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Unfettered ChatGPT Access in First-Year Engineering: Student Usage & Perceptions

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Abstract

In the midst of artificial intelligence (AI) generative models becoming commonplace and widely available, academia stands at a crossroads: embrace AI or resist AI. Each institution, department, professor, and student faces this choice. AI represents an unprecedented ability to solve problems quickly with reasonable accuracy. Open AI's ChatGPT is one such example of a generative model powered by Large Language Models (LLM). ChatGPT can solve many coding problems in a variety of computer programming languages.

Here, we seek to understand the real world consequences of embracing generative AI in general and ChatGPT in particular through the lens of coding in C++ and MATLAB. Students in the second semester of a year-long first year engineering class were given unlimited access to generative AI to use on homework, quizzes, and exams throughout the course. On each assessment, if they used AI, they were asked to explain how they used it.

At the end of the semester, we collected survey feedback from two sections of this class. From thematic analysis of the qualitative survey results as well as students' explanations of their use of ChatGPT on three assessments, we explored both *how* and *why* students might use AI in a first year engineering course. We characterized ChatGPT usage as either productive or unproductive for learning and defined four general reasons why students engaged with AI in this course: ChatGPT as

1) A learning aid
2) A coding resource specifically
3) An inevitability
4) A personal perspective

We discuss some of the ways that students can use AI responsibly as an asset to their learning. Their responses also show student awareness and current understanding of the positives and negatives of AI use for acquiring and applying foundational programming skills. The results also show that the majority of students who chose to use AI did so to enhance their learning rather than replacing their original work.

Introduction and Background

Large language models (LLMs) are artificial intelligence (AI) tools trained to create human-like content such as text and images through simple prompts by processing extremely large sets of data [1], [2]. LLMs include generated pre-trained transformers (GPT) like ChatGPT, an Open AI tool. A very popular LLM since its release in 2022, ChatGPT has garnered attention from both industry and academia. These tools have been applied across various fields for purposes including generating codes in programming [3], helping with language translation [4], writing assistance[5], replying to mental health questions [6], and scheduling construction projects [7].

In the academic context, ChatGPT has been used in research, teaching and learning [8] including within journalism [9], [10], applied linguistics and engineering [9], [11], [12]. Specifically in applied linguistics, it was used to create assessments [12]. In journalism, it was found to improve the quality of writing produced by students [13]. In the engineering field, it has been used to support student learning in industrial engineering, chemical engineering, and software engineering [12]. A chemical engineering case study described its use to cultivate students' problem solving, critical thinking and solution evaluation skills through course assignments [9]. In one example, students were required to build a power plant virtual model. This assignment engaged their knowledge of programming and basic thermodynamic concepts.

ChatGPT also has the potential to influence assessment methods and design of course materials both positively and negatively [8], [14]. On the positive side, some faculty have successfully used it to create assessments or grade student work; on the negative side, it has the potential to present challenges to academic integrity if proper precautions are not taken [15]. Also, these tools are relatively new, and students that embrace them may have additional opportunities in the future as long as they also learn the key learning objectives in their courses.

In this paper, we present a mixed method case study that investigates whether, how, and why a student would choose to utilize ChatGPT in a foundational first year engineering course when presented with unfettered access to AI tools. The following research questions guided our investigation:

1. How did students use ChatGPT when given the freedom to make their own choices?
2. Why did students make the choice to use or not use ChatGPT?

In the following sections, we provide the course context, discuss study methods, share our findings, then conclude with suggestions that we hope other engineering educators will find useful.

Curricular Context

This study took place within the first year engineering program at Northeastern University, a mid-sized, private university in Boston, United States. The program serves all first year students in the college of engineering, regardless of major. The program consists of a two semester sequence covering computer aided design (CAD - AutoCAD, Solidworks), introductory coding (C++, Arduino, MATLAB), and engineering design (design process, ethics), taught by a faculty team dedicated to first year engineering.

After students submitted their first homework assignment (coding an RPG fighting game in C++ that usually takes 7+ hours), the instructor introduced the power of ChatGPT by asking the bot to create the game live during class. Students were gobsmacked while the AI solved a problem they had agonized over for a week in a matter of seconds. This drove home the power of ChatGPT. Using this example, the class examined the code ChatGPT made and explored the advantages and disadvantages. The class discussed how to use ChatGPT to enhance their learning while not replacing their learning (e.g. reviewing concepts, remembering syntax, finding minor errors). Throughout the semester, the instructor continued discussing ChatGPT to solve problems and emphasize strategies for learning *with* AI.

This study specifically focuses on three individual coding assessments (quizzes and exams) given in the Spring 2023 semester by one instructor. Each assessment is a take home, two-day, timed, multi-attempt assessment that uses rotating questions to make each attempt unique. This specific assessment system has been discussed previously [16]. Each assessment uses question banks on Canvas organized by topical area and within each bank, questions within a given bank are approximately the same level of difficulty.

The participants of the study are 57 first year engineering students enrolled across two sections of the course. All engineering students at this university have a common first year and students from different engineering majors are mixed together in the same course. Across first year engineering in the 2022-2023 school year, 52% of students were women-identifying students.

Methods

The data for this study includes students' descriptions of their use or non-use of AI on the three coding assessments described in the Curricular Context, as well as end-of-semester survey responses about the AI policy in the class. A collaborative, iterative coding scheme was applied to both data sets and is described in more detail for each below.

Survey
The end-of-semester survey included 13 questions that inquired about students' experiences in the course and their thoughts on the semester-long project, the instructor teaching style and AI

policy, as well as general course feedback. Regarding AI, students were asked to answer the free response prompt:

> *This semester ChatGPT was allowed to be used in my class on homework, quizzes, and exams. How did this option affect your learning and study habits? How do you feel about using this option in the future?*

Fifty-six students responded to the prompt. We began analysis with one author taking a first pass reading the anonymized student responses and noting ideas related to reasons to use or not use AI and if they did use AI, how did they use it. All three authors met to discuss these initial thoughts and turn them into themes. We then collaboratively coded 25% of the responses before coding was completed by one author. All authors reviewed the full set of coded responses and any disagreements were settled through discussion and consensus using 3-yes, 1-no system. By ensuring that all authors had a say in the coding and final decisions, we minimized bias in the analysis.

