RFE EAGER: Exploring Cultural Nuances in Student Use and Adoption of Generative AI Tools in Engineering Education: An Overview of Initial Findings and Directions for Future Work

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Dr. Cassandra McCall is an Assistant Professor in the Engineering Education Department at Utah State University (USU). Her research focuses on the intersections of disability, identity formation, and culture and uses anti-ableist approaches to enhance universal access for students with disabilities in STEM, particularly in engineering. At USU, she serves as the Co-Director of the Institute for Interdisciplinary Transition Services. In 2024, Dr. McCall received a National Science Foundation CAREER grant to identify systemic opportunities for increasing the participation of people with disabilities in engineering. Her award-winning publications have been recognized by leading engineering education research journals at both national and international levels. Dr. McCall has led several workshops promoting the inclusion of people with disabilities and other minoritized groups in STEM. She holds B.S. and M.S. degrees in civil engineering with a structural engineering emphasis.

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Daniel Kane is a third-year Ph.D. student in the department of engineering education at Utah State University. His research interests include spatial ability, accessibility for students with disabilities, artificial intelligence in education, and enhancing electric vehicle charging system infrastructure. Daniel has contributed significantly to the development of the Tactile Mental Cutting Test (TMCT) which is a significant advancement in assessing spatial ability for blind and low-vision populations. His research has helped inform teaching methods and develop strategies for improving STEM education accessibility. Currently, he is studying how AI tools are utilized by students across USU's colleges to optimize their educational value. Daniel has also served as president of the ASEE student chapter at USU where he initiated outreach activities at local K-12 schools and promoted student engagement in research.

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Michaela Harper is a doctoral student at Utah State University, pursuing a Ph.D. in Engineering Education. She holds a Bachelor's degree in Environmental Studies, focusing on STEM and non-traditional education approaches, and a Master's degree in Engineering Education, where she explored faculty perspectives on Generative Artificial Intelligence (GAI). Michaela's current research delves deeply into the effects of disruptive technologies on engineering education, driven by her passion for uncovering the foundational nature of phenomena and applying an exploratory and explanatory approach to her studies. Her work aims to illuminate how technological advancements reshape educational landscapes through student and faculty engagement.

Dr. Wade H Goodridge, Utah State University

Wade Goodridge is a tenured Associate Professor in the Department of Engineering Education at Utah State University. His research often has a focus on what drives us to learn, how we learn and how well we do it, and what can improve that learning. This work is often directed with a spatial thinking emphasis. Dr. Goodridge has investigated different learning modalities (fully online, hybrid, blended courses), cognitive and metacognitive learning processes (self-regulation, engineering problems solving, neural efficiency in engineering problem solving) learning motivators (engineering self-efficacy), and effective and personalized engineering education interventions (tactile engineering curriculum, physical

teaching models, XR environments and AI informed systems of delivering and monitoring engineering learning). Dr. Goodridge has created a valid and reliable instrument to assess spatial ability in blind and low vision (BLV) learners thus opening new areas of research centered on tactile spatial ability. He has created tactile and visual learning tools and has offered professional development experiences on how to improve the education of tomorrows engineers.

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Dr. Oenardi Lawanto is a professor in the Department of Engineering Education at Utah State University, USA. He received his B.S.E.E. from Iowa State University, his M.S.E.E. from the University of Dayton, and his Ph.D. from the University of Illinois at Urbana-Champaign. Dr. Lawanto has a combination of expertise in engineering and education and has more than 30 and 14 years of experience teaching engineering and cognitive-related topics courses for his doctoral students, respectively. He also has extensive experience in working collaboratively with several universities in Asia, the World Bank Institute, and USAID to design and conduct workshops promoting active-learning and life-long learning that is sustainable and scalable. Dr. Lawanto's research interests include cognition, learning, and instruction, and online learning.

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Abstract

Advances in AI technologies are gaining increasing attention from university administrators, teachers, and students as they become more ubiquitous in higher education. Key concerns associated with increased adoption include impacts on students' overall learning outcomes and academic integrity. This NSF EAGER project seeks to explore the evolution of students' perceptions and use of AI tools during their engineering programs. Specifically, this project employs a mixed methods design to capture students' perspectives on AI tools, including their frequency of use, reasons for use, and approaches to use. Quantitative data for this study were collected through a university-wide survey distributed to all undergraduate and graduate students (n = 1679 total respondents) at a large land-grant university in the western US. Qualitative data is currently being collected via semi-structured interviews with engineering students (n = 21).

Findings to date have uncovered interesting and nuanced insights into how and why students choose or choose not to adopt or not adopt Generative AI tools, such as ChatGPT, into their educational workflows. These insights lay the foundation for further work examining the existing culture of engineering education and how it shapes students' current use and adoption of Generative AI tools, as the technology – and our knowledge of it – continues to evolve. Lastly, we highlight challenges related to conducting this work due to rapidly changing public perceptions of Generative AI at the methodological level.

