Examining the Opportunities and Challenges of Using Artificial Intelligence for Engineering Technical Writing Courses

Dr. Susan J Ely, University of Southern Indiana

Dr. Ely began her academic career at the community college level, after having worked as an engineer in areas of manufacturing, distribution, logistics and supply chain. She is the Director of Technology Programs and Assistant Professor in Manufacturing at the University of Southern Indiana. Research includes student retention and engagement, mentoring and support of women in engineering and lean applications in non-manufacturing environments.

Dr. Milad Rezvani Rad, University of Southern Indiana

Dr. Milad Rad is an Assistant Professor in the Engineering Department at the University of Southern Indiana. He earned his Ph.D. in Mechanical Engineering from the University of Alberta in Canada. Besides his specialization in functional thermally sprayed coatings, he explores innovative AI-driven approaches to enhance student engagement in the classroom.

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Abstract

The implementation of artificial intelligence (AI) has provided students and educators in engineering fields with countless opportunities and complex challenges. The prospects of using AI-powered sophisticated tools for crafting well-structured, coherent, and compelling essays in higher learning institutions are both promising and potentially problematic for students and faculty pursuing the use of AI to enhance learning in the classroom. AI offers distinctive benefits to students such as real-time feedback, grammar and style suggestions, and content generation assistance. AI is also able to analyze students' writing styles and provide instant feedback on the areas that need further improvement and modification which can lead to an iterative and self-improving process that would be beneficial to the professional development of future engineers. Many AI writing tools are freely available to students at no cost, making this resource accessible to all. Despite the advantages, AI may provide students with some misleading information and outdated data. AI tools are also highly dependent on the phrasing of the prompts, potentially leading to suggestions that stifle creativity or misinterpret students' intentions. AI-generated text is unable to capture the nuance, context, and subjective nature of writing, making the AI responses have a voice distinctive from the voice of the individual. In addition, like any other evolutionary technology, there are increasing concerns regarding the ethical implications of AI in education that must be carefully studied.

With these factors in mind, an engineering technical writing class was used to further examine the evolving landscape of academic writing and detect the domains in which students and educators can appropriately utilize AI tools. In this regard, several writing tasks were outlined, wherein undergraduate engineering students were asked to write with and without AI's assistance in order to explore the pros and cons of using natural language processing (NLP) models for technical writing and gauge the interest and enthusiasm of students in utilizing AI tools. Then, a comprehensive comparative analysis was conducted to analyze several factors including writing style, the structure of paragraphs, the accuracy of numerical data, and the empathetic language of the essays written by students and those generated by AI. In light of the analysis conducted, this paper aims to identify and explain the advantages and disadvantages of relying on AI tools and emphasize the need for careful consideration of ethical and pedagogical aspects to ensure a harmonious integration of AI into the educational landscape. Recommendations for best practices within engineering curriculum, as well as samples of assignments are also presented in this work.

Keywords: Artificial Intelligence, Enhanced Learning Outcomes, Technical Writing, Generative Pre-trained Transformer, Real-Time Dynamic Feedback.

Introduction:

The recent noticeable advancements in artificial intelligence (AI) have garnered the attention of scientists across various fields. One of these areas is use of ChatGPT for technical writing. It is generally believed that reviewing and editing articles to make sure that they are accurate and free from errors are among the laborious and time-consuming tasks in academia. However, this task, among many others, can be performed by using AI thanks to some promising features it offers such as error detection, improving text coherence, and trend identification [1]. It can also be used for summarization and data analysis as well, which are amazing tools for conducting academic research. Although using ChatGPT can facilitate the essay writing process, there is an increasing

concern about the ethical considerations and the significance of balancing AI assistance with students' involvement required for developing students' essential skills [2].

Although students who used ChatGPT in project-based, reflective, critical thinking, and research-related writing assessments have faced some challenges and shortcomings, they managed to get satisfactory results with proper training and input. Therefore, the success rate relies on the level of students' understanding of ChatGPT usage and expected output. However, there is always a risk associated with mastering this technique that can alter the balance of risk and reward for students [3].

