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ChatGPT in engineering education: a breakthrough or a challenge?

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ChatGPT in engineering education: a breakthrough or a challenge?

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Abstract

In engineering education, where hands-on problem-solving and technical proficiency especially in physics-based learning are critical, the role of artificial intelligence (AI) tools like ChatGPT remains debated; whether AI serves as a breakthrough innovation or presents new challenges. This study seeks to bridge that gap by examining the impact of ChatGPT on mechanical engineering students in a project-based course. It explores how students used AI tools to understand key concepts, support group collaboration, and improve coding and writing tasks. Using survey data from first-year students encouraged to integrate AI into their coursework, the research provides insights into the ethical and educational implications of AI in engineering education, considering both its benefits and challenges. The findings indicate that while ChatGPT was widely utilized for coding tasks such as MATLAB programming and enhancing conceptual understanding, its impact on group collaboration was modest. Ethical concerns, including the temptation to misuse AI, highlight the need for structured guidelines to ensure responsible AI usage. The study also identifies the necessity of verifying AI-generated outputs, as AI tools may produce inaccurate or misleading information, particularly in technical problem-solving. This paper offers recommendations for optimizing AI-assisted learning, fostering critical thinking, and adapting assessment practices to balance AI's educational benefits with academic

integrity. These insights aim to guide educators and policymakers in effectively integrating AI into engineering and physics education while addressing its challenges to create a productive learning environment.

Supplementary material for this article is available online

1. Introduction

The rapid advancement of artificial intelligence (AI), including tools like ChatGPT, along with the increasing number of students using AI [1, 2] to assist with academic tasks, has sparked growing interest in understanding its impact on both teaching and learning processes [3]. While AI offers potential benefits such as improving accessibility to knowledge [4, 5], concerns remain regarding its influence on academic integrity, overreliance, and the development of critical thinking skills [1, 6–11]. In the context of engineering education, where hands-on problem-solving and technical proficiency are essential [12], it is still unclear whether AI serves as a breakthrough innovation or presents new challenges that need to be addressed.

Because mechanical engineering curricula are deeply rooted in physics principles, particularly in areas such as dynamics, thermodynamics, and material mechanics, developments in engineering education naturally overlap with concerns central to physics education. Integrating AI tools like ChatGPT into this context presents an opportunity to explore how students interact with physics-based problem-solving and computational tasks using emerging technologies.

This study seeks to bridge that gap by investigating the role of ChatGPT in engineering education, specifically examining its impact on mechanical engineering students in a project-based course. It explores how students used AI tools to understand key concepts, support group collaboration, and improve coding and writing tasks. The research draws on survey data from first-year students who were encouraged to use AI tools during their coursework, offering insights into the ethical and educational implications of AI in engineering education, considering both its potential benefits and challenges.

By analysing students' experiences, this study contributes to the ongoing debate on whether AI enhances learning or introduces new challenges. It also examines ethical concerns, such as the temptation to rely on AI without fully engaging with technical problems. The findings will help educators assess whether tools like ChatGPT enhance learning efficiency or pose challenges to academic integrity and skill development.

To provide a comprehensive understanding of the role of AI tools like ChatGPT in engineering education, this paper is organized into several key sections following the introduction. First, the materials and methods section outlines the study design, participant demographics, and data collection techniques employed to gather insights on student engagement with AI. Following this, the results and discussions section presents the findings from the survey, highlighting students' familiarity with AI tools, their usage patterns, and perceptions of AI's impact on their learning outcomes. The discussion also delves into ethical considerations, along with the concerns and challenges associated with AI integration in educational settings. Finally, the recommendations section offers practical guidance for educators on how to effectively implement AI tools in the classroom, followed by a conclusion that summarizes the main insights and implications of the study.

2. Materials and methods

2.1. Study design and participants

This study was conducted during an introductory mechanical engineering course for first-year students, with a total of 54 participants aged between 18 and 25 years old. Of these, 46 students responded to the questionnaire, representing an 85.2% response rate. The respondents included 7 female students, accounting for 15.2% of the sample.

The course, which is part of a Bachelor of Science in Engineering program, introduced students to fundamental theories, physics principles, and models used in engineering, particularly in mechanics and applied physics. It was structured into three key components:

1. A written exam on theoretical concepts, including core physics topics and engineering models.
2. A MATLAB programming project, where groups of 3–4 students solved a real-world mechanical problem using MATLAB, such as modelling motion, analysing static forces, and exploring vibrations.
3. A final presentation, requiring students to deliver an oral presentation and submit a written report detailing their project results.