Assessments

On all three of the coding assessments, in addition to solving the coding problems, students were asked to answer the free response prompt:

> *Did you use ChatGPT on this exam? If so, please explain how you used it. Defend your use of ChatGPT and explain if it was useful and how. If you did not use it, please say that you did not use it on this exam and why. Regardless of your choice, please do not write more than 4-8 sentences about this.*

This resulted in 169 total responses (55-57 responses on each of the three assessments). Based on their responses to this prompt, we first sorted the anonymized data based on student usage of AI: those who did not use AI and those who did. For both groups, we read each response closely to characterize why students chose to use (or not use) AI on the assessment; for those who used AI, we also analyzed how they used it. We evaluated AI usage as either productive or unproductive for learning. Productive uses of AI *enhance* the learning process, while unproductive uses of AI *replace* the learning process. This concern about the potential of ChatGPT to replace learning is one that other researchers have also raised [8], [15]. The analysis of this assessment data was conducted as a joint effort of all three authors; each code and characterization was decided by consensus. In the Findings section, we represent the data both quantitatively – to show the distribution of usage of AI – as well as qualitatively, to more fully characterize the ways first year students may use AI on coding assessments.

Findings & Discussion

The findings were divided into *How might students use ChatGPT?* and *Why might students use ChatGPT?* to address the guiding questions of this study. When given unlimited access, we explored how students used AI on their assessments and the motivation behind their use of AI.

How might students use ChatGPT?

Students used AI on their exams in a variety of ways, some productive for learning and some unproductive. We defined these differences by looking at how using ChatGPT compared with other available non-AI resources. For instance, if a student uses ChatGPT to explain a concept and give examples of the syntax, the student is reviewing that concept and how to use it in a different context. This is productive for their learning. By comparison, if a student copies and pastes the exam prompt into ChatGPT and submits the generated solution, AI is replacing their learning. This is unproductive. Below is a list of the specific use cases we observed across a C++ Exam (their 3rd assessment on C++), a MATLAB Quiz (1st assessment on MATLAB), and a MATLAB Exam (2nd assessment on MATLAB). By "assessment" we exclusively mean quizzes and exams.

Activities deemed Productive for Learning

- Fixing small errors/troubleshooting code
- Looking up general concepts
- Solving a single specific concept (evaluated on a case-by-case basis). Examples:
  - Reversing an array
  - Checking how to call a function
  - Checking what a Boolean return function is
  - Calculating the length of an array
- Verifying syntax - especially for students who know/are learning multiple coding languages simultaneously
- Asking ChatGPT to make examples to show how to apply a concept (not using the assessment questions)
- Demonstrating deep understanding of what they know and don't know and using ChatGPT to fill in specific knowledge gaps
- Fixing compiling issues (student compared ChatGPT to Grammarly)
- Doing their best first, then looking for help (evaluated on a case-by-case basis)
- *Specifically supportive of Multilingual/English Language Learners* - asking ChatGPT to "break down the question" into parts they do and don't understand and then using ChatGPT to explain the parts they do not understand in simpler language

Activities deemed Unproductive for Learning

- Solving whole problems / turning in the ChatGPT answers without vetting them or trying to understand (student specifically acknowledged their 'laziness' in comments)
- "Tweak for efficiency" "more concisely" - student compared their code with ChatGPT and then used ChatGPT code instead (instructor did not get to see the student's original code)
- Using ChatGPT to get started on a problem then coding themselves afterward (replacing initial thoughts)

When judging whether a behavior was productive or unproductive, we considered how a student using different resources would behave, how much mastery was demonstrated before ChatGPT was used, and how significantly AI changed their code directly. AI use that substituted for other allowed resources (i.e. they could look up syntax in the lecture slides or in ChatGPT), allowed the student to demonstrate their current level of mastery before use, and/or minimally changed the student's code directly were deemed productive. We coded *Productive for Learning* when students explained things thoroughly, were specific about what exactly they asked for examples of, and exactly how AI helped them. Most students (87% - 90%) either did not use ChatGPT or used it in a productive manner (Figure 1).

A student who uses ChatGPT to start a problem is missing the process of converting a word problem into a coding problem. Comparing their code to ChatGPT, deciding ChatGPT did a better job, and submitting the AI code prevents us from seeing what the student built and how close their code was to success. Lastly, students that replaced their effort with heavily using ChatGPT failed to show a mastery of the material. Each of these examples were deemed *Unproductive for Learning* how to code.

In some cases, students made claims that were not clear in how they used ChatGPT. In these cases, we did not characterize their work to avoid assumptions wherever possible. Examples of this are where they used the phrases, "got stuck," "check my answer", or "check my work" without further elaboration. In these cases, we could not verify whether they used their own work or the AI. In most cases, the student wrote enough in their response to use the criteria presented above to classify the work as productive or unproductive.

