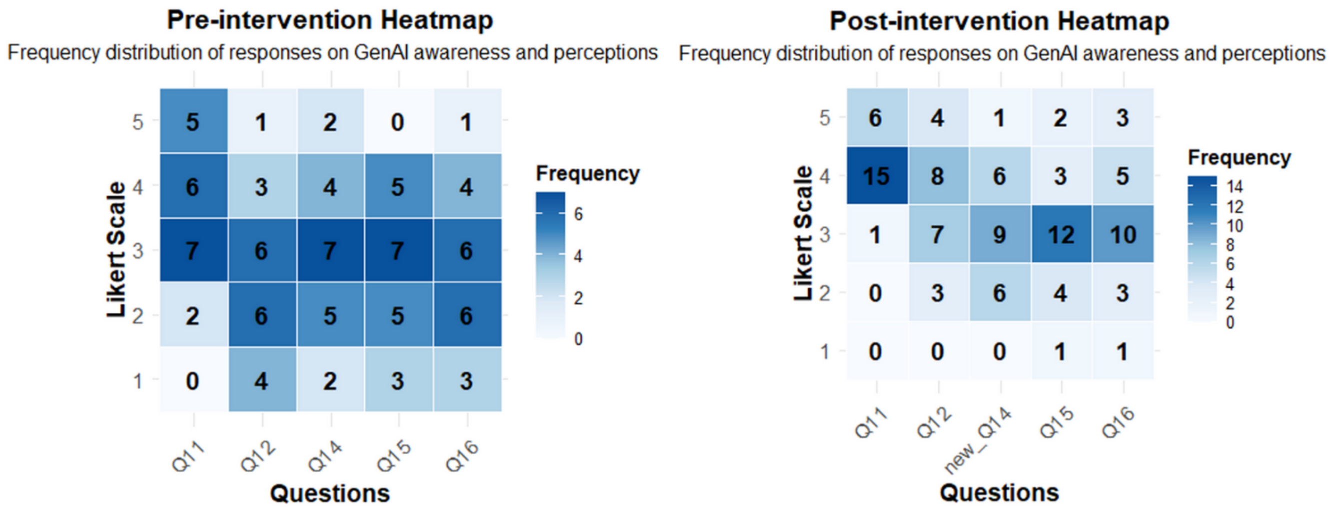

Fig. 2. Pre- and post-intervention heatmaps illustrating the frequency distribution of students' responses to selected questionnaire items on awareness and perceptions of GenAI. darker shades represent higher response frequencies on a 5-point Likert scale.

Table 3 provides a detailed breakdown of these shifts, presenting the distribution of Likert scale responses for key questions. The data highlights the overall positive trend in students' familiarity with and perceptions of GenAI. For example, the mean score (M) for Q12 increased significantly from the pre- to post-intervention responses ($M = 2.55$ to $M = 3.65$), reflecting a notable improvement in students' understanding of GenAI tools. Standard deviation (SD) reveals reduced variability for Q12 ($SD = 1.146$ to $SD = 0.988$), indicating greater consensus among students in their post-intervention perceptions. Similarly, Q14 (“I believe that using GenAI tools supported me in the Educational Technology course”) showed a moderately high mean score post-intervention ($M = 3.50$, $SD = 1.000$), reinforcing the tool’s perceived relevance to their studies. Q15 (“I believe that using GenAI tools will generally help me in my studies”) and Q16 (“I believe that GenAI tools are important for my field of study”) also demonstrated increases in their mean scores and lower standard deviations post-intervention, signifying improved agreement and confidence in the applicability of GenAI tools.

These trends are visualized in Fig. 3, which depicts the differences in Likert scale responses before and after the intervention.

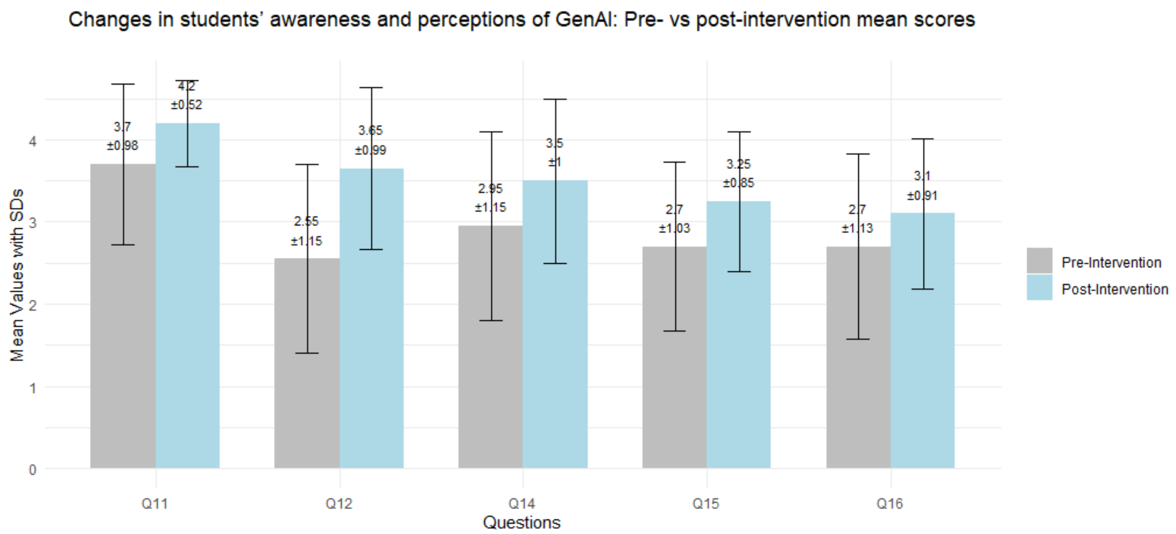

Fig. 3. Comparative bar chart of pre- and post-intervention mean scores for selected questions on awareness and perceptions of GenAI tools. Error bars indicate standard deviations (SDs).