Throughout the course, students were permitted to use AI-assisted tools, such as ChatGPT, for assistance in learning and coding. However, they were strongly encouraged to use these tools as learning aids rather than simply copying content.

2.2. Data collection

Data were collected through a survey distributed via the Canvas learning platform after the completion of the group projects. The survey consisted of 15 questions, 12 multiple-choice and 3 open-ended, designed to gather both quantitative and qualitative data. The survey assessed students' familiarity with AI tools prior to the course, the frequency of ChatGPT use during the course, the purposes for which AI tools were used (e.g. coding, report writing, idea generation), and students' perceptions of the benefits, challenges, and ethical considerations associated with using AI tools in the learning process.

2.3. Data analysis

The collected data were analysed using both quantitative and qualitative methods. Quantitative data from the multiple-choice questions were summarized using descriptive statistics such as percentages and frequencies to reveal patterns in ChatGPT usage. Key metrics included how frequently students used ChatGPT, the specific tasks it was used for, and the perceived impact of ChatGPT on their understanding of mechanical engineering concepts.

Qualitative data from the open-ended questions were analysed through thematic analysis, identifying recurring themes related to students' perceptions of ChatGPT. The findings from these qualitative themes were used to contextualize and enrich the interpretation of the quantitative results.

3. Results and discussions

3.1. AI familiarity and frequency of use

The survey revealed that a significant portion of the cohort (71.7%) had already used AI tools like ChatGPT prior to being admitted to the university, as well as before enrolling in this course, which is the first in their program. Meanwhile, the remaining 28.3% indicated no prior experience with these technologies. This distribution highlights a diverse range of familiarity levels within the student body, suggesting that while AI tools are becoming more common in educational settings, a notable portion of students still had limited exposure to such technologies before starting the course.

The high percentage of students familiar with AI tools indicates that these technologies have already begun to penetrate engineering education, especially in technical fields like mechanical engineering. This suggests an increasing trend where students, particularly in engineering, are leveraging AI to support their learning outside traditional pedagogical frameworks. However, the students who had not used AI tools prior to the course reflect an opportunity for educators to

introduce these technologies in a structured manner, ensuring equitable access to the benefits of AI-assisted learning.

The survey also captured the frequency with which students utilized AI tools, such as ChatGPT, throughout their project work. 32.6% of students reported using AI tools 'Rarely,' while 6.5% stated they used them 'Never.' A majority of students indicated more frequent use, with 32.6% using AI tools 'Sometimes' and 28.3% reporting they used them 'Often.'

The predominance of students using AI tools infrequently reflects a cautious or supplementary approach to AI-assisted learning, where most students appear to have used these tools sparingly. This might indicate that while students are aware of AI's potential, they are not fully integrating it into their workflow for every aspect of the project. However, the specific reasons behind these usage patterns were not explicitly explored in the survey.

3.2. AI applications and effectiveness

Figure 1 illustrates the various purposes for which students utilized AI tools, such as ChatGPT, during their project work and coursework. The most commonly reported use was assisting with MATLAB programming and implementation, highlighting the value of AI tools in supporting coding-related tasks, a critical component of engineering education, particularly in project-based learning environments.

Another frequent use was understanding key concepts and theories related to the project, indicating that AI serves as a supplementary resource alongside traditional teaching methods. Additionally, some students used AI to improve the structure and clarity of their reports, suggesting its potential as a writing aid. Others employed AI tools to explore complex real-world scenarios, brainstorm ideas, or for other specialized purposes beyond the predefined categories.

Beyond these specific applications, students had varied perceptions regarding AI's overall effectiveness in supporting their learning. More than half of the respondents (56.5%) agreed or strongly agreed that AI tools contributed to their understanding of mechanical engineering concepts, emphasizing their potential role in engineering education. However, 34.8% remained neutral, suggesting that while AI tools did not hinder their learning, they were not perceived as significantly impactful either. A small portion (8.7%) disagreed or strongly disagreed, indicating that AI did not effectively aid their comprehension, possibly due to different learning preferences or challenges in using AI tools effectively.

In the context of MATLAB implementation, 39.1% of students found AI tools somewhat helpful but still required additional resources for full comprehension. Another 34.8% stated that AI tools made MATLAB easier to understand and apply, showing that for over a third of students, AI significantly facilitated their ability to use MATLAB in their coursework. However, 23.9% of students felt that AI tools did not help much, while 2.2% reported that AI tools made MATLAB more confusing, suggesting that AI's effectiveness in technical applications varies among students.