Methodology:
This case study involved the introduction of a new module regarding Artificial Intelligence in engineering classrooms by looking at the use of generative and non-generative AI in an engineering technical writing course.
This module took place in a second-year course titled "Experimental Design and Technical Writing" at a midwestern medium-sized public university. This course supports the ABET accreditation criteria for Student Outcomes, including outcomes 3, 4, 5 and 6, which state: "Students will develop an ability to communicate effectively with a range of audiences (Outcome 3); Students will have an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economics, environmental, and societal context (Outcome 4); Students have an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives (Outcome 5); Students will have the ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (Outcome 6)" [4]. This course also supports an institution requirement of each program integrating "embedded writing experiences" to support the linkage between foundational skills of a bachelor of science degree and each specific major. The requirements for this embedded writing experience include, "(1) Writing assignments should be integrated throughout the semester and used to enhance the learning of course content; (2) Written assignments should constitute a significant portion of the course grade, counting for a minimum of 35% of total course evaluation in a three credit-hour course, or its equivalent; (3) Instruction should include brief lessons on writing in the particular discipline; (4) Each course should have at least one sustained or long-term writing project, e.g., a research paper, an argument, a detailed lab results report; (5) The sustained project should synthesize some of the major objectives of the course; (6) At least one assignment must involve instructor feedback on student drafts and opportunities for revision; and (7) Each college/department should determine broad parameters for what constitutes acceptable writing in the discipline(s)." [5].

As a course directed towards engineers, most writing assignments are specific to experiments completed during face-to-face instructional sessions. These experiments involve the generation of data through simplistic methodologies, allowing students to quickly gather data for analysis and authoring short technical reports. The student-driven methodologies and data generation make these courses less susceptible to plagiarism through copying internet content. However, the course aims to help students improve their writing techniques, including using active voice, academic language, and use of appropriate grammatical structures. These topics, in addition to graphical

displays of data are critical for engineers both within their educational setting and in future career paths.

The methodology for this case study was based on previously established best practices from institutions that are establishing standards for the integration of AI into classrooms. While not specifically engineering coursework, these practices are germane to the university context, regardless of discipline. One widely cited practice established the following framework for establishing AI literacy within a course. Their seven steps include: "1. Understanding how AI works 2. Deciding when to use AI and when not to 3. Valuing AI 4. Applying effective prompt engineering methods 5. Evaluating AI output 6. Adding human value 7. Displaying digital adaptability" [6]. This framework informed the construction of the AI module, which was integrated early in the semester to help establish boundaries on when AI was appropriate for use within the course. The establishment of boundaries such as these is also a best practice established by numerous collegiate establishments when trying to balance the inevitable use of AI by students in their classrooms [7, 8, 9, 10, 11].

The structure of the module was as follows:

1) A 75-minute class period was dedicated to the exploration of non-generative AI tools for proofreading and writing support, including Grammarly and Hemmingway. This session also included a discussion on the differences between generative AI and non-generative AI.
2) Students were asked to write a 500-word essay about their journey in selecting their specific engineering discipline. Students were encouraged to include personal elements including familial connections to the engineering field, their thoughts and emotions about the selection and their experience so far.
3) Students used a non-generative AI tool to proofread their work and make improvements and then conducted a peer review process with their classmates.
4) A 75-minute class period was used to discuss generative AI, such as ChatGPT and the impact of prompts on AI output was discussed. Students experimented with various prompts related to pursuing their specific discipline. Students completed an iterative cycle of refining their AI prompts to try to have the output more closely resemble their original work.
5) Once a similar work had been generated by ChatGPT, students reflected on the similarities and differences between their original work and the AI-generated content. Students were asked to note how the AI-generated essay may have added elements that their essay was missing, as well as potential inaccuracies or less desirable aspects of the AI-generated work.
6) Students submitted a single document including their fully revised self-authored work (proofed by non-generative AI tools and peer review), their final prompt and response from ChatGPT and their reflection on both works.
7) Students completed a survey about AI usage, perceptions, adaption to other coursework and expectations for the future.