Table 3. Pre- and post-intervention means (M) and standard deviations (SD) for selected questions on students’ awareness and perceptions of GenAI tools

Question	Pre-intervention		Post-intervention	
	M	SD	M	SD
Q11. I know what artificial intelligence is.	3.70	0.979	4.20	0.523
Q12. I know what generative artificial intelligence (GenAI) is.	2.55	1.146	3.65	0.988
Q14. I believe that using GenAI tools could support me in the Educational Technology course.	2.95	1.146	×	
New Q14. I believe that using GenAI tools supported me in the Educational Technology course.	×		3.50	1.000
Q15. I believe that using GenAI tools will generally help me in my studies.	2.70	1.031	3.25	0.851
Q16. I believe that GenAI tools are important for my field of study.	2.70	1.129	3.10	0.912
Q18. I believe that GenAI tools should be integrated as teaching aids across other courses.	×		2.95	1.276
Q19. I believe that I will use GenAI tools on my own initiative for other courses.	×		3.00	1.257

Further insights were drawn from students’ responses to Q18 (“I believe that GenAI tools should be integrated as teaching aids across other courses”) and Q19 (“I believe that I will use LLMs on my own initiative for other courses”). While both items showed moderate agreement (Q18: $M = 2.95, SD = 1.276$; Q19: $M = 3.00$, $SD = 1.257$), the standard deviations indicated variability in how students perceived the utility of LLMs for future use. These results suggest cautious optimism among students, with some enthusiastic about expanding GenAI’s role in their education, while others remain uncertain about its broader applicability.

The correlation analysis revealed several key relationships between the variables both pre- and post-intervention. Before the intervention, a significant correlation was observed between Q11 and Q12 ($r = 0.718$, $p = 0.00036$), highlighting a strong connection between general AI understanding and GenAI familiarity. The correlation between Q14 and Q15 ($r = 0.477$, $p = 0.0336$) indicates the relevance of GenAI’s anticipated support in the course (Q14) to its learning potential (Q15). Similarly, the correlation between Q15 and Q16 ($r = 0.642$, $p = 0.00226$) highlights the relationship between GenAI’s learning potential (Q15) and its teaching potential (Q16). After the intervention, certain relationships became more pronounced, particularly the correlation between Q14 and Q15 ($r = 0.588$, $p < 0.005$) and between Q15 and Q16 ($r = 0.688$, $p = 0.0008$). Additionally, a moderate to strong positive correlation was observed between Q14 and Q16 ($r = 0.577$, $p < 0.006$), highlighting the relevance of GenAI in supporting specific courses (Q14) to its utility as a teaching tool (Q16). Concerning the questions Q18 and Q19 that were introduced in the post-intervention questionnaire, the strongest correlations were observed with Q16 (Q19 and Q16: $r = 0.735$, $p < 0.001$; Q18 and Q16: $r = 0.728$, $p < 0.001$), highlighting a strong link between recognizing the importance of GenAI tools for educators (Q16) and their perceived utility both as a learning (Q19) and teaching (Q18) aid. No other statistically significant correlations were observed, likely due to the small sample size and reduced statistical power. This suggests that weaker relationships may not have been detected, and the findings should be interpreted with caution.

The post-intervention questionnaire also included the open-ended question “What do you specifically think the integration of GenAI tools in the Educational Technology course offered you?” (Q17). Based on the students’ responses to it, the following thematic categories were identified (Table 4):

Familiarity with GenAI: Students frequently emphasized how the integration of GenAI tools helped them become familiar with their functionalities, applications, and potential. Responses reflected that many students were introduced to GenAI for the first time and gained a better understanding of how these tools operate. This learning experience served as a foundation for further exploration and skill development.

Creativity and Resource Creation: The tools were recognized for their ability to inspire creativity and assist in generating new ideas, particularly for producing visual and multimedia resources. Students appreciated the role of GenAI in supporting imaginative thinking and enhancing their ability to create engaging content for educational purposes.

Efficiency and Convenience: Several students highlighted the practical advantages of using GenAI tools, describing how these tools streamlined their work processes and made tasks quicker and more manageable. They noted how structured support provided by GenAI facilitated the completion of assignments, saving time and effort.

Table 4. Categorized student responses to the open-ended question: "What do you specifically think the integration of GenAI tools in the Educational Technology course offered you?" (Q17)

Category	Explanation	Response examples
Familiarity with GenAI	Students gained familiarity with GenAI tools, including their functionalities, applications, and potential.	"The integration of AI into the course taught me how to use it, as I didn't know how before…" "I became more familiar with AI since I often used it to search for specific things." "I gained familiarity with AI tools, which helped me build a foundation for further exploration."
Creativity and Resource Creation	GenAI tools inspired creativity, helped students generate new ideas, and facilitated the production of visual and multimedia resources.	"It helped me more with the creative part." "It gave me many ideas." "It helped me create images for the site and inspired ideas for the WebQuest."
Efficiency and Convenience	GenAI tools made tasks easier and faster, offering structured support for completing assignments.	"Quick responses, concise information on topics, and help with structuring assignments." "It made it easier for me to find various things I needed." "With the right prompt, AI provides a good guide on how to approach an assignment."
Broader Knowledge and Insights	Students gained new knowledge and perspectives from working with GenAI tools, enriching their understanding.	"It broadened my general knowledge by providing more information." "It gave me more knowledge and a better understanding of the course." "A broader perspective on things."
Critical Reflection on GenAI	Students evaluated the limitations, challenges, and broader implications of using GenAI tools in education.	"It allows for more complete and immediate knowledge but comes with a higher risk of misinformation." "It makes many mistakes, so cross-checking information is necessary. It often needs guidance to understand something."