These findings highlight a diverse range of student experiences with AI tools. While many found them beneficial for coding, conceptual learning, and writing, others remained neutral or sceptical about their impact. AI appears to be most effective when used as a complement to traditional learning methods, rather than a replacement. The variability in responses suggests that structured AI integration is crucial, ensuring that AI tools enhance rather than substitute essential engineering education practices.

3.3. Student perceptions of ChatGPT's effectiveness in writing, learning, and problem-solving

Students were also asked whether ChatGPT improved their ability to write and organize their project reports. A majority (67.4%) indicated that ChatGPT made no difference, suggesting that most students relied on other strategies or resources for writing. One possible explanation is that students had access to a structured report template and a dedicated lecture on report writing, which likely reduced the need for AI assistance. Additionally, strict university plagiarism policies may have discouraged some
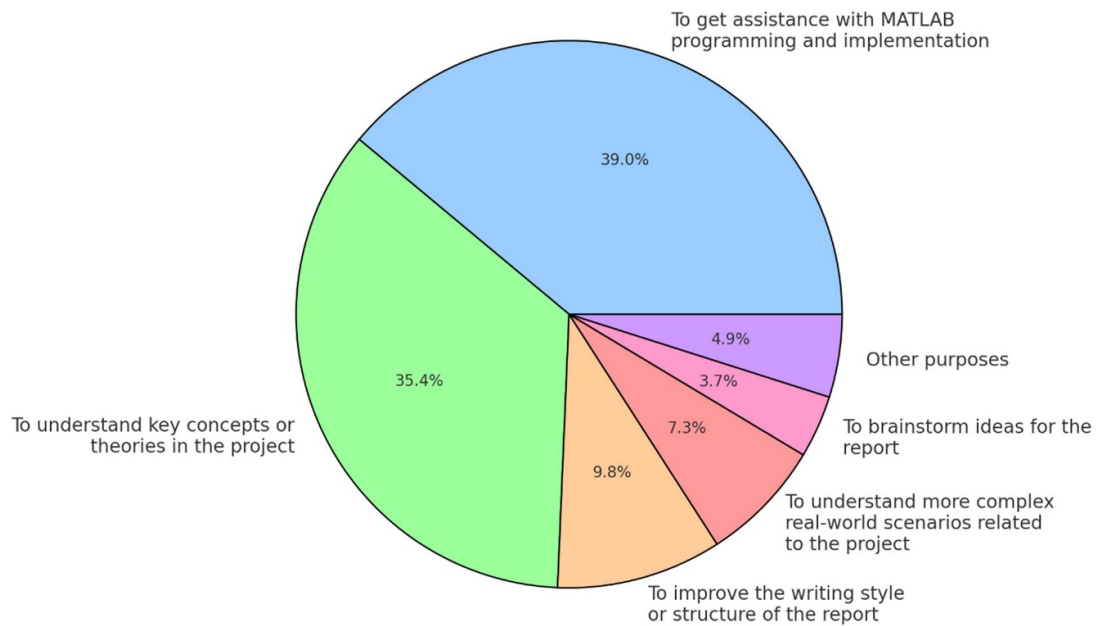
Figure 1. Purposes of AI tool (ChatGPT) usage among first-year mechanical engineering students.

students from using ChatGPT [13], as reflected in open-ended responses where concerns were raised about ensuring that group members did not simply copy AI-generated content.

On the other hand, 28.3% of students reported that ChatGPT somewhat improved their ability to write and organize reports, indicating that a notable portion of the cohort found AI useful for structuring content, generating ideas, or refining their reports. It is worth noting that ChatGPT was not explicitly encouraged for this purpose, which may explain why some students did not consider using it for writing. A small percentage (4.3%) stated that ChatGPT made writing and organization more difficult. This could reflect challenges in using the tool effectively or possibly issues with over-reliance on AI, leading to difficulties in managing the content independently.

When asked whether ChatGPT made their learning process more effective in writing and technical analysis, responses were split. While 39.1% of students agreed, an equal percentage (39.1%) remained neutral, suggesting that although a significant portion found AI helpful, an equally large group did not experience a substantial impact. The neutral responses could reflect students who either did not use AI extensively or found alternative methods more effective for managing their workload.

A smaller subset (13%) strongly agreed that ChatGPT significantly improved their efficiency, suggesting that certain students were able to maximize the tool's benefits. In contrast, 4.3% disagreed and another 4.3% strongly disagreed, indicating that for a minority, AI tools were either ineffective or even detrimental to their efficiency in writing or technical analysis.