Results and Discussion:
The researchers reviewed the survey data in addition to the reflections submitted for the assignment as discussed above. This module was first deployed in the Fall of 2023 to two sections of students, each with a different instructor. In Spring 2024, the module was deployed to three sections, two with one instructor and one section with a different instructor. Therefore, the results presented below represent a total of 58 students across multiple grades and majors. The demographics for the study are presented in Table 1.

Table1. Demographics of Survey Respondents							
Age	**19**	**20**	**21**	**22**	**23+**	**Not Answered**	**Total**
Number of Students	15	21	8	7	5	2	58
Percentage of Students	26%	36%	14%	12%	8.6%	3.4%	100%
Major	**Mechanical**	**Civil**	**Electrical**	**Manufacturing**	**Engineering**	**Other**	**Total**
Number of Students	28	12	13	5	0	0	58
Percentage of Students	48%	21%	22%	9%	0%	0%	100%

Table 1. Demographics of Survey Respondents

After basic demographic information, the survey questions were divided into three areas of inquiry: first, use of generative AI within the Experimental Design and Technical Writing Course; second, the use of generative AI for all other coursework; third, expectations for future use of generative AI.

In the first area of inquiry, students were asked about previous use of AI for educational purpose, the impact of the classroom activities on their view of AI and the impact of the classroom activities on other assignments within the course. It was found that just over half (57%) of students had prior exposure to ChatGPT before using it specifically for technical writing. After completing the assignments, approximately 57% of students said the module had positively impacted their view of AI. While 72% of students stated that there was no change in use of AI for the class, the students noted that they found that generative AI was useful for the “generation of ideas”. While ideation was the most popular task among students using ChatGPT, students also expressed interest for using it for proofreading their work. Interestingly, 81 percent of students stated that they used non-generative AI tools (such as Grammarly or the Hemmingway Ap) to assist in proofreading their work as a result of the in-class exercises. Figures 1, 2 and 3 depict the exact breakdown of student survey responses.

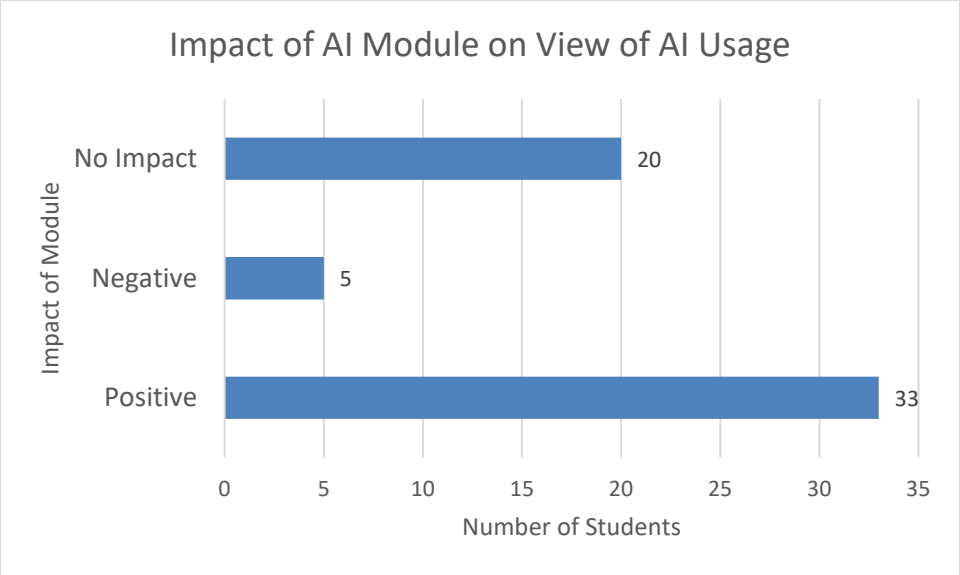

Figure 1. Impact of AI Module in ENGR 291 on student's view of generative AI (ChatGPT)