Figure 1 shows the percentage of students who did not use ChatGPT (purple - lowest section of bars), used ChatGPT productively (dark blue - mid section of bars), and used ChatGPT unproductively (light blue - top section of bars). Across all three assessments, we consistently saw unproductive use by 6 or 7 students. Productive use fluctuated with the exam difficulty - the MATLAB Quiz was easiest, followed by the C++ Exam, followed by the MATLAB Exam. This perceived assessment difficulty trends with the 'productive use of AI' numbers and by extension, is inversely proportional to the 'did not use AI' numbers.
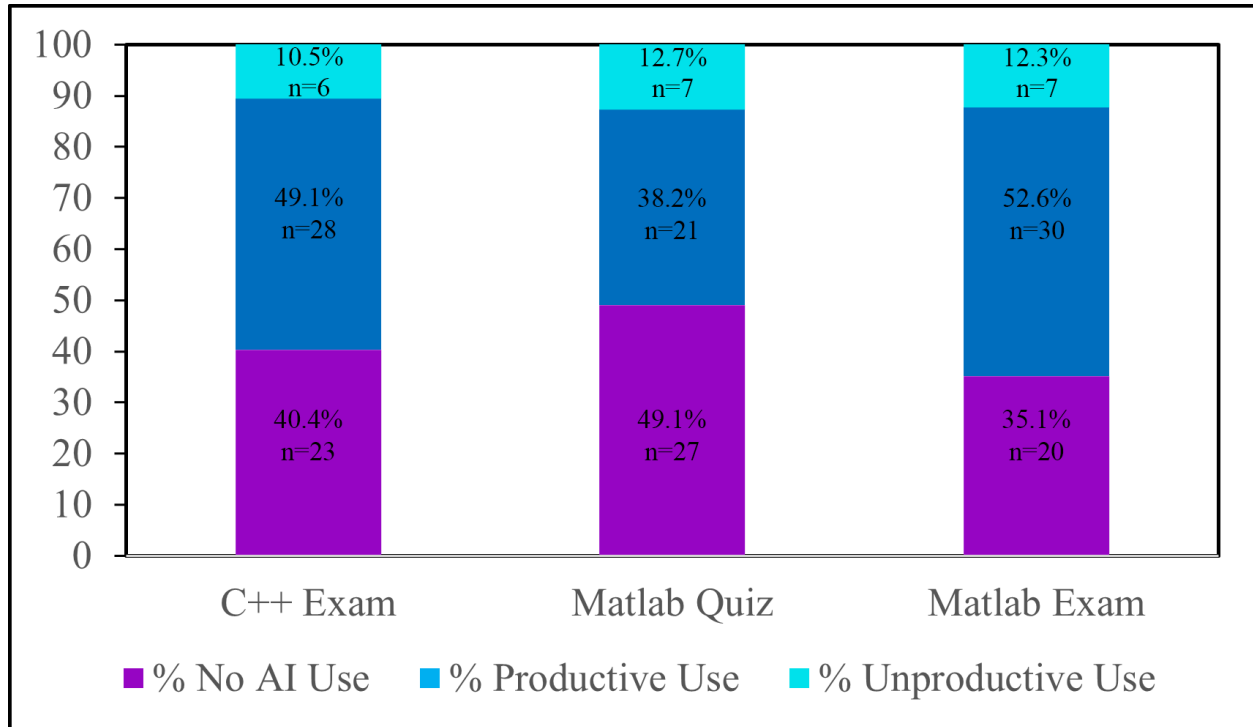
Figure 1: Percent of students voluntarily using ChatGPT on coding assessments. Students using AI unproductively stayed consistent at ~10% and productive AI use shifted with assessment difficulty. Students who did not use ChatGPT are purple/the lowest section of the bars. Students who use ChatGPT are in blue with 'productive use' shaded as the dark blue/the mid section of bars and 'unproductive use' shaded as the light blue/the top section of bars.

Examples of productive and unproductive responses

From our dataset, we selected submissions by students to highlight how we judged cases that might not be clearly productive or unproductive. We bolded the sections of the excerpts that are most relevant below.

C++ Exam:

> *I did use Chat GPT on this exam. I used it to help **me fix an issue with my code on question 2**, which was about Jill and Jack's age. I ran into an issue where it would swap the age and then see Jill's age as less than Jack's, so it would make it divisible by 6 by subtracting. It was not supposed to do this because it already swapped, so it was supposed to just move on. **I didn't know what I had done wrong, so I put it into ChatGPT and compared my code with theirs.** I found that I used 3 if statements rather than 1 if statement and 2 else-ifs. This solved the issue because I think that it looked at one if statement instead of all of them.*

The student had finished the question and had a specific error that they understood was not working. They used ChatGPT to compare their code and found a specific technique that

ChatGPT used that differed from their own. They implemented that solution into their code (did not copy and paste). Throughout this use case, the student explained why they needed help and what they knew before using AI.

MATLAB Exam:
> *Similarly to my other exams,* **I used Canvas slides to review first, then used ChatGPT's solution of the question** *to get a better feel for how the problem could be solved. More often than not on this exam* **it was wrong**, *but since I had reviewed the content it* **gave me a good starting point. Starting from a blank coding window is way more intimidating than starting from something ChatGPT** *came up with even if it is mostly wrong. I do way less copy pasting from ChatGPT than I do* **asking it to troubleshoot my code, check my syntax, ask it specific things** *(how to get variables in a title which led me to sprintf, which I was not very aware of before), and more specific knowledge questions that would be hard to find in the Canvas slides. One area it really helped was the input output part; I was really struggling to get my input read in Q3.* **I also used doc** *[built-in help menu]* **every time I ran into a command I didn't understand in the AI's code so I ended up learning quite a bit in addition to figuring out the answers.**

This student mixes unproductive and productive uses for AI. Using ChatGPT to answer questions, fix syntax and troubleshoot are all productive ways to use AI. However, using AI as a starting point and looking at its full solution are unproductive and can negatively affect learning. Lastly, they used ChatGPT in conjunction with MATLAB's "doc" function to learn more deeply the commands from MATLAB documentation. This additional learning was enhanced by using AI. In the MATLAB Exam, we had two students who had mixed productivity cases so we coded one as productive and one as unproductive to balance the response count.

MATLAB Exam
> *I use chatgpt* **as a guide** *to help see* **what codes I'm missing from my code** *and explaining the use of the code on how to use in my code.* **So I can understand the functionality of the code.** *But ChatGPT would use could be* **too complicated for me to understand during the exam so instead I would use MATLAB documentation to help explain the code and methods** *I could use which provides examples on how use the codes in MATLAB. I also took look at my assignments that involve functions to help understand the code also as guide to solve these problems. I would look up the code in the MATLAB documentation if I don't understand how ChatGPT is using the code correctly.*

This student found the code that ChatGPT made was difficult to understand, so rather than using code that was too complicated, they used other resources to solve the exam problems. Mixing AI with reference documentation allowed the student to learn what they did not understand before

the exam. Although this had potential to be unproductive, we decided that the learning outweighed the reliance and coded this response as productive.

Why might students use ChatGPT?