Broader Knowledge and Insights: Students reported that working with GenAI tools enriched their understanding and broadened their perspectives. Through their interactions with these tools, they accessed new knowledge and information, which contributed to a more comprehensive grasp of course content and concepts.

Critical Reflection on GenAI: Students reflected on the limitations and challenges of using GenAI tools in education, such as the potential for misinformation and the need for cross-verification of generated content. Their responses demonstrated an awareness of the complexities involved in leveraging these technologies effectively and responsibly.

This analysis underscores the multifaceted impact of integrating GenAI tools into the course, highlighting their potential to foster familiarity, creativity, and efficiency while also encouraging critical thinking and reflection on their broader implications.

Fig. 4 visually represents the frequency of responses within each category. Notably, the highest number of responses fell under the themes of *Creativity and Resource Creation* and *Broader Knowledge and Insights*, indicating students' recognition of GenAI's potential in fostering creative outputs and expanding their understanding. The theme *Critical Reflection on GenAI*, while less frequent, highlights the nuanced engagement of students with the limitations of these tools.

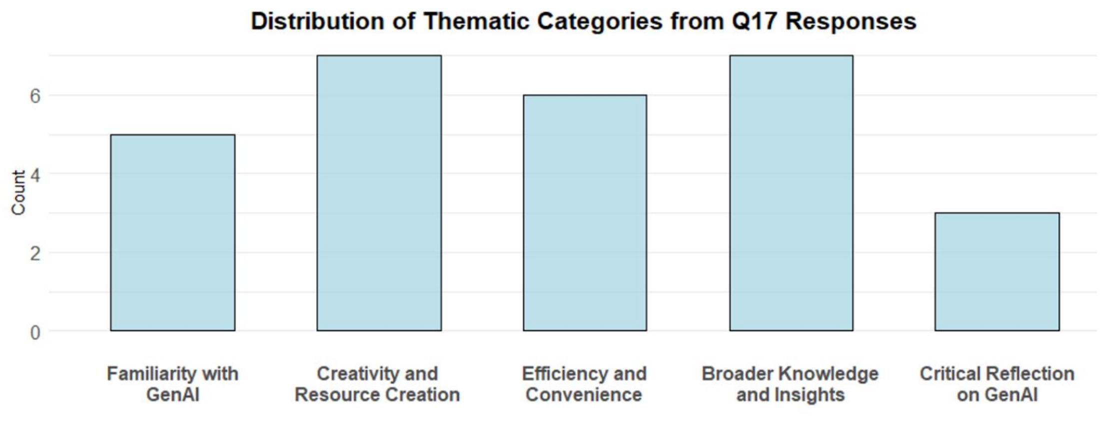

Fig. 4. Distribution of student responses across thematic categories for the open-ended question: "What do you specifically think the integration of GenAI tools in the Educational Technology course offered you?" (Q17).

V. Discussion

This section addresses the study's research questions: RQ1, which explores how the redesigned Educational Technology course shaped pre-service Mechanical Engineering educators' perceptions of GenAI's potential as a teaching and learning tool, and RQ2, which delves deeper into how these educators used and perceived the applications of GenAI tools for ideation, instructional design, and content creation. Together, these inquiries provide a comprehensive understanding of both the broader impacts of GenAI integration on students' familiarity and perceptions, as well as the specific affordances and limitations of these tools in supporting instructional practices.

RQ1: How did the pre-service Mechanical Engineering educators' experience with the redesigned Educational Technology course shape their perceptions of GenAI's potential as a teaching and learning tool?

The integration of GenAI tools into the redesigned Educational Technology course had a notable impact on students' familiarity with these technologies and their perceptions of their potential for teaching and learning. Pre- and post-intervention results (Table 3, Fig. 2) indicate a significant improvement in students' awareness of both artificial intelligence and GenAI, with higher frequencies of agreement observed in Likert scale categories for related questions (Fig. 1). Additionally, responses showed reduced variability, suggesting a greater consensus among students regarding their familiarity with these technologies. Reflections from Q17 further confirm that hands-on exposure to GenAI tools during the course contributed to this familiarity, providing a foundation for exploring their functionalities and applications (Table 4. *Learning and Familiarity with GenAI*). Building on this enhanced familiarity, students demonstrated a positive shift in their perceptions of GenAI's educational potential. Prior research highlights that familiarity with AI tools enables users to better recognize their benefits, such as supporting personalized learning and improving efficiency [36, 37]. Consistent with these findings, the results of this study show that students gained an increased appreciation for GenAI's role in education.