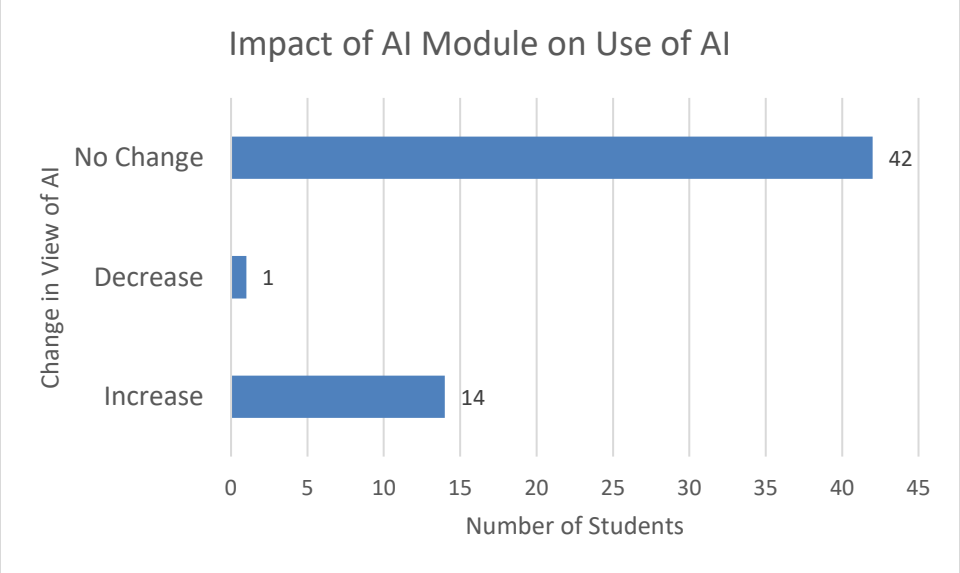

Figure 2. Impact of AI module in ENGR 291 on student use of AI in ENGR 291 "Experimental Design and Technical Writing"

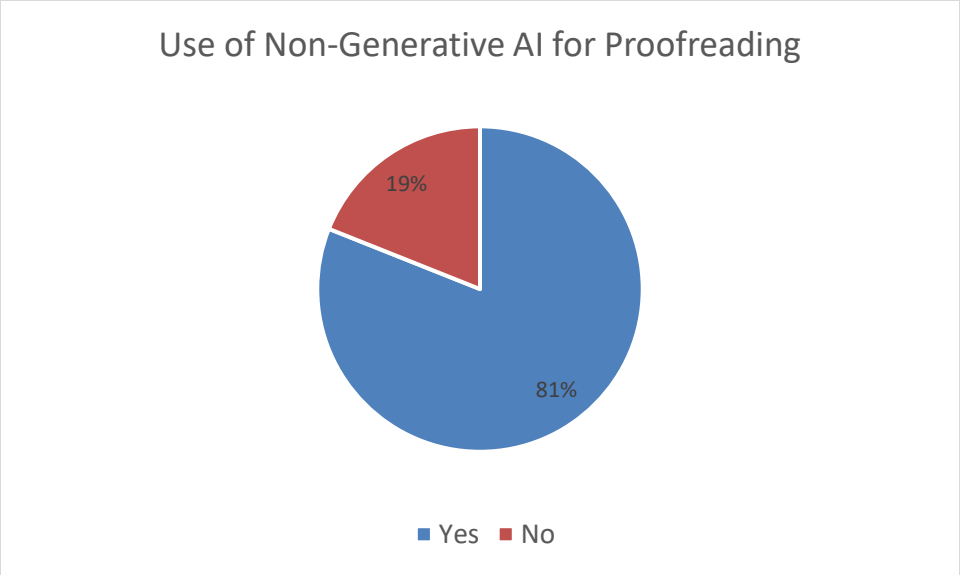

Figure 3. Use of non-generative AI (Grammarly or Hemmingway Ap) in ENGR 291 due to AI module