To assess AI's role in concept comprehension and problem-solving, students were also asked whether ChatGPT helped them understand the project's subject matter and solve real-world problems. Half of the respondents (50%) stated that AI tools somewhat improved their understanding, indicating that many students found AI useful in clarifying concepts and bridging theoretical knowledge with real-world applications. Additionally, 10.9% reported that ChatGPT significantly improved their understanding, showing that some students effectively leveraged AI's capabilities for learning.

Conversely, 2.2% of students stated that AI tools distracted from their learning and problem-solving, suggesting that for a small number, AI usage may have interfered with their ability to

focus on the task. Furthermore, 37% of students reported that AI made no noticeable difference in their understanding or problem-solving abilities. This could indicate that these students relied more on traditional methods or considered AI a supplementary rather than a primary learning tool. Overall, the collected data suggests that while some students found AI tools beneficial for understanding and problem-solving, their effectiveness varied significantly across the cohort. While a portion of students effectively leveraged AI for learning, others saw little impact, and a small number even found AI distracting. These findings indicate that AI's role in education is not universally positive or negative but highly dependent on individual learning preferences, prior experience, and the way AI tools are integrated into the learning process.

3.4. Ethical and behavioural considerations

To assess students' perceptions of AI's role in report structuring, the survey asked, '*How helpful was ChatGPT/AI in structuring and organizing your report?*' A majority (52.2%) indicated that AI tools had no impact on their report writing. This suggests that many students did not find AI particularly useful for organizing their reports, likely as mentioned earlier, due to the availability of a structured template and a lecture on report writing, which may have provided sufficient guidance and reduced reliance on AI tools.

Meanwhile, 23.9% of students found AI tools to be not very helpful, while 21.7% believed that AI tools were somewhat helpful. This distribution indicates that although some students saw value in AI for structuring reports, it did not provide a significant advantage, especially when they were following a strict report template. A small percentage (2.2%) found AI tools to be extremely helpful, suggesting that for a minority of students, AI played a key role in improving their ability to organize content effectively.

The survey also explored concerns about academic integrity by asking, '*Did you feel tempted to copy ChatGPT's answers into the report without fully understanding them?*' The responses indicated that 47.8% of students ensured they understood everything before using AI-generated content, demonstrating a commitment to maintaining academic integrity, responsible AI usage and ensuring that AI-generated content was comprehensible before inclusion in their work. This shows a conscious effort to use AI tools as aids rather than shortcuts. Meanwhile, 43.5% of students reported that they used ChatGPT solely as a learning tool, emphasizing that nearly half of the cohort viewed AI as a supplementary resource for gaining a better understanding, rather than a content-generation tool. This highlights the educational potential of AI tools when used responsibly. However, 8.7% of students admitted that they were sometimes tempted to copy ChatGPT's answers without fully understanding them. This suggests that while most students prioritized comprehension before using AI-generated content, a small portion found it difficult to resist the convenience of AI.

Further concerns regarding AI's influence on learning were examined through the question, '*Do you think students might use AI tools in a way that avoids real learning or thinking during report writing or technical analysis?*' Responses revealed insightful perspectives on the implications of AI usage in academic work. Out of 43 responses for this question, a significant majority 93% responded 'Yes,' expressed concerns that AI tools could be misused in a way that undermines real learning. This reflects the widespread apprehension among students about the potential for over-reliance on AI during report writing or technical analysis. Conversely, only 7% of respondents felt that AI tools do not inherently lead to avoidance of real learning, indicating that they view AI as more of a supportive learning tool when used appropriately.

Key themes from 'Yes' responses:

- **Temptation to bypass learning:** Many students highlighted how easily AI could be used to generate complete solutions without engaging in deeper understanding. For example, one student mentioned, 'it is easy to just rewrite the answers without understanding,' signalling the risk of students taking shortcuts to complete assignments.

- **Future consequences of misuse:** Several responses emphasized the long-term negative impact of avoiding real learning. One student pointed out, 'it will probably result in difficulties later in the program,' reflecting concerns that students who misuse AI will face academic or professional challenges later on.
- **Dependence on AI:** A common theme among the 'Yes' responses was the fear of growing dependence on AI. As one student noted, 'AI makes it easy to get answers without learning,' underscoring the risk of students substituting AI for independent thought and effort.
- **Ethical concerns and AI's role:** While many students viewed AI's misuse as problematic, they also recognized the potential for AI to assist with learning. Some respondents emphasized that students could be tempted to misuse AI but should learn to use it responsibly. One remarked, 'If you use it correctly, it can absolutely be very useful,' suggesting that the responsibility lies with students to balance AI's role in their academic work.