Perceptions of GenAI as a Learning Tool. Students' perceptions of GenAI as a tool to enhance their learning were generally positive but nuanced. Responses to Q15 (Table 3 and Fig. 2) revealed a growing recognition of GenAI's ability to enhance learning efficiency and support personalized educational experiences. Students were also slightly confident about using GenAI tools independently for their other courses, as indicated by their responses to Q19 (Table 3). Students' reflections in Q17 (Table 4 and Fig. 3) revealed their appreciation for GenAI's ability to efficiently and conveniently streamline their learning processes by broadening their knowledge and providing concise information and creative ideas. However, the challenges they identified, including inaccuracies and the need for iterative refinement of outputs, tempered their enthusiasm and underscored concerns about the tools' reliability. These findings align with observations by Monib *et al*. [38], who noted that while learners value GenAI tools like ChatGPT for their efficiency and ability to streamline tasks, they remain cautious about the quality and accuracy of the outputs. Such dual perspectives highlight both the promise and the limitations of using GenAI as a learning tool.

Perceptions of GenAI as a Teaching Tool. Students' perceptions of GenAI's potential to support teaching were more ambivalent. While many recognized its utility in enhancing creativity, supporting lesson planning, and streamlining content creation (Table 4), the slight post-intervention increase in responses to Q16 reflected moderate recognition of GenAI as a teaching tool in Mechanical Engineering Education. This was also the case with Q18 responses that indicated cautious optimism (Table 3 and Fig. 2). These findings align with observations by Bae *et al*. [39], who noted that pre-service teachers often recognize the importance and usefulness of GenAI tools but may not feel fully confident in integrating them into their teaching practices. Such ambivalence may stem from uncertainties about GenAI's reliability and the complexities of adapting it to real-world teaching contexts. Bae *et al*. emphasize the need for structured experiences to bridge this gap, suggesting that professional development opportunities targeting AI literacy could play a pivotal role in building educators' confidence and competence in leveraging GenAI for teaching.

Interconnected Perceptions: Teaching and Learning. The interconnected nature of students' perceptions of GenAI as both a teaching and learning tool was evident in the results. Correlation analysis (Section IV.B) revealed strong post-intervention links between students' perceptions of GenAI's utility in the course (Q14) and its broader applications in learning (Q15) and teaching (Q16). These findings suggest that as students recognize GenAI's relevance in specific educational contexts, they also begin to perceive its wider applicability across various teaching and learning scenarios. Similarly, the strong correlations between Q16 (teaching potential) and Q18/Q19 (utility in teaching and learning) indicate that understanding GenAI's relevance to education as a field positively influences its perceived use in diverse contexts.

These relationships highlight the value of structured course activities that embed GenAI in authentic teaching and learning scenarios. Such experiences help students critically evaluate and adapt these tools for varied educational purposes, fostering both familiarity and critical engagement. By doing so, pre-service educators can develop nuanced perspectives on GenAI's potential to transform teaching and learning.

RQ2: How did pre-service educators use and perceive the applications of GenAI tools for ideation, instructional design, and content creation during the redesigned Educational Technology course?

The redesigned Educational Technology course introduced pre-service educators to GenAI tools, focusing on three key applications identified by Moundridou *et al*. [3]: ideation (generating ideas to address instructional challenges), instructional design (assisting in organizing and structuring activities and lesson plans), and content creation (producing resources in various formats such as text and multimedia). Students' reflections and activity outcomes revealed their perceptions of how these tools supported these applications, while also highlighting limitations and areas for further refinement.

Ideation—Students perceived GenAI tools as useful for generating ideas, especially in providing starting points for instructional challenges. In the Web 2.l0 lesson (Section IV.A), students used an LLM to brainstorm applications of Web 2.0 tools in a WebQuest. Some groups appreciated the tool's capacity to generate "many great ideas" and justify its suggestions comprehensively, though most interacted with the tool only once, suggesting limited engagement with its iterative potential. Similarly, in the lesson plan activity, GenAI tools offered general guidance but often required refinement to better align with specific instructional needs (Table 1: *Reliability and Supervision*). Negative feedback from the WebQuest project revealed dissatisfaction with GenAI-generated ideas in certain cases, as one group rejected ChatGPT's suggestions entirely, deeming them irrelevant. Responses to Q17 (Table 4 and Fig. 3) further highlighted students' mixed perceptions: while many valued the tools for their creative potential, others recognized their limitations in producing nuanced, context-specific ideas.

Instructional Design—Students' experiences revealed that GenAI tools can facilitate planning and structuring instructional activities but require significant user oversight. In the lesson plan activity, students used LLMs to draft inquiry-based lesson plans (Table 1), noting the efficiency with which organized frameworks were generated. However, many found the outputs too simplistic for specialized topics, necessitating iterative adjustments to ensure alignment with instructional objectives. Similarly, during the WebQuest project (Section IV.A), students used ChatGPT to conceptualize activity sequences, assign roles, and draft evaluation rubrics. While these applications align with Hu *et al.*'s [2] observations about GenAI streamlining instructional planning, students noted that the tool's generic outputs often failed to account for the nuanced demands of their projects. These perceptions underscore the importance of critical user intervention to refine GenAI-generated instructional designs.

Content Creation—GenAI tools were perceived as effective for generating multimedia content, particularly for efficiency in creating visuals. In the Image GenAI activity, students appreciated the tools' ability to produce visually engaging materials quickly, with reflections emphasizing their utility for crafting original images (Table 2: *User Experience*). Responses to Q17 (Table 4) echoed this sentiment, with students acknowledging that GenAI tools enhanced their creative outputs. However, challenges arose in ensuring the relevance and accuracy of the generated content. In the Image GenAI activity, students reported that the tools often produced irrelevant or inaccurate outputs (Table 2: *Accuracy and Output Quality*), such as mismatched visual representations. Dissatisfaction with text-based outputs in the WebQuest project (Section IV.A) further highlighted limitations in using GenAI for content creation.