Although students showed a positive impact for using ChatGPT and an overwhelmingly positive response to non-generative tools for writing courses, the survey results revealed a level of dissatisfaction regarding its impact in facilitating enhanced learning of fundamental engineering concepts. According to the survey results, students rarely use it for other core engineering courses. Based on the survey, 43 percent of respondents never use AI for engineering coursework and 34% rarely use ChatGPT for engineering coursework. However, 24 percent of respondents stated that they do use ChatGPT for their English courses. In addition, 53 percent of students were neutral when asked if they could achieve a deeper understanding of engineering topics by utilizing this powerful tool. Students were fairly evenly divided when reflecting on the dependability of ChatGPT responses, with 45% judging the responses as reliable and 48% of respondents judging ChatGPT responses to be somewhat unreliable. Figures 4, and 5 provide the division of responses for this section of questions.

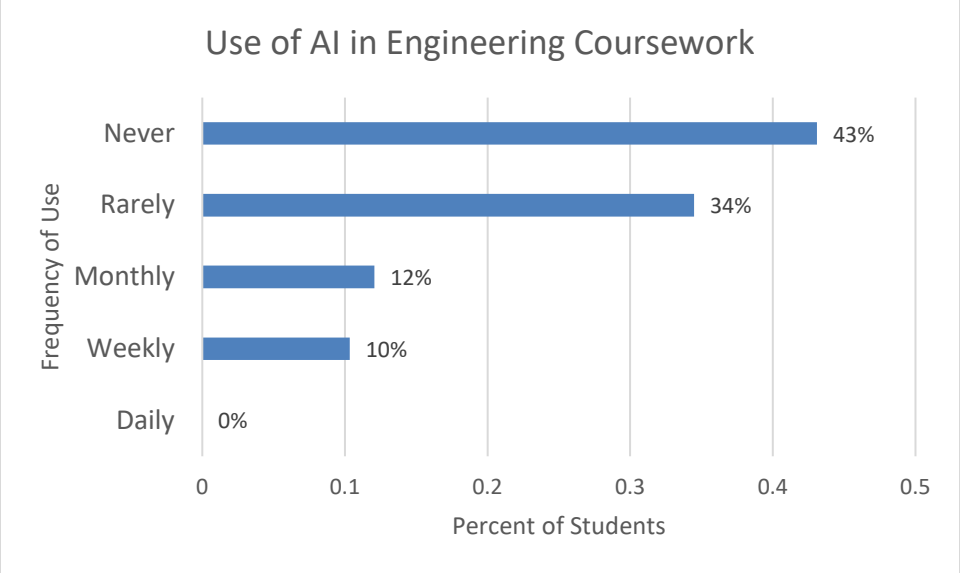

Figure 4. Frequency of use for learning and understanding engineering concepts

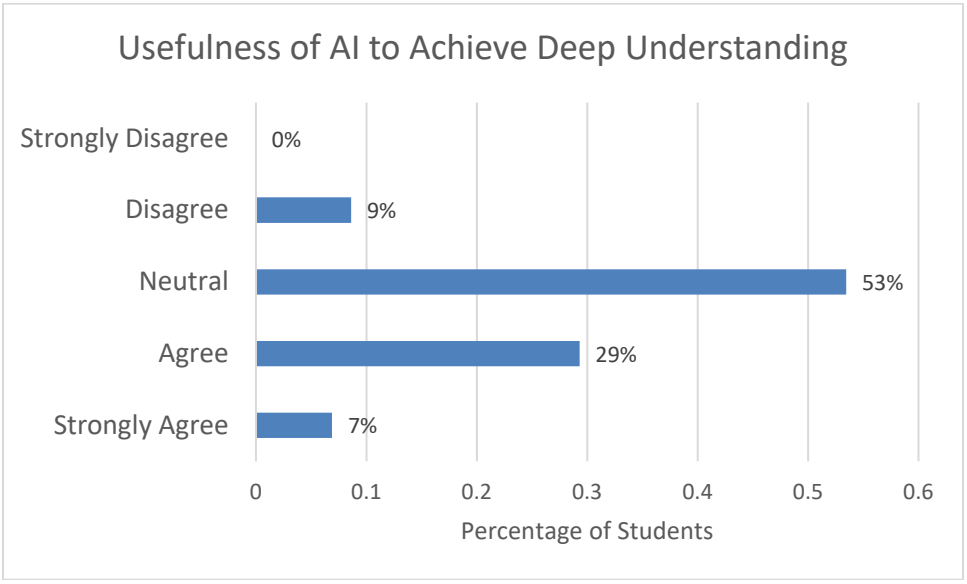

Figure 5. Student's perceived usefulness of ChatGPT to achieve a deeper understanding of engineering concepts