In order to address the research question *why* first year students might use AI, we examined both the assessment and survey data for student reasoning behind this choice. Analysis of the survey responses resulted in 11 themes relating to students' use of AI in the course. These themes are summarized in Table 1 (the full codebook can be found in Appendix A). We also generated a count of each code based on the full data set, shown in Figure 2.

Table 1: Codes for survey responses with short definitions. The definitions represent the stance taken by the student in their response. The full codebook including further clarification on the definition and representative examples for each code can be found in Appendix A.

Code	Short Definition
(tool)	AI is a useful tool for students.
(crutch)	AI has the potential to replace learning.
(tutor)	AI can be used to learn a specific concept.
(reflect)	AI can help or hinder learning depending on who uses it and how.
(speed)	AI can solve a problem quicker than using other resources.
(adv)	Code generated by AI is too advanced.
(bad)	Code generated by AI is bad/not useful/incorrect.
(comp)	Compared themself to others who did/did not use AI.
(future)	AI is a necessary future skill.
(priorities)	Use (or not use) of AI is related to the student's learning priorities.
(skynet)	AI cannot or should not be banned because that will not change access to it.

These themes suggest why students might use (or not use) AI in a first year engineering class and were supported by students' responses on the assessments as well. Whereas the survey responses included more discussion of the use of AI on homework assignments and in the course overall, the assessment question asked students to describe why they chose to use (or not use) AI on that particular assessment. This question yielded more detailed responses expanding on some of the themes from the survey data. This section of the findings is organized by the role that ChatGPT played in these students' learning of programming - as a learning aid, a coding resource, an inevitable technological advancement, and their personal perspectives of AI's role in their learning. This categorization draws from both the survey and assessment data, and examples from both sources are included to support this characterization.
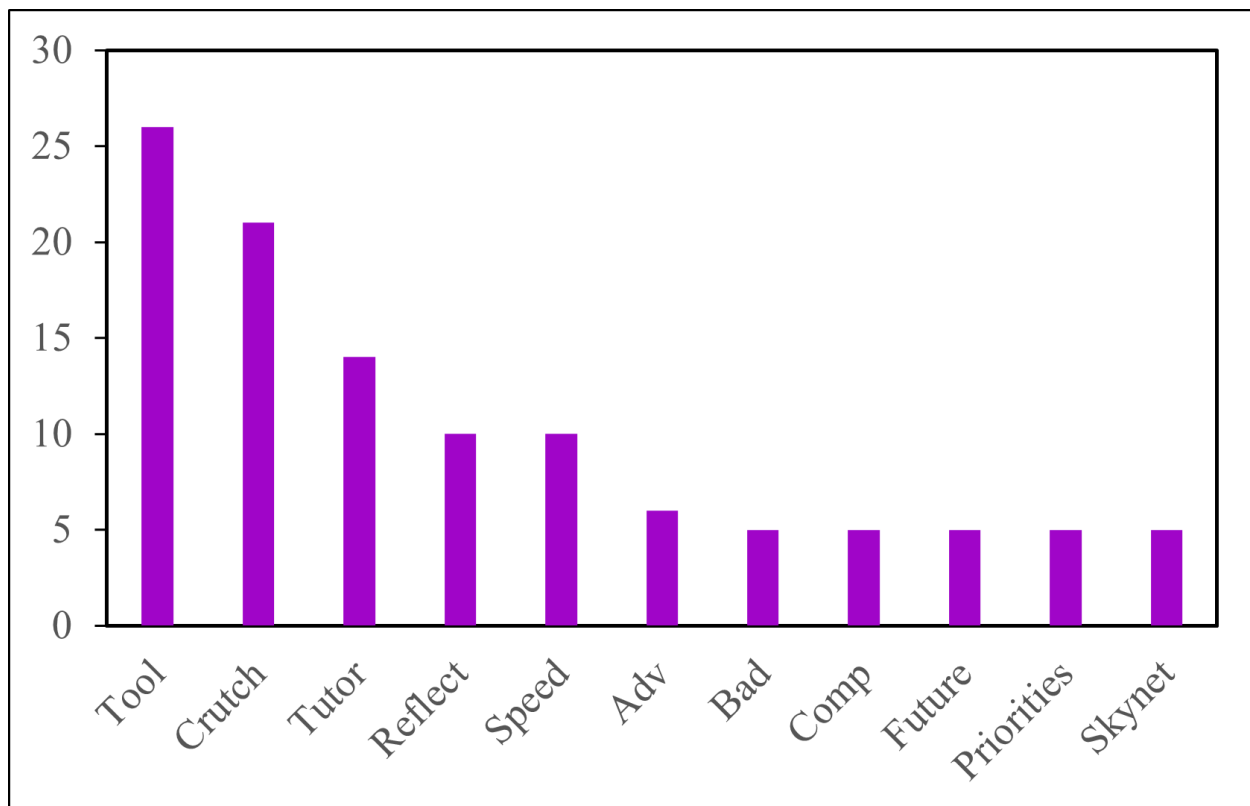
Figure 2: From the survey (N=56), codes measured the sentiment of students toward ChatGPT and AI from their classroom experiences. Each open-ended response could have one code, multiple codes or no codes.

ChatGPT as a learning aid

Many students chose to use ChatGPT throughout the course because they saw it as a useful learning aid. This was clear from the survey responses, where 45% (n = 26) of students' survey responses described the usefulness of ChatGPT as a tool for programming (code: *tool*). While this code identified responses most closely connected to *how* students used ChatGPT (as a tool for troubleshooting, debugging, or error-checking code), it also demonstrates that nearly half of the students saw ChatGPT as a useful tool, and one that they often chose over others. This was common in the assessment responses as well, with many students describing their use of ChatGPT to solve small, specific problems. For example, one student wrote *"I would ask it how to write specific syntax (make arrays that are all zeros, for loops syntax, math modifiers)."*

While the *tool* code captured the way students used ChatGPT for specific tasks during the coding process, 25% of student responses to the survey also described ChatGPT as a learning aid beyond syntax or debugging code (code: *tutor*). These responses also often included elements of personalized help or access to help outside of the available hours for other support tools (professor office hours, peer tutors, etc.). *"...Having a tool to be able to help me when others*

aren't available to help was amazing." As detailed above, these responses included descriptions of how students used ChatGPT in ways that were productive for learning, like seeking line-by-line explanations of code functionality and asking for practice or example problems for specific concepts.