Introduction

Since its release in November 2022, Chat Generative Pre-trained Transformer (ChatGPT) has attracted significant global attention and debate due to its dialogic power, intuitive interface, and widespread availability as an open-source application [1]. While the full impacts of ChatGPT, as well as other generative artificial intelligence (GAI) applications, on education are unknown, scholars have demonstrated its potential to significantly alter and disrupt the established practices and paradigms that guide contemporary teaching and learning praxis [1], [2]. Proponents of GAI tools suggest that this technology can – and should – be leveraged as a powerful aid to make learning more engaging and personalized [3], [4]. Others argue that the adoption of the AI tools has already become ubiquitous to industry workflows, shifting conversations from a student-centered focus (i.e., impacts on learning) to an industry-centered focus (i.e., a skill that needs to be obtained for workforce preparation) as evidenced by recent adoptions of AI degree requirements in university engineering curricula.

In the field of engineering education, prior research has focused on gaining deeper insights into how the technology functions e.g., [5], [6] and gathering instructor and faculty reactions to its use. However, little work has focused on understanding why and how undergraduate students engage with GAI to learn engineering content. One exception to this statement is a recent mixed-methods study by Bonsu and Baffour-Koduah [7] who examined students' perceptions and intentions to use GAIs, such as ChatGPT; however, this study was conducted outside of the US context and did not include engineering. Gaining this insight is critical for harnessing the capabilities of disruptive technologies in US engineering education programs because students may engage with them for a variety of reasons (e.g., feeling pressured to quickly meet an assignment deadline, check understanding of concepts, desiring to be on equitable ground with peers who use it, etc.) that can inform pedagogical, curriculum, and assessment design.

To this end, this EAGER project utilizes an explanatory sequential mixed methods design to explore student perceptions and use of AI tools while in their engineering programs. Specifically, our work is guided by two research questions: (1) why do undergraduate students choose or choose not to engage with generative artificial intelligence (GAI) tools; and (2) how do undergraduate engineering students perceive and utilize advancing GAI tools to assist their learning? For this paper, we focus our discussion on the emergent findings from the qualitative phase of this study as well as identify key challenges related to conducting this work during rapid technological evolution and changing public perceptions. We conclude this paper by highlighting implications for the engineering education research community and plans for future work.

Theoretical Framing

The qualitative portion of this work is informed by Engeström's [8] activity theory (shown in Figure 1) to analyze student use of GAI. Through this lens, student use of these technologies is the activity system in which the meanings and potentials of disruptive technologies are not dictated by their design, but rather by how they are applied by their users [2], [8]. Activity theory has been proven to be a particularly valuable framework for examining the use of disruptive technologies among higher education students [2]. In the context of this work, activity theory provides a particularly useful frame for examining the sociotechnical system of engineering education in which students' decisions to use or to avoid GAI use due to a variety of factors including rules, social and professional norms and hierarchies, and outcomes (i.e., goals).

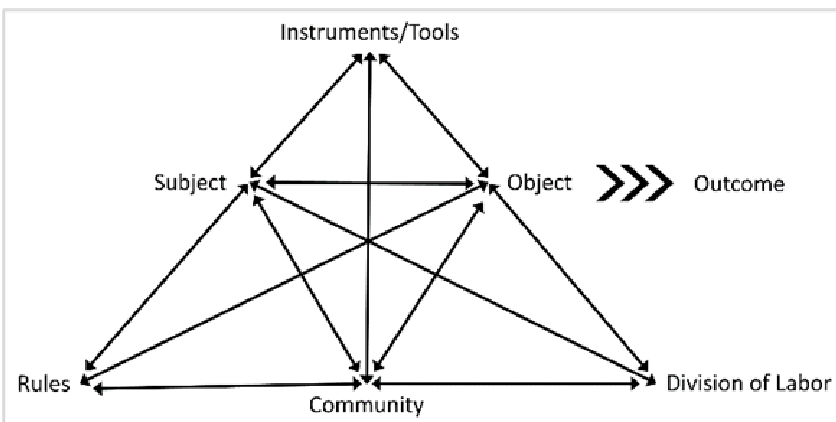

Figure 1: Engeström's Activity Theory (adapted from [8])

Prior Work: Summary of Quantitative Research Phase

Participants for this study were undergraduate students in the College of Engineering consisting of four departments at the undergraduate level: (1) Biological Engineering, (2) Civil and Environmental Engineering, (3) Electrical and Computer Engineering, and (4) Mechanical and Aerospace Engineering. The survey incorporated items focused on AI technology reuse intention [9] , perceptions of AI's impact on career development [10], and learning strategies [11].

Overall, the AI use was about two thirds for all engineering students (see Figure 2 for frequencies). The survey further questioned students who reported no prior AI use about intent for future use, these results are shown in Figure 3.