Themes from 'No' responses:

- **AI as a supportive tool:** The minority of students who responded 'No' indicated that they do not see AI as inherently harmful. One student remarked, 'AI can be a really good learning tool if used correctly,' emphasizing that when used appropriately, AI has the potential to enhance understanding rather than detract from it.
- **Student responsibility:** A key point made by those who answered 'No' was that the responsible use of AI lies in the hands of the students. They believe that AI tools provide assistance but require a disciplined approach to ensure students continue to engage with the material meaningfully.

The overwhelming 'Yes' responses indicate that students recognize both the value and the risks of AI tools in academic settings. While there is clear acknowledgment of AI's ability to assist in learning, most students are concerned that its convenience might tempt some to bypass critical thinking or in-depth analysis. This feedback underscores the need for educators to emphasize the proper use of AI and to create academic environments where critical thinking and active learning are encouraged.

To address these concerns, it is crucial to integrate AI literacy into the curriculum. Educators should help students understand the appropriate use of such tools and provide clearer guidelines and strategies that discourage misuse while promoting AI as an aid for enhancing understanding rather than as a shortcut. By guiding students on how to effectively and ethically use AI, we can ensure that it becomes a tool for learning enhancement rather than a means of avoiding real intellectual effort.

To explore AI's role in collaborative work, students were asked, '*Did using ChatGPT improve your group's collaboration on project analysis and report writing?*' An overwhelming majority (82.2%) reported that ChatGPT made no difference to their collaboration, suggesting that AI tools did not significantly impact teamwork or communication among group members. This may indicate that students relied more on traditional collaboration methods or found AI to be less effective in facilitating group interactions.

Meanwhile, 15.6% of students indicated that ChatGPT was somewhat helpful for the collaborative writing of the report but not for the project analysis. This suggests that while AI tools may have supported collaborative writing tasks by helping organize or structure content, they were less effective when it came to the technical analysis, which likely required more direct teamwork and specialized expertise. A very small percentage (2.2%) stated that ChatGPT hindered their collaboration, suggesting that in a few cases, the use of AI tools may have caused confusion or created obstacles in group dynamics.

3.5. Student recommendations for future AI integration

To explore students' perspectives on the future role of AI in education, the survey asked, '*Would you recommend the continued use of AI tools like ChatGPT in future project-based courses?*' Students were given three response options: 'Yes,

but with guidelines,' 'No, they should be restricted,' and 'Yes, absolutely.'

A majority of respondents (71.1%) recommended continuing the use of AI tools but with guidelines, indicating that while students generally support AI integration in education, they recognize the need for proper frameworks to ensure responsible and effective usage. These guidelines could help address concerns about over-reliance on AI and ensure that students engage critically with the material rather than passively depending on AI-generated content. Meanwhile, 22.2% of students responded 'Yes, absolutely,' expressing strong support for the unrestricted use of AI tools in project-based courses. This group likely views AI as a valuable learning resource that enhances efficiency and problem-solving without requiring strict limitations. A small percentage (6.7%) believed that AI tools should be restricted, likely reflecting concerns about potential negative impacts, such as undermining students' independent learning or leading to inappropriate use of AI-generated content.

These findings suggest that, while there is widespread support for integrating AI tools like ChatGPT in future courses, there is also a clear desire for structured guidance to ensure that AI is used in ways that complement, rather than replace, traditional learning processes.

To further explore students' perspectives on AI tools, a total of 31 students responded to the question, *'What changes would you recommend regarding the use of AI tools in future courses, both for project work and report writing?'* This follow-up question allowed for a deeper understanding of their opinions and highlighted the nuances in their feedback. The responses varied in detail and opinion, with several key themes emerging from their feedback.

Key themes from the responses:

- **Need for clear guidelines**: A significant number of students emphasized the importance of establishing structured guidelines on how to use AI tools effectively and responsibly. These

students believe that while AI can be a valuable asset for learning, formal guidance is essential to prevent misuse and ensure AI supports, rather than replaces, critical thinking. One student expressed, *'Using AI with guidelines and being taught how to use it as a tool for learning would be favourable,'* while another highlighted the need for *'clear guidelines so there is no misunderstanding between teachers and students.'*

While students broadly supported AI integration, the nature of the guidelines they seek appears to centre on clear boundaries regarding appropriate AI use. This includes when AI should be used, how AI-generated content should be evaluated, and what its limitations are. Without these structures in place, students recognize the risk of over-reliance on AI tools, which may unintentionally hinder the development of problem-solving and analytical skills.