While students described the usefulness of ChatGPT for coding, they also acknowledged that it is possible to rely too much on the tool and undercut one's own learning. The second most common code, *crutch*, was used to tag responses where students described this possibility, either as something that happened to themselves or their peers, or as something they aimed to avoid by limiting their dependence on AI for coding. One student summarized the issue neatly, writing *"However I also think it hindered my learning in a small way because I leaned more towards using ChatGPT rather than making mistakes and figuring things out, which ultimately is how learning works."* This response embodies a view that learning happens through "making mistakes and figuring things out," which was echoed in other responses. Another student wrote, "*I would prefer to do my own work when learning new topics as it would help me grasp the information better,*" describing both a sense of ownership over learning ("do my own work") as well as familiarity with the material as a deciding factor in not relying on ChatGPT.

The assessment data supported these themes as well. Students often described choosing to use AI due to a lack of understanding, either as a tool for syntax support or debugging, as a tutor to review concepts and see example problems, or as a crutch to solve problems for them. That said, students also described choosing *not* to use ChatGPT on the assessments to combat this very issue of overreliance.

ChatGPT as a coding resource specifically

Some students (17%, n = 10) chose to use ChatGPT over other resources for its advantages in time (code: *speed*). One student summarized many facets of this speed in their response, *"Sometimes, when google fails and you're short on time, Chat GPT is a great alternative (though still taken with a grain of salt)."* It was common for students to describe ChatGPT as a powerful, more efficient search engine, or as a faster way to find information than reading through code forums, looking through lecture slides, or reviewing their own notes.

Other responses focused more on the time pressures that students face between school, work, and life as a reason to turn to AI for support. This was especially common in the assessment responses. For instance, one student wrote on the C++ exam,

> *Instead of spending a lot of time working out what small parts I missed, or searching through the slide shows to remember how to work the complicated parts, I used ChatGPT to find the errors and correct them. I didn't intend to use it initially, but as time constraints weighed on me, I gave in.*

This student describes working out details of a problem or looking through slide shows as taking a lot of time and cites time constraints as a force pushing them (seemingly against their will) towards the use of ChatGPT.

The assessment responses revealed some student reasoning for using AI that was distinct from the themes in the survey responses. These reasons to use AI on an assessment included overcoming a language barrier, feeling stuck on a problem, or having trouble getting started with a problem. Student reasoning around using AI when they "got stuck" was one that we found both challenging to characterize as researchers and intriguing as engineering educators. For example, one student wrote on the MATLAB quiz,

> I used chatGPT ALOT this exam and it shocked me how fast I was able to learn things on the go. … _First I did the code on my own, then_ **when I got stuck** _I used chatGPT to check the answer_ and see how I could adapt it to my code; _sometimes it was really bad_ (misinterpreted Cypress walking forward for the x axis and did the whole problem backwards) _but sometimes it was REALLY good_ (cleaned up my plotting syntax for the penguin almost perfectly).

Here they describe using ChatGPT to "check the answer," which resulted in both "really bad" code and "REALLY good" code. In each case, the student was able to describe the exact issue they were having that prompted them to use AI, then explained precisely how the AI interpreted the problem. This serves as evidence that seeing example code prompted deeper thinking of their own code, and potentially that reflecting on their AI use during the assessment also promoted their learning. The student continued,

> **_Sometimes I got really stuck_** _and used it to troubleshoot_ (like when I asked it how to make my vectors the same size for the plotting or how to make my index for a loop not be a negative number). _And almost every few minutes I would ask it how to write specific syntax_ (make arrays that are all zeros, for loops syntax, math modifiers).

In this case, the student describes using ChatGPT more as a coding _tool_ for troubleshooting and syntax, rather than as a tutor for understanding coding concepts. The student concludes,

> I really enjoyed using AI, it felt like _I had a better version of google or a professor_ over my shoulder the whole time who I could ask to get me back on track; although _I still had to be careful_ because many times it was incorrect or not doing what I intended it to do.

The way the student described AI as "a better version of google" or "a professor over my shoulder" is reminiscent of the _speed_ motivation for choosing to use ChatGPT. The stipulation "I still had to be careful" captures the connection between a student asking AI to generate code, and then analyzing that code to understand if it does what is intended using principles familiar to the student.

Some students talked about choosing *not* to use ChatGPT due to its *limitations* as a coding resource, either producing ineffective code (*bad*, 9%, n = 5) or using techniques unfamiliar to or too advanced for the students (*adv*, 9%, n = 5). The assessment responses also included descriptions of students trying to use ChatGPT as a coding resource, but ultimately not using it as they encountered ineffective or overly advanced code. "Bad" code included everything from "slight inaccuracies," to code that returned "incorrect values," to code that "simply did not run due to syntax errors." Some students also described ChatGPT failing to work for MATLAB (though in fact, ChatGPT is able to generate effective MATLAB code).

Overly advanced code, while solving the problem, was described by one student *as "more convoluted/complex than is actually required."* Encountering overly advanced code would sometimes prompt students to engage in behaviors that we characterized as productive for learning. For instance, one student wrote, "*Sometimes it would offer solutions that we hadn't learned about in class, so I had to make sure I was understanding what was and wasn't taught to double check the chatgpt edits.*" Other times, overly advanced code would just turn students away from using AI. For example, a student wrote that it took "*too long to try and decipher ChatGPT's code,*" at which point they turned to *"the slides and [their] old homework submissions instead."* While students valued ChatGPT as a coding resource for its speed, it often came with the caveat that the code produced might be ineffective or incomprehensible, either driving students to abandon the AI or to embrace more productive learning strategies.