The findings demonstrate that the redesigned Educational Technology course effectively introduced pre-service educators to the diverse applications of GenAI tools, equipping them with foundational skills and fostering an awareness of their potential and limitations. Across all three applications, students valued GenAI tools for their ability to provide initial guidance, streamline workflows, and enhance creativity. However, recurring challenges—including generic outputs, limited contextual depth, and the need for refinement—highlighted the critical role of user oversight and active engagement in realizing these tools' educational potential. These insights align with prior research, which underscores GenAI's complementary role in instructional design and content creation [2, 3] and emphasizes the necessity for educators to critically evaluate and adapt outputs to meet specific learning objectives and students' needs [4, 9, 40].

While the results suggest that these tools require further refinement to better support nuanced educational contexts, they also highlight the value of iterative, hands-on experiences in building pre-service educators' technical confidence and pedagogical judgment. This approach is echoed in the work of Mishra *et al*. [8], who advocate for teacher education programs to balance technical and pedagogical training, fostering effective integration of GenAI into instructional practices.

VI. Conclusions

The integration of GenAI tools into the redesigned Educational Technology course provided pre-service Mechanical Engineering educators with valuable insights into the opportunities and challenges of incorporating artificial intelligence in education. The course enhanced their familiarity with GenAI and deepened their understanding of its potential to streamline teaching and learning processes, improve efficiency, and foster creativity. While students recognized the tools' utility in ideation, instructional design, and content creation, their reflections also highlighted the need for critical oversight to address limitations such as generic outputs and contextual inaccuracies. These findings emphasize the dual role of GenAI as both a facilitator and a subject of critical evaluation, underscoring the importance of iterative, hands-on experiences in developing educators' technical confidence and pedagogical adaptability, equipping them to use these technologies effectively and critically evaluate their role in diverse educational contexts.

The integration of GenAI tools into education necessitates a strong commitment to ethical practices, particularly in safeguarding privacy, ensuring data security, and addressing biases inherent in AI systems. As students interact with GenAI platforms, it is essential that institutions and educators ensure compliance with data protection regulations, maintaining transparency about how data is collected, processed, and used. Additionally, biases embedded in AI-generated content could inadvertently perpetuate stereotypes or inaccuracies, underscoring the need for rigorous critical evaluation of outputs before their application in educational settings. Adherence to established ethical guidelines and frameworks is critical to navigating these challenges responsibly. Resources from the European Commission [41], the U.S. Department of Education [42], and UNESCO [43] provide valuable recommendations for fostering the ethical and impactful use of AI in education. By incorporating these principles, educators can ensure that the adoption of GenAI tools enhances learning experiences while upholding academic integrity and ethical standards.

VII. Limitations of the Study

One of the primary limitations of this study is the small sample size, which may have impacted the statistical power of the findings. A post-hoc power analysis was conducted to evaluate whether the sample size was sufficient to detect statistically significant differences in pre- and post-intervention responses. The analysis indicated that a sample size of approximately 42 participants would have been required to achieve sufficient statistical power. Consequently, the results should be interpreted with caution. Additionally, the absence of responses from 11 enrolled students, who either opted out of the questionnaires or were absent during administration, may have introduced selection bias. These non-respondents could represent a subset of the population with differing levels of engagement or interest in the course and GenAI tools. Future studies should aim to include larger sample sizes and implement mechanisms to mitigate non-response, such as collecting demographic information at the outset or designing follow-up strategies to understand reasons for non-participation. These measures would enhance the generalizability and robustness of the findings.

In addition to the small sample size, this study's findings are influenced by several other limitations that should be considered. The study focused on immediate post-intervention effects without follow-up assessments to evaluate long-term retention or the practical application of the learned skills. This constraint, imposed by the semester-long course structure, limited the exploration of the sustained impact of the intervention on students' teaching practices and the integration of GenAI tools in real classroom settings. Similarly, the absence of a control group restricted the ability to isolate the intervention's effects and account for potential external influences.

The study was conducted in a specific cultural and institutional context—a Greek institution with pre-service Mechanical Engineering educators—whose familiarity with and positive attitudes toward technology likely influenced the findings. While no significant technical challenges were encountered during the course, the participants' high level of technological readiness and reliable access to digital tools may limit the generalizability of the results to other populations with differing technological competence or attitudes toward GenAI tools.

Future research should address these limitations by incorporating longitudinal components, control groups, and more diverse and larger samples across varied disciplines and institutional contexts. Expanding the scope of data collection to include long-term evaluations would provide deeper insights into the sustained impact and broader applicability of GenAI tools in education.

APPENDIX

Appendix A

Pre-Intervention Questionnaire

1) Demographic Data:
   Q1. Gender.
   Q2. Year of study at ASPETE.
   Q3. Type of high school.
   Q4. Direction in high school.
   Q5. Order of preference for the department where I study.
   Q6. My grade in the 3rd semester Computer Applications in Education course.
   Q7. I own a PC.
   Q8. I have an internet connection.
   Q9. I am familiar with PC use.
   Q10. I am familiar with internet use.
2) Awareness and Perceptions of AI:
   Q11. I know what artificial intelligence is.
   Q12. I know what generative artificial intelligence (GenAI) is.
   Q13. Which of the following GenAI tools have you used? (Select all that apply.)
   Q14. I believe that using GenAI tools could support me in the Educational Technology course.
   Q15. I believe that using GenAI tools will generally help me in my studies.
   Q16. I believe that GenAI tools are important for my field of study.