Regardless of some shortcomings and minor inaccuracies, students asserted that they plan on using ChatGPT more in the future in their academic program and even in their professional endeavors after graduation. In a survey of college students nationwide (N= 1,000) only 37% of students stated an intention to use AI in their future coursework, compared to the 60% of respondents in this study [12].

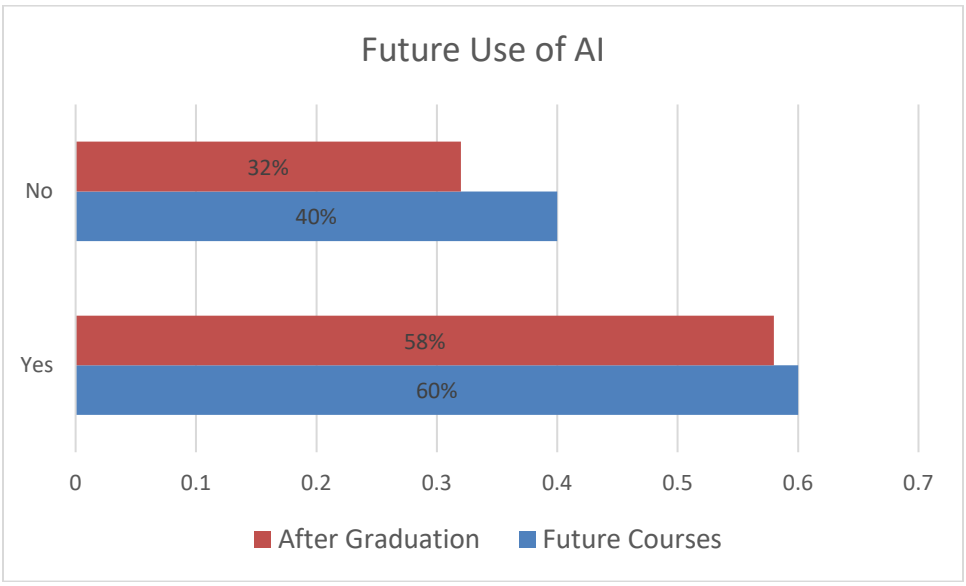

Figure 6. Student reported intention regarding future use of AI in other coursework and after graduation

Interestingly, when asked about the students' optimism about the future of artificial intelligence, responses were not consistently uniform. While some students expressed high levels of optimism, a few were concerned about the recent rapid advancements that can bring about additional risks

and challenges in the near future. Those who viewed the future positively (highly optimistic or optimistic) made up over half of the responses (53%) and agreed that AI could improve lives and positively impact industries. Those cautious or pessimistic (30%) reported doubts and concerns about the risks associated with AI. The BestColleges nationwide survey had 48% express concern about the impact of AI on society [12]. This shows that USI students who completed this AI-specific module were less wary about the future of AI compared to the average national response. This aligns with the study conducted by Hommel, where STEM students stated "It's true that we can't predict where this (AI) is all going, but I feel better just having discussed it" [11]. The responses from this survey are displayed in Figure 7.