ChatGPT as an inevitability

When students reflected on whether or not AI should continue to be allowed in this first year engineering course, they tended to call on two differing perspectives. Some students took the stance that AI *should be allowed* because it is a relevant, useful, or necessary tool for future work and schooling environments (code: *future*, 9%, n = 5). For example, students characterized AI as "*a real tool in the world,*" one that is "*important for students to be familiar with moving forward,*" and something that is becoming "*more prevalent in an increasing number of workplaces.*"

Conversely, other students claimed that AI *can't or shouldn't be banned* because a classroom policy doesn't change people's access to AI (as a reference to the classic, unstoppable Terminator AI, we coded this as *skynet,* 9%, n = 5). When students say, "*I think it is a great learning tool that should be used in the future, especially since students are going to have access to it anyway*" and AI usage is "*hard to control*" and "*isn't going away,*" they are expressing that learning how to use AI is both necessary and unstoppable. Some students anticipated that even if AI were banned as a classroom policy, that wouldn't stop some students from using it: "*it is so easy to access and people will still use it if it's not [allowed].*" Yet another student brought in that it can actually be helpful to use AI, which increases the draw, even against classroom policy: "*I think that whenever someones told that its "banned" yet could provided [sic] useful help to them, there*

will be people that still use it." This willingness to use AI regardless of its status as "allowed" or "cheating" exemplifies the struggle professors have with managing AI in the classroom and demonstrates the inevitability of the technology that students feel. These themes around the inevitability of ChatGPT did not arise in the assessment data, likely due to the nature of the questions as specific and embedded within the exam or quiz.

ChatGPT as a personal perspective

There was evidence throughout the survey responses that students were thinking reflectively about all of the dependencies surrounding their choice to use (or not use) ChatGPT throughout the semester. Students considered how there are many ways to use the tool that might affect their learning, compared their usage and success with AI to their peers, and described balancing their priorities as students.

One common line of thinking was that the effectiveness of ChatGPT for learning or performance in the course depends on how it's being used (code: *reflect,* 18%, n = 10). For instance, one student wrote, "*Even though it's true that some people are just going to make it do all of their assignments, those who really want to learn can take advantage of it.*" There's a sense of inevitability around unproductive uses of AI, but also the possibility of using AI to learn. Another student expanded on this idea, describing using AI *"as a tool to look up for [sic] examples or something like that"* as a productive learning strategy. The student continues,

> *However, if they just use it to copy and paste the answer without understanding the learning concept, it could be affect[ing] the way they learn. If they only want to complete an assignment to get a good grade or pass the class, it could be a bad idea. So I<u>think it depends on the way the student use[s] it</u>.*

Another student connected this reasoning to the question around continuing to allow access to AI in class: "*I feel that if it was not allowed, people would use it without trying to learn from it, <u>it being acknowledged encourages people to use it in a learning way</u>.*" Engineering educators may find this perspective comforting as they make choices about acknowledging or encouraging the use of AI in their own classrooms.

Other students talked about how one's own knowledge of the topic at hand influences the usefulness of ChatGPT. For instance, students noted differences between novice and experienced coders:

> <u>*For someone who has programmed before, it is extremely useful*</u> *because you can pick out pieces here and there and get the correct information you need, but <u>for someone who hasn't [programmed before] it's just going to create a lot more confusion</u>.*

This student identified familiarity with programming as an important factor in being able to make productive use of code generated by AI. One student even wrote, "*I had to learn when to use it and when not to,*" framing when to use AI as a learning outcome of having unfettered access to the tool.

In reflecting on the usefulness of ChatGPT, some students made a rhetorical move to describe how AI might be useful for *other* students (code: *comp*, 9%, n = 5). For example, one student wrote, "*I could see how it could be helpful for students trying to get through a coding assignment when they're not sure where to begin.*" Another student, who didn't view themselves as an AI user, but endorsed it being allowed in class, wrote, "*I still see how it would [be] useful to others.*" These arguments were often in favor of continuing to allow the use of AI in this first year engineering course.

Other students described the ways that others' usage of AI influenced their own decisions to use or not use the tool. One student wrote, *"I definitely was impacted by [my friends'] decisions to use it as they were able to cut down on the time spent on homework assignments while I chose to work through the assignments on my own."* This comparison came down to speed as a deciding factor in favor of using AI. However, the same student continued, "*I saw some of my classmates abuse its capabilities early on and then they struggled later on to code in matlab without it,*" acknowledging the potential to undercut learning as reasoning against using AI.

Some students further ascribed a comparative advantage to those who choose to use AI. One student described AI as a tool that enables students who know how to use it to be more successful than their peers. Another student connected this to a potential classroom ban on AI, writing, "*Banning something that there is little regulatory control over, makes advantages to those that use it regardless, and a disadvange [sic] to those that follow the rules.*" This student positions open access to AI as a matter of equity, as a way to allow the same advantages of using AI for all students. This reasoning also appeared in the assessment data, where students described choosing to use AI to avoid being at a disadvantage compared to their peers who did choose to use it on assessments.

Finally, students' reflective reasoning often included an element of prioritization of learning, which students used to argue both for and against the use of AI (code: *priorities*, 9%, n = 5). This prioritization took on two distinct flavors. Both are summarized neatly in one student's response: "*I might try it now and again in the future to do simple or tedious work that I already understand; however, I would prefer to do my own work when learning new topics as it would help me grasp the information better.*" This student described using AI for "simple or tedious" work that they already understand. What was considered simple or tedious varied across students. For example, one student wrote "*I did use it shamelessly on the ethics quiz because I knew that ChatGPT was pretty good at writing and I didn't feel like studying the ethics stuff*" (we note that this student described greatly enjoying ethics as an in-class discussion activity). Another student also connected writing and the choice to use AI, writing "*i think chat gpt is a helpful learning tool and i don't like writing or typing so it would've been great!*" In the

assessment data, some students talked specifically about not understanding or enjoying coding in MATLAB, which led to them choosing to use AI on the MATLAB assessments.

The other idea invoked by the first student's response, *not* using AI when learning new topics, was echoed by others and reflects the previous findings of AI as both a potential tutor and potential crutch. One student wrote,

> For me I genuinely value the knowledge I gain from my experiences with coding because *it's a skill I want to continue to build on outside of this class* therefore I wanted my work to be completely my own so that any feedback on it would be a reflection of my work only. *Using ChatGPT would diminish that kind of feedback* for me and I wouldn't be able to improve as much as I want to.