- **AI as a learning support, not a shortcut**: Many students expressed concerns that AI might be misused as a shortcut, allowing students to bypass critical thinking. Several responses stressed that AI should aid in understanding concepts rather than simply providing answers. One student remarked, *'AI should help students understand concepts, but it should not solve problems for students and give them only the final answer,'* while another emphasized, *'No copy and pasting, there's a big difference between using AI to understand and learn versus just copying what ChatGPT says without thinking about it.'*

This distinction highlights an important issue in AI-assisted learning: AI should serve as a tool for exploration and comprehension, not a substitute for independent thinking. If students simply copy AI-generated responses without questioning or engaging with them, they miss the opportunity to truly learn, deepen their understanding, and develop problem-solving skills. Additionally, AI does not have the ability to assess comprehension in a meaningful way. AI-generated responses are based on patterns in data rather than true understanding

or reasoning and cannot determine whether a student truly comprehends the material. This reinforces the need for students to critically evaluate AI output, refine their responses, and cross-check information rather than accepting it at face value.

- **Training and demonstrations**: Some students called for educators to take an active role in demonstrating the appropriate use of AI tools. One student proposed that *'the teacher can show the students how to use it and give examples of how it can be helpful,'* indicating a desire for hands-on guidance. Similarly, another student suggested, *'Maybe showing how it can be implemented in a good and learning way.'* This reflects a call for educators to model the correct use of AI in a way that enhances learning.

- **Awareness of AI's limitations**: Several students pointed out that AI-generated content is not always accurate and that students should be taught to critically evaluate the results. For example, one response urged educators to *'put stronger emphasis that it is not a "truth machine" and many things it writes will be incorrect.'* Another recommended *'giving students a heads-up that AI will sometimes make something up when it does not know the answer.'* This theme reflects a recognition among students of the need to approach AI-generated content with scepticism and verify its accuracy.

The majority of students, therefore, recognize the value of AI tools but express concern about their potential misuse. The recommendation for clearer guidelines suggests that students are aware of the risks associated with AI and would benefit from structured support on how to use these tools in an ethical and educationally productive way. Additionally, the emphasis on using AI as a learning aid, rather than a shortcut, highlights students' desire for tools that support, rather than replace, their intellectual engagement. Students also appear to be mindful of AI's limitations, with some calling for more education around the pitfalls of AI-generated content, such as inaccuracies or incomplete answers. This shows a growing awareness of the need to critically assess the results provided by AI.

It is also worth noting that a small group of students expressed satisfaction with the current use of AI tools, suggesting that no major changes are necessary. These students emphasized personal responsibility in managing their own AI usage. Responses such as *'I think it worked fine as it is,'* and *'No changes, but you have your own responsibility to not overuse it,'* reflect confidence in using AI tools without requiring further regulations or adjustments. However, it is important to consider that maintaining the status quo may not require deep reflection on potential risks or long-term implications of AI in education. While personal responsibility is a key factor, it does not eliminate the need for structured guidelines to ensure that AI is used effectively and ethically across different learning environments. Moreover, as AI continues to evolve and its role in education expands, ongoing reassessment of its benefits, challenges, and necessary safeguards will be crucial, even for those who currently see no need for changes.

3.6. Additional insights from student experiences

A total of 27 students provided responses to the question, *'Is there anything else you would like to share about your experience using AI tools like ChatGPT for both the project and the report?'* The responses revealed a mix of additional insights into the use of AI tools, with some students noting benefits, challenges, and areas for improvement in AI integration into academic work.

Key themes from the responses:

- **AI as a tool for understanding and clarification**: Several students shared that they found AI tools helpful in clarifying concepts or understanding difficult aspects of their projects, particularly in technical areas. For instance, one student said, *'I think it is a great tool when not understanding problems or getting another view on a problem,'* while another highlighted AI's role in helping with MATLAB programming, saying, *'Our main benefit was using it to*

understand MATLAB and some of the more difficult parts of our assignment.' These responses suggest that students appreciated AI for its explanatory power and for offering alternative perspectives on technical challenges.

- **Limited use for report writing**: A notable number of students mentioned that they did not rely heavily on AI for the actual writing of reports. One student stated, *'Our group did not use AI basically at all for the actual report writing. Maybe we missed an opportunity, but I find that formatting is such a large part of report writing that ChatGPT cannot really help.'* Another remarked, *'Only used AI as a small helping tool.'* This indicates that while AI tools were valuable for understanding and learning, they were not seen as particularly useful for the more nuanced tasks of writing and formatting reports.