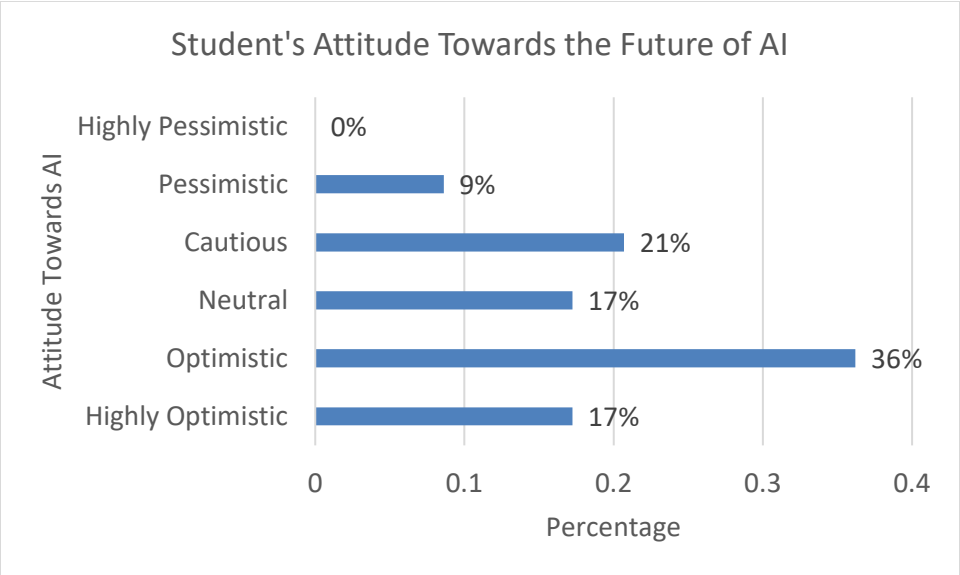

Figure 7. Student's attitudes towards the benefits and risks of AI in the future

With such a nuanced topic, engaging students emotionally when facing the questions about the moral use of AI, as well as their future careers and lifestyle [6, 8, 11] is critical for preparing students for a future where AI is already prolific with applications across numerous industries. The qualitative responses from the survey assist instructors in understanding how AI is currently being used and what opportunities there may be to expand student's responsible use.

The following comments were supplied by students about the purposes they use ChatGPT for.
"Give ideas or different way of explaining things."
"Better understanding of theories and applications."
"Help to break down certain topics or revise phrasing."

Of course, the experience of students working with ChatGPT was not flawless. They highlighted the following points when asked about challenges they encountered.
"Modern research is not possible due to the software only being up to date as of September 2021."
"The information is not always to date."
"When assessing heat transfer problems, it tends to only derive certain equations from the governing equations. However, it won't use the parameters you give it."

The majority of the students also expressed that they do not use ChatGPT for in-depth explanations; instead they rely on it for quick clarifications, as expressed in the following comment.
"When I do not understand something, ChatGPT provides some information that is helpful and gives a better understanding."

Here are the specific suggestions provided by students for further progress and advancement of ChatGPT:
"It's a good tool for explanation, not great for solving calculations."
"It should use better resources when providing information."
"Updating to current data rather than data two years old."

Conclusion:
Although the process of writing an essay was remarkably simpler when ChatGPT was used for writing, independent writing yielded more accurate and dependable results. By so doing, students noted that when they do research on their own, they can use valid sources such as published books and journal articles rather than blogs and non-peer-reviewed research works. Furthermore, students understood that the statistics provided by ChatGPT are not up to date for they should rely on credible sources such as official government websites for the most current information. More importantly, the students found out that ChatGPT fails to yield satisfactory results when used in some domains, including but not limited to, personal experiences, emotions, predications and evaluations, which indicates its limitation beyond factual and objective content.

As engineering faculty, it is critical that we proactively support students in the responsible use of AI. This study supported previous research in which exposure and open discussions about the ethical use of AI helped students to be more accepting of the future use of AI both within university settings and later on in life [2, 6, 8, 11]. While only two semesters of data have been collected thus far, the positive response from the students, especially compared to nationally reported attitudes of college students, demonstrates the value of modules such as this. Technical Writing is a natural fit, as generative AI is most frequently used in writing exercises, however, expansions into other technical subjects can also benefit by this research and by future study.

Note: No generative AI tools were used in the authorship of this work.

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