This student describes learning to code as a priority in their education, and something they want to continue outside of class. They connect this to feedback, maybe from assignments or assessments, and describe using AI as diminishing that feedback and inhibiting their ability to improve as a programmer. Some students wrote more explicitly about the choice to not use AI specifically on exams for a few different reasons. One student wrote, "*I never wanted to use it on tests or quizzes, because I really enjoy the challenge of these assessments and want to see how much I know/can do without using outside tools/resources.*" This student and others viewed exams as an enjoyable challenge and an opportunity to test their own skills, which the use of AI would take away from.

This was reflected in the assessment data as well. One student wrote that the quiz "is like a puzzle," and others described desiring and enjoying the challenge of an exam. Some said that using AI on an assessment would "takes [sic] away [their] skillset" or defeat the purpose of the test. Others chose not to use the AI on assessments because they didn't feel the need to, either because they were confident in their skills or because they had enough other resources to succeed (slides, past homework, built-in "help" commands, etc.). Students' reflections about their choices to use or not use AI revolved around its potential effects on their learning and performance in the course, comparison to their peers, and priorities as students.

Limitations

This research was done in the second semester of a year-long class. Students had one semester to work on fundamental coding skills and practice. Upon learning the fundamentals, many students felt confident in coding even if they struggled for some part of the first semester. Future research could explore the effect on the first semester, but we have concerns around students who might become reliant if AI is introduced too early in a new coder's education, especially since this specific concern was outlined by students in this study.

As described in the Findings, some students will use ChatGPT or other AI systems to shortcut their education and avoid learning. In our results, this was most prevalent in students who

viewed coding as something unimportant to their future as an engineer or who felt they did not have the skills necessary to complete the assessment effectively. Using AI to replace confidence is a big hurdle pro-AI professors must overcome because we seek to supplement education with AI, not replace learning. On the other hand, banning AI outrightly also has unintended consequences.

In the Fall 2023 term, students were tasked with an asynchronous, open-notes, multi-attempt C++ assessment [16] with explicit instructions to not use ChatGPT and other AI and to not copy answers from the internet (a hedge against websites like Chegg and CourseHero). Despite discussions in class and specific language on the assessment, 20% of students (N=93), used AI on the exam. This experience highlights risk with banning AI services in an asynchronous assessment setting. Some students will use these resources regardless of their acceptability. As a result, we are left with the option to lean into AI as discussed above, return to non-technological exams (i.e. on paper, during class), or adapt our digital assessments to prevent AI from solving them correctly or at all.

Conclusion

When given complete access to generative AI, students used these new tools to both help and hinder their learning. In this study, the majority of students either did not use AI or used it to enhance their learning. About 10% (n = 7) of students showed a reliance that replaced some learning on exams. When asked if access to AI should continue, the majority of students thought AI should be accessible to mimic real world resources, act as a tutor when normal resources are inaccessible, and act as a Grammarly/Spell Check equivalent for coding (fixing small errors and syntax).

Students who chose not to use ChatGPT expressed reasons such as the likelihood of producing code that is ineffective, unfamiliar or too advanced for their level. Other reasons were related to impacts on their learning such as not wanting the use of ChatGPT to deprive them of seeing how much they knew or could do without outside resources or take away from their skillset.

This research demonstrates productive and unproductive uses of ChatGPT by first year students on coding assessments, as well as students' reasoning about why they choose to use (or not use) AI within an introductory engineering course. Future work could continue to characterize productive and unproductive usage of AI by first year students, or by students throughout their academic careers. As AI becomes increasingly prevalent in our daily lives, student proficiency with the tool will likely change, inviting more study. Additionally, research could explore curricular interventions to teach students how to use AI as a learning aid. We are also curious about the long-term impacts of ChatGPT usage on student learning trajectories (e.g. do students that use ChatGPT for coding get hired at the same rate, how do they perform during job interviews, do their stay in engineering and/or computer science fields). Future research could

involve longitudinal studies of students who begin using AI productively (or unproductively) early in their academic careers and how that affects their performance over time. However, there is much still unknown about the role of AI in our future daily professional lives; we want to emphasize the focus on characterizing the nature of students' engagement with AI, rather than evaluating it. One key finding of this study was the potential for ChatGPT to be used productively as a learning aid and as a coding resource. Future work could seek to compare the educational effectiveness of AI against other digital tools and traditional teaching methods.

As AI continues to shape higher education, professors are faced with a choice to embrace this new technology or suppress it. We encourage you to face this fundamental change head on and incorporate AI into your classes!

References

[1] A. Radford, K. Narasimhan, T. Salimans, and I. Sutskever, "Improving Language Understanding by Generative Pre-Training".Blinded for Review

[2] I. L. Alberts *et al.*, "Large language models (LLM) and ChatGPT: what will the impact on nuclear medicine be?," *Eur. J. Nucl. Med. Mol. Imaging*, vol. 50, no. 6, pp. 1549–1552, May 2023, doi: 10.1007/s00259-023-06172-w.

[3] M. Chen *et al.*, "Evaluating Large Language Models Trained on Code." arXiv, Jul. 14, 2021. doi: 10.48550/arXiv.2107.03374.

[4] W. Jiao, W. Wang, J. Huang, X. Wang, S. Shi, and Z. Tu, "Is ChatGPT A Good Translator? Yes With GPT-4 As The Engine." arXiv, Nov. 02, 2023. doi: 10.48550/arXiv.2301.08745.

[5] T. Eloundou, S. Manning, P. Mishkin, and D. Rock, "GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models." arXiv, Aug. 21, 2023. doi: 10.48550/arXiv.2303.10130.

[6] H. Kumar *et al.*, "Exploring The Design of Prompts For Applying GPT-3 based Chatbots: A Mental Wellbeing Case Study on Mechanical Turk." arXiv, Sep. 22, 2022. doi: 10.48550/arXiv.2209.11344.