- **Caution around AI reliability**: Some students expressed concerns about the reliability of AI-generated content. One response noted, *'I did rarely use AI tools, I do not think it is reliable and feels robotic for writing the report,'* while another mentioned using an AI detector to verify if someone in the group was relying too much on AI. Additionally, one student shared, *'We sometimes got stuck when the AI got different results from us. Therefore, it is important to use reliable sources like the book in order to properly understand and get the correct results.'* These responses suggest that students are aware of the limitations of AI and its potential to produce incorrect or inconsistent results, particularly in technical contexts in consistent with findings in [14].

- **Positive experiences with AI for coding**: Some students praised AI tools for their effectiveness in helping with coding tasks. One student described AI as *'far superior to Google and other search engines'* for coding, adding, *'I think AI is the easiest way to learn coding.'* This reflects the perception that AI is a valuable resource for programming assistance, especially in resolving coding issues and understanding programming languages.

- **Lack of additional feedback**: A significant portion of the responses consisted of simple

'No' or '.' responses, indicating that many students did not have further thoughts to share about their experience with AI. This might suggest that for some, the use of AI was minimal or that they did not find it impactful enough to warrant additional commentary.

So, students value AI as a supplementary tool for understanding and technical work, particularly in programming. However, they remain wary of over-reliance on AI, particularly in areas where accuracy and nuance are important. This reflects a broader awareness of both the strengths and limitations of AI tools and highlights the importance of integrating them thoughtfully into academic tasks.

4. Recommendations

The integration of AI tools, particularly ChatGPT, into education presents both opportunities and challenges that must be addressed through structured guidance. While ChatGPT offers significant potential for enhancing learning, it also raises concerns among students and educators about over-reliance, ethical misuse, and the erosion of critical thinking skills. The following recommendations provide a pathway to ensure that AI tools are used responsibly, addressing these concerns and ensuring that AI enhances rather than undermines learning, while maintaining academic integrity.

4.1. Establish clear ethical guidelines and usage boundaries

Educational institutions must establish clear usage boundaries and ethical guidelines for the use of AI tools such as ChatGPT. These guidelines should specify how AI can be used ethically for instance, to assist with generating ideas, coding, and understanding concepts, while prohibiting the direct copying of AI-generated content without comprehension. Ensuring that AI supports learning without undermining academic integrity is critical, and these guidelines should emphasize that AI is a tool to complement student-driven learning, rather than replace it. Institutions should also regularly update these guidelines to account for evolving AI capabilities and ensure they remain

aligned with the latest ethical standards and educational practices.

4.2. Foster AI literacy and critical thinking

AI literacy should be an integral part of engineering curricula, ensuring that students not only understand how to use AI tools but also grasp their limitations. Students need to be trained to critically evaluate AI-generated outputs, cross-check information against reliable sources, and develop the ability to question AI solutions rather than passively accept them. To prevent over-reliance on AI, institutions should incorporate AI literacy and critical thinking into the curriculum. This involves encouraging reflective assignments that require students to explain how they used AI tools in their learning process and how these tools contributed to their understanding of engineering concepts. AI-based assignments that require students to demonstrate their understanding beyond what AI can achieve on its own should be prioritized. Such tasks might include verifying AI-generated solutions, explaining their reasoning, and demonstrating independent thought. These approaches ensure that students critically engage with AI tools, fostering deeper learning and meaningful interaction with course material.

4.3. Promote active learning and ensure AI supports student-driven learning

While AI tools like ChatGPT can be valuable in enhancing learning, they should be integrated into a broader pedagogical framework that prioritizes active learning and collaboration. It is essential that these tools facilitate rather than replace student-driven learning. Educators should design assignments that require students to engage deeply with the material, using AI tools to support, not substitute, their learning process. This can be achieved through hands-on problem-solving, group work, or project-based learning that encourages critical analysis and collaboration. AI-based assignments can be structured to require students not only to use AI but also to demonstrate their individual understanding by explaining how they applied AI tools and reflecting on how the tools helped solve complex problems. Even in

collaborative projects where AI assists with tasks like coding, students should still be required to contribute meaningfully and demonstrate independent understanding of the overall project.