Post-Intervention Questionnaire

1) Demographic Data:
   Q1-Q10. Same as Pre-Intervention Questionnaire.
2) Perceived Impact and Future Use of LLMs:
   Q11-Q13. Same as Pre-Intervention Questionnaire Q11-Q13.
   Q14. I believe that using GenAI tools supported me in the Educational Technology course.
   Q15-Q16. Same as Pre-Intervention Questionnaire Q15-Q16.
   Q17. What do you specifically think the integration of GenAI tools in the Educational Technology course offered you?
   Q18. I believe that GenAI tools should be integrated as teaching aids across other courses.
   Q19. I believe that I will use GenAI tools on my own initiative for other courses.

Appendix B

Activity 1: 'Generative AI in Education' Lesson Activity

In this activity, you will collaboratively practice using some of the Generative AI tools introduced during the lesson with your group.

Before You Begin:

1. Review the lesson presentation and Chapters 3 and 4 of the guide available in the "Educational Material" section of the course.
2. Register (all group members) on the following tools and familiarize yourselves with their features:
   - OpenAI – ChatGPT 3.5
   - Google – Gemini
   - Adobe – Firefly
   - Craiyon
   - Deep Dream Generator
3. As a group, select a topic from your field that you hypothetically would like to teach to vocational high school students. This topic will be the basis for developing inquiry-based lesson plans using the tools.

Part A: Using TextGenAI Tools (to Generate Lesson Plans)

1. Use ChatGPT and Gemini (some group members with one tool, and others with the other) as assistants to create each an inquiry-based lesson plan.
2. Do not limit yourself to the first response you receive. Engage in a back-and-forth dialogue to refine and improve the output.
3. Share/export your conversation and save the corresponding link.

Discussion Board Task: Each group should create a discussion thread and have all group members respond to the following prompts:

- What was the topic for which you tried to create a lesson plan?
- Share the link to your conversation with the tool.
- Reflect: Was the final output satisfactory? What were its shortcomings? What do you think could be done to get "better" responses? Is there anything else worth commenting on?

Part B: Using ImageGenAI Tools (to Generate Relevant Images)

1. For the same topic, each group member should use a different tool from the following: Firefly, Craiyon, or Deep Dream Generator.
2. Create an image that you would present to your students to spark their interest and orient them to the topic.
3. Save the generated image and record the prompt you used.

Discussion Board Task: In the same discussion thread, each group member should respond to the following prompts:

- Which tool did you use?
- What was the prompt you gave?
- Attach the file of the image generated by the tool.
- Reflect: Was the result what you expected? What were its shortcomings? How do you think better results could be achieved?

Activity 2: 'Leveraging Web 2.0 Tools' Lesson Activity

In this activity, you will explore ways to incorporate various Web 2.0 tools into the design of a WebQuest.

Below are the Web 2.0 tools you will evaluate for their potential integration:

- Digital comic creation tools
- Word cloud creation tools
- Video creation tools
- Digital interactive poster creation tools
- Website or blog creation tools

Proposing Applications for Web 2.0 Tools in a WebQuest

For each tool, answer the following:

- Which section(s) of the WebQuest would you use the tool in?
- How would you use the tool?
- For what purpose?
- Who would use the tool in each case (students or educators)?

Seeking AI Assistance for Tool Utilization

If you found it challenging to generate ideas for one or more of the tools above, seek assistance from ChatGPT or Gemini. Provide the following:

- The link to your conversation with the AI tool.
- Your reflection: Were the ideas provided by the AI useful? What worked well, and what could be improved?

Final WebQuest Project: Submission Guidelines

For your final project, you will work with your group to design a WebQuest for a vocational high school course within your field of expertise. This project will integrate the theoretical and practical knowledge you have gained throughout the course.

Your WebQuest should be hosted on a website that your group creates and publishes using *Canva* or a similar platform.

Submission Requirements

When submitting your project, include the following details:

1. Group Members' Names: List the full names of all group members.
2. URL of the WebQuest: Provide the link to your published WebQuest.
3. Title of the WebQuest: Specify the title of your WebQuest.
4. Use of Generative AI Tools: If you utilized any Generative AI tools, answer the following:
   - Which Generative AI tools did you use?
   - Why did you use each tool, and how was it applied in the project?
   - Did you find these tools helpful in designing or developing the WebQuest? If yes, explain how they assisted you. (For example: Did they clarify something you didn't understand? Provide ideas? Generate content that you wouldn't have created on your own?)

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

MM and NM contributed equally to this work. Both authors were involved in the conceptualization and design of the study, the collection and analysis of data, and the interpretation of results. MM and NM collaboratively wrote and revised the manuscript. Both authors have read and approved the final version of the paper.

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References

[1] M. Moundridou and K. A. Papanikolaou, "Educating engineer educators on technology enhanced learning based on TPACK," in *Proc. 2017 IEEE Global Engineering Education Conference (EDUCON)*, Athens, Greece: IEEE, Apr. 2017, pp. 1243–1250. doi: 10.1109/EDUCON.2017.7943007

[2] B. Hu, L. Zheng, J. Zhu, L. Ding, Y. Wang, and X. Gu, "Teaching plan generation and evaluation with GPT-4: Unleashing the potential of LLM in instructional design," *IEEE Transactions on Learning Technologies*, 2024.