[7] S. A. Prieto, E. T. Mengiste, and B. García de Soto, "Investigating the Use of ChatGPT for the Scheduling of Construction Projects," *Buildings*, vol. 13, no. 4, Art. no. 4, Apr. 2023, doi: 10.3390/buildings13040857.

[8] M. M. Rahman and Y. Watanobe, "ChatGPT for Education and Research: Opportunities, Threats, and Strategies," *Appl. Sci.*, vol. 13, no. 9, Art. no. 9, 2023.

[9] M.-L. Tsai, C. W. Ong, and C.-L. Chen, "Exploring the use of large language models (LLMs) in chemical engineering education: Building core course problem models with Chat-GPT," *Educ. Chem. Eng.*, vol. 44, pp. 71–95, 2023.

[10] J. V. Pavlik, "Collaborating With ChatGPT: Considering the Implications of Generative Artificial Intelligence for Journalism and Media Education," *Journal. Mass Commun. Educ.*, vol. 78, no. 1, pp. 84–93, Mar. 2023, doi: 10.1177/10776958221149577.

[11] J. Qadir, "Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education," in *2023 IEEE Global Engineering Education Conference (EDUCON)*, May 2023, pp. 1–9. doi: 10.1109/EDUCON54358.2023.10125121.

[12] S. Onal and D. Kulavuz-Onal, "A Cross-Disciplinary Examination of the Instructional Uses of ChatGPT in Higher Education," *J. Educ. Technol. Syst.*, 2023.

[13] M. Irfan, L. Murray, and S. Ali, "Integration of artificial intelligence in academia: A case study of critical Integration of artificial intelligence in academia: A case study of critical teaching and learning in higher education," *GSSR - Glob. Soc. Sci. Rev.*, vol. 8, no. 1, pp. 352–364, 2023, doi: 10.31703/gssr.2023(VIII-I).32.

[14] S. Nikolic *et al.*, "ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity," *Eur. J. Eng. Educ.*, vol. 48, no. 4, pp. 559–614, 2023.

[15] I. Adeshola and A. P. Adepoju, "The opportunities and challenges of ChatGPT in education," *Interact. Learn. Environ.*, 2023.

[16] D. Davis and C. Winston, "Decreasing Student Stress Through Multi-Attempt Digital Engineering Assessments with Rotating Questions," presented at the ASEE Annual Conference & Exposition, 2022, p. 15.

Appendix

Appendix A: Full codebook for survey responses, including the code, short definition, clarifications, and one representative example.

Code	Short Definition	Clarifications	Example
(future)	AI is a necessary future skill.	A response that indicates that the student believes ChatGPT is a relevant, useful, or necessary skill in future work and schooling environments.	"I believe this resource should remain open to students in the future, especially as it becomes more prevalent in an increasing number of workplaces."
(tutor)	AI can be used to learn a specific concept.	A response that describes how a student used AI to learn coding concepts (more than just debugging or syntax). These responses also often included elements of personalization or accessing help outside of hours for other support tools (office hours, tutors, etc.).	"This option made me feel like I had more support in learning because I could get professor-level help at any time, even if I'm doing work outside of professor or [makerspace] hours."
(tool)	AI is a useful tool for students.	A response with explicit use of the word "tool." A response where the student acknowledges the usefulness of AI for troubleshooting, verifying syntax, debugging, and error-checking code.	"I think it was a good tool."
(comp)	Comparative description of AI use.	A response where the student acknowledges how ChatGPT might be useful for others. A response where students describe other's use (or not) of AI influencing their own choice to use (or not use) AI. A response that includes a description of comparative advantage for students who do use AI.	"I definitely was impacted by [my friends] decisions to use it as they were able to cut down on the time spent on homework assignments while I chose to work through the assignments on my own .... I saw some of my classmates abuse its capabilities early on and then they struggled later on to code in matlab without it."
(skynet)	AI can't or shouldn't be banned because that will not change access to it.	A response describing AI as inevitable, as impossible to ban, hard to control/monitor, or as something that people will have access to regardless of a classroom policy.	"I can definitely say for certain that it isn't going away though, so accepting that students will continue to use it rather than trying to avoid it entirely seems to be the right call."

(reflect)	AI can help or hinder learning depending on who uses it and how.	A response that shows reflective thinking about the students' use of AI in learning. This also includes the idea that the effectiveness of ChatGPT is dependent on how it is used, and (for coding specifically) whether you are a new or experienced coder.	"For someone who has programmed before, it is extremely useful because you can pick out pieces here and there and get the correct information you need, but for someone who hasn't it's just going to create a lot more confusion."
(bad)	Code generated by AI is bad/not useful/incorrect.	A response where a student indicates that code generated by AI is not effective or does not work as intended.	"I used it once or twice for matlab code, and the code it gave me was not correct. It either returned incorrect values, or simply did not run due to syntax errors. "
(adv)	Code generated by AI is too advanced.	A response where a student indicates that code generated by AI is too advanced for the student or uses techniques not discussed in class.	"Although the code that ChatGPT provides may serve its purpose, it's often more convoluted/complex than is actually required."
(speed)	A benefit of AI is its speed.	A response where a student indicates that using ChatGPT is faster than other options. This also includes explicit mention of using AI as a replacement for a search engine (Google) or a connection between being pressed for time and choosing to use AI for support.	"Sometimes, when google fails and you're short on time, Chat GPT is a great alternative (though still taken with a grain of salt)."
(priorities)	Use (or not use) of AI is related to priorities.	A students' learning priorities dictate their described use (or not use) of AI for learning. This could look like choosing to use AI because the student is uninterested or not confident in a topic, or not using AI because the student wants to learn the topic on their own.	"I might try it now and again in the future to do simple or tedious work that I already understand; however, I would prefer to do my own work when learning new topics as it would help me grasp the information better."

| (crutch) | AI has the potential to replace learning. | A response that describes how AI can be used to undercut or replace learning. Also includes responses with a rationale for when AI might be used more heavily (instead of other resources). Many of these responses also indicated that the student thought more complete learning happens through conversation with others or through figuring something out on your own. | "However I also think it hindered my learning in a small way because I leaned more towards using ChatGPT rather than making mistakes and figuring things out, which ultimately is how learning works." |