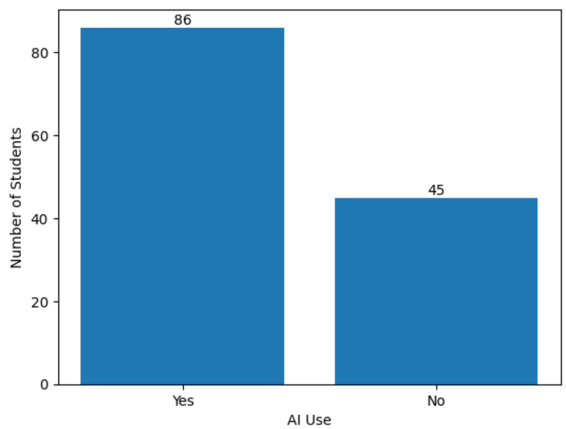

Figure 2: Reported AI use among engineering students

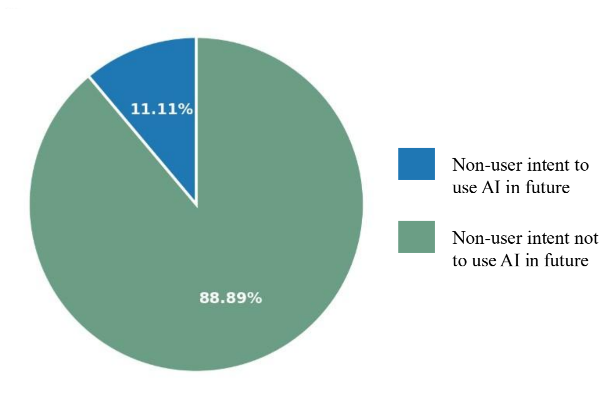

Figure 3: Use intent among students who have not yet used AI

Current Work: Ongoing Qualitative Research Phase

This portion of the study consisted of interviews conducted with 21 undergraduate engineering students during the Fall 2024 and Spring 2025 academic semesters. Interviews lasted about 1 hour, and questions were asked about the benefits and challenges they experienced using AI tools.

Emergent Findings: Factors Influencing Student GAI Use

Initial analysis of participant interviews highlighted three factors that influenced students' use of GAI to facilitate their learning. These factors include: (1) the academic level at which the student is working, (2) the nature of the learning task, and (3) the availability of support personnel such as faculty and teaching assistants. A key example of these factors and how they influence one another comes from an interview with M, who is an upper-level mechanical engineering student:

Interviewer:	What is the most important thing that you can get out of your learning?
M:	Out of my learning, I would say, is the kind of problem-solving process that engineers in any discipline have to kind of excel at. Like intuition, knowing where to look for things, knowing how to make connections. Stuff like that.
Interviewer:	Do you feel like GAI has played a role in your education and developing these skills that you mentioned?
M:	No. I think that it would be detrimental for me to try to use it to problem-solve. Yeah, like it's, it's played a role in my college

education. I have used it for certain things, but none of the like, fundamental things that an engineer should do.

Interviewer: So how do you pick what you use GAI for and what you don't use GAI for?

M: If it's like a menial task like, if I have to, like, I'll use it to summarize a—What are they called, not reports?—papers, research papers that I have to read, before I read it so that I know kind of what I'm getting into. So, it's quicker, and I get more of it. And I've done the same, sort of, with lectures. Like, what part of this giant set of lecture slides has to do with this problem? Instead of scrolling 160 slides to get to, kind of, what I need to look for.

Through this exchange, M identifies uses the terms "intuition" juxtaposed with the term "menial" to delineate the tasks that he views as suitable for GAI use. Drawing from activity theory, we designate these factors as distinguishing between *person work* and *tool work* under the *division of labor* category. Person work captures those tasks that participants view as too complex or above the capabilities of GAI, particularly its limitations surrounding "gut feeling" and human judgement. In contrast, tool work captures tasks that participants view as "menial" or redundant – tasks that they may perceive as not as useful or beneficial for their academic goals.

David (pseudonym), another mechanical engineering student, alludes to a similar comparison, explaining that the GAI he uses cannot easily assist him with homework help because the course content is too complex:

> Yeah. So, one of the main things I found is that at the level that I'm at, AI is usually wrong. Or, if you, you know, throw in a specific problem like, what's the heat loss of this? It will generate a bunch of stuff. If you look at it, you're like, "okay, okay, okay." But then, you look at it closer, and it's, "Okay, none of this makes any sense." [. . .] But you have to—you can't just give it a whole problem and work through. You have to break down the problem that you have into steps and be, "Okay, I'm at this step. What is an equation? Or where would I go to work on this step?" Then it can give helpful information on that and can give you ideas on things to try within that problem.

In his response, David also brings in the third factor that influences students' decisions to utilize GAI in their learning: the availability of timely resources and support when needed. Like many students utilizing GAI, David tends to use it as a temporary tutor – something that he can