[3] M. Moundridou, N. Matzakos, and S. Doukakis, "Generative AI tools as educators' assistants: Designing and implementing inquiry-based lesson plans," *Computers and Education: Artificial Intelligence*, vol. 7, 100277, Dec. 2024. doi: 10.1016/j.caeai.2024.100277

[4] T. Butler-Ulrich, J. Hughes, and L. Morrison, "Creativity and generative AI for preservice teachers," *IntechOpen*, 2024. doi: 10.5772/intechopen.1007517

[5] T. K. F. Chiu, "The impact of Generative AI (GenAI) on practices, policies and research direction in education: a case of ChatGPT and Midjourney," *Interactive Learning Environments*, pp. 1–17, Sep. 2023. doi: 10.1080/10494820.2023.2253861

[6] A. Barrett and A. Pack, "Not quite eye to A.I.: Student and teacher perspectives on the use of generative artificial intelligence in the writing process," *International Journal of Educational Technology in Higher Education*, vol. 20, no. 1, p. 59, Nov. 2023. doi: 10.1186/s41239-023-00427-0

[7] I. Celik, "Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education," *Computers in Human Behavior*, vol. 138, p. 107468, Jan. 2023. doi: 10.1016/j.chb.2022.107468

[8] P. Mishra, M. Warr, and R. Islam, "TPACK in the age of ChatGPT and Generative AI," *Journal of Digital Learning in Teacher Education*, vol. 39, no. 4, pp. 235–251, Oct. 2023. doi: 10.1080/21532974.2023.2247480

[9] X. Zhai, "Transforming teachers' roles and agencies in the era of generative AI: Perceptions, acceptance, knowledge, and practices," *Journal of Science Education and Technology*, Nov. 2024. doi: 10.1007/s10956-024-10174-0

[10] V. Alexandrowicz, "Artificial intelligence integration in teacher education: Navigating benefits, challenges, and transformative pedagogy," *Journal of Education and Learning*, vol. 13, no. 6, p. 346, Nov. 2024. doi: 10.5539/jel.v13n6p346

[11] M. Saimon, F. Mtenzi, Z. Lavicza, K. Fenyvesi, M. Arnold, and J. M. Diego-Mantecón, "Applying the 6E learning by design model to support student teachers to integrate artificial intelligence applications in their classroom," *Education and Information Technologies*, Jun. 2024. doi: 10.1007/s10639-024-12795-9

[12] M. J. Koehler and P. Mishra, "Teachers learning technology by design," *Journal of Computing in Teacher Education*, vol. 21, no. 3, pp. 94–102, Mar. 2005. doi: 10.1080/10402454.2005.10784518

[13] P. Mishra and M. J. Koehler, "Technological pedagogical content knowledge: A framework for teacher knowledge," *Teachers College Record: The Voice of Scholarship in Education*, vol. 108, no. 6, pp. 1017–1054, Jun. 2006. doi: 10.1111/j.1467-9620.2006.00684.x

[14] K. J. Crippen and L. Archambault, "Scaffolded inquiry-based instruction with technology: A signature pedagogy for STEM education," *Computers in the Schools*, vol. 29, no. 1–2, pp. 157–173, Jan. 2012. doi: 10.1080/07380569.2012.658733

[15] M. Y. Tee and S. S. Lee, "From socialisation to internalisation: Cultivating technological pedagogical content knowledge through problem-based learning," *AJET*, vol. 27, no. 1, Mar. 2011. doi: 10.14742/ajet.984

[16] B. Kramarski and T. Michalsky, "Preparing preservice teachers for self-regulated learning in the context of technological pedagogical content knowledge," *Learning and Instruction*, vol. 20, no. 5, pp. 434–447, Oct. 2010. doi: 10.1016/j.learninstruc.2009.05.003

[17] Y.-F. Yeh, K. K. H. Chan, and Y.-S. Hsu, "Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process," *Computers & Education*, vol. 171, p. 104238, Oct. 2021. doi: 10.1016/j.compedu.2021.104238

[18] B. Dodge, "WebQuests: A technique for internet-based learning," *Distance Educator*, vol. 1, no. 2, pp. 10–13, 1995.

[19] J. Summerville, "WebQuests: An aspect of technology integration for training preservice teachers," *Techtrends Tech Trends*, vol. 44, no. 2, pp. 31–34, Mar. 2000. doi: 10.1007/BF02822950

[20] S. Ebadi and M. Rahimi, "An exploration into the impact of WebQuest-based classroom on EFL learners' critical thinking and academic writing skills: A mixed-methods study," *Computer Assisted Language Learning*, vol. 31, no. 5–6, pp. 617–651, Jul. 2018. doi: 10.1080/09588221.2018.1449757

[21] V. Shabunina, O. Tur, V. Maslak, and V. Sarancha, "Educational WebQuests as an innovative method of project-oriented training of electrical engineering students," in *Proc.* 2022 *IEEE 4th International Conference on Modern Electrical and Energy System* (MEES), Kremenchuk, Ukraine: IEEE, Oct. 2022, pp. 1–6. doi: 10.1109/MEES58014.2022.10005687

[22] S. M. Şahin and M. H. Baturay, "The effect of 5E-learning model supported with WebQuest media on students' achievement and satisfaction," *E-Learning and Digital Media*, vol. 13, no. 3–4, pp. 158–175, May 2016. doi: 10.1177/2042753016672903

[23] C. Tsichouridis, M. Batsila, D. Vavougios, and A. Tsihouridis, "WebQuests: From an inquiry-oriented instruction to the connectivist approach to science teaching for the 21st century learners," *Advances in Intelligent Systems and Computing*, vol. 1134, Cham: Springer International Publishing, 2020, pp. 395–405. doi: 10.1007/978-3-030-40274-7_40

[24] H. G. Taylor, "The WebQuest model for inquiry-based learning using the resources of the world wide web," in *Networking the Learner*, D. Watson and J. Andersen, Eds., Boston, MA: Springer US, 2002, pp. 319–328. doi: 10.1007/978-0-387-35596-2_32

[25] R. Kundu and C. Bain, "Webquests: Utilizing technology in a constructivist manner to facilitate meaningful preservice learning," *Art Education*, vol. 59, no. 2, pp. 6–11, Feb. 2006. doi: 10.1080/00043125.2006.11651581

[26] M. Haralson, A. Hoaglund, K. Birkenfeld, and B. Rogers, "Using Webquests to support pre-service teachers' attitudes toward diversity: A model for the future," *Education*, vol. 136, no. 4, pp. 413–420, 2016.
[27] M. Moundridou, E. Zalavra, K. Papanikolaou, and A. Tripiniotis, "Collaborative content authoring: Developing WebQuests using SlideWiki," in *The Challenges of the Digital Transformation in Education*, M. E. Auer and T. Tsiatsos, Eds., vol. 916, Cham: Springer International Publishing, 2020, pp. 202–214. doi: 10.1007/978-3-030-11932-4_21
[28] L. Banh and G. Strobel, "Generative artificial intelligence," *Electronic Markets*, vol. 33, no. 1, p. 63, Dec. 2023. doi: 10.1007/s12525-023-00680-1
[29] W. M. Lim, A. Gunasekara, J. L. Pallant, J. I. Pallant, and E. Pechenkina, "Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators," *The International Journal of Management Education*, vol. 21, no. 2, p. 100790, Jul. 2023. doi: 10.1016/j.ijme.2023.100790
[30] A. Bandi, P. V. S. R. Adapa, and Y. E. V. P. K. Kuchi, "The power of generative AI: A review of requirements, models, input–output formats, evaluation metrics, and challenges," *Future Internet*, vol. 15, no. 8, p. 260, 2023. doi: 10.3390/fi15080260
[31] Y.-C. Hsu and Y.-H. Ching, "Generative artificial intelligence in education, part one: The dynamic frontier," *TechTrends*, vol. 67, no. 4, pp. 603–607, 2023. doi: 10.1007/s11528-023-00863-9
[32] C.-H. Lin, K. Zhou, L. Li, and L. Sun, "Integrating generative AI into digital multimodal composition: A study of multicultural second-language classrooms," *Computers and Composition*, vol. 75, p. 102895, 2025. doi: 10.1016/j.compcom.2024.102895
[33] K. T. Kotsis, "Integrating ChatGPT into the inquiry-based science curriculum for primary education," *European Journal of Education and Pedagogy*, vol. 5, no. 6, pp. 28–34, 2024. doi: 10.24018/ejedu.2024.5.6.891
[34] N. M. Matzakos and M. Kalogiannakis, "An analysis of first year engineering students' satisfaction with a support distance learning program in mathematics," *Education and Information Technologies*, vol. 23, no. 2, pp. 869–891, 2018. doi: 10.1007/s10639-017-9641-y
[35] K. Okoye and S. Hosseini, *R Programming: Statistical Data Analysis in Research*, Singapore: Springer Nature Singapore, 2024. doi: 10.1007/978-981-97-3385-9
[36] C. K. Y. Chan and W. Hu, "Students' voices on generative AI: perceptions, benefits, and challenges in higher education," *International Journal of Educational Technology in Higher Education*, vol. 20, no. 1, 43, 2023. doi: 10.1186/s41239-023-00411-8
[37] C. Stöhr, A. W. Ou, and H. Malmström, "Perceptions and usage of AI chatbots among students in higher education across genders, academic levels and fields of study," *Computers and Education: Artificial Intelligence*, vol. 7, 100259, Dec. 2024. doi: 10.1016/j.caeai.2024.100259
[38] W. K. Monib, A. Qazi, and M. M. Mahmud, "Exploring learners' experiences and perceptions of ChatGPT as a learning tool in higher education," *Education and Information Technologies*, Oct. 2024. doi: 10.1007/s10639-024-13065-4
[39] H. Bae, J. Hur, J. Park, G. W. Choi, and J. Moon, "Pre-service teachers' dual perspectives on generative AI: Benefits, challenges, and integrating into teaching and learning," *Online Learning*, vol. 28, no. 3, Sep. 2024. doi: 10.24059/olj.v28i3.4543
[40] P. MacDowell, K. Moskalyk, K. Korchinski, and D. Morrison, "Preparing educators to teach and create with generative artificial intelligence," *Canadian Journal of Learning and Technology*, vol. 50, no. 4, pp. 1–23, Nov. 2024. doi: 10.21432/cjlt28606
[41] European Commission, Directorate General for Education, Youth, Sport and Culture, *Ethical Guidelines on the Use of Artificial Intelligence (AI) and Data in Teaching and Learning for Educators*, Publications Office of the European Union, 2022. doi: 10.2766/153756
[42] U.S. Department of Education, Office of Educational Technology, *Artificial Intelligence and the Future of Teaching and Learning: Insights and Recommendations*, Washington, DC: U.S. Department of Education, 2023.
[43] UNESCO, *Guidance for Generative AI in Education and Research*, Paris: UNESCO, 2023. doi: 10.54675/EWZM9535