4.4. Design adaptive assessments to uphold academic integrity

Given the increasing use of AI in education, traditional assessment methods should be re-evaluated to ensure they emphasize the learning process rather than just the final product. Continuous formative assessments can help reduce over-reliance on AI tools by focusing on how students engage with the material over time. Adaptive assessments that challenge students to verify AI-generated content, explain their reasoning, and demonstrate independent thought should be incorporated into coursework. These assessments ensure that AI tools are used to enhance, rather than undermine, learning and are essential to maintaining academic integrity in an AI-driven environment. Oral defences, where students are required to present and justify their work, can further ensure they fully understand the material. During these oral evaluations, educators can ask follow-up questions or request simple changes to problem parameters, requiring students to quickly adjust their solutions, thereby demonstrating a deep understanding of the problem and their ability to adapt to new conditions. In addition to traditional exams, reflective assignments can also assess the depth of students' comprehension and their ability to apply AI tools responsibly in their learning process.

4.5. Enhance teacher support and training to develop AI-supported learning environments

The effective use of AI in education depends not only on students' abilities but also on educators' understanding of AI tools. The successful integration of AI tools into education requires that educators are well-equipped to manage and guide their use thoughtfully. Institutional teaching culture and departmental pedagogical traditions play a crucial role in shaping how new technologies, including AI, are introduced and utilized

in academic settings [15]. Institutions should offer professional development and ongoing training for teachers, providing them with the knowledge and skills necessary to integrate AI effectively into their teaching practices. Teachers must be aware of both the opportunities AI offers to enhance learning and the potential risks, such as over-dependence and ethical concerns. By equipping educators with the tools and frameworks to manage AI integration responsibly, institutions can foster AI-supported learning environments that promote collaboration, critical thinking, and academic integrity. This balanced approach ensures that AI enhances, rather than replaces, traditional learning methods. Institutions should also create AI-specific learning communities or forums where educators can share best practices, challenges, and new strategies for AI integration in teaching.

5. Conclusion

This study reveals the dual nature of AI tools like ChatGPT in higher education. While students appreciate the benefits of AI in helping them navigate complex technical tasks particularly in physics-related problem-solving and engineering modelling, many are also concerned about the potential for misuse and over-reliance. The majority of students acknowledge that AI can be a helpful tool, but only if used responsibly and with proper oversight. There is a strong call for structured guidelines and educational frameworks to ensure that AI serves as a learning aid rather than a substitute for human expertise and critical thinking. Students must also be taught to use AI tools thoughtfully, critically, and ethically.

However, challenges such as the risk of over-reliance, ethical misuse, and AI-generated inaccuracies cannot be overlooked. AI does not always provide correct or contextually appropriate answers, requiring students to cross-check information with reliable sources. Additionally, some students admitted to the temptation of copying AI-generated content without fully engaging with it, raising concerns about academic integrity. While AI can enhance learning, its effectiveness depends on how it is integrated into education and whether students use it as a tool for understanding rather than a shortcut for completing assignments.

While AI presents opportunities for enhancing learning and engagement, it is important to recognize that AI itself does not possess formal qualifications, professional accountability, or independent judgment. Rather than viewing AI as a partner in education, it should be seen as a supplementary tool that supports student learning under human supervision. Educators and institutions must take an active role in guiding AI integration, ensuring that students critically engage with AI-generated content rather than passively accepting it.

Ultimately, the future of AI in education lies in finding the right balance, leveraging AI's strengths to enhance learning efficiency, technical skill development, and conceptual understanding, while reinforcing academic integrity, critical thinking, and ethical responsibility. By fostering AI literacy and proper evaluation skills, students can effectively use AI to support their learning without diminishing the importance of human reasoning and expertise. With the right policies and educational strategies in place, AI has the potential to revolutionize learning while preserving the core values of academic integrity and intellectual growth.

5.1. Limitations

Despite the valuable insights provided by this study, it is important to recognize certain limitations. The focus on first-year students may limit the generalizability of the findings to other academic levels or disciplines. Additionally, the reliance on self-reported data introduces potential bias, as students' perceptions may not fully align with their actual use of AI tools. Future research should address these limitations by incorporating diverse student groups and objective measures of AI interaction, thereby providing a more comprehensive understanding of how AI tools impact learning in different contexts.

Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: https://doi.org/10.6084/m9.figshare.28536422.

Ethical approval

The study described in this manuscript was conducted in accordance with *Lag (2003:460) om etikprövning av forskning som avser människor (SFS nr: 2003:460),* which outlines the ethical considerations for research involving human subjects in Sweden. Additionally, informed consent was obtained from all subjects involved in the study to ensure compliance with ethical standards. The participants' personal information was kept confidential during the research process. They were informed that participation was voluntary and that they could withdraw from the study at any time.

Conflict of interest

The author declares that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Appendix. Supplementary data

Supplementary data related to this article can be found online at https://doi.org/10.6084/m9.figshare.28536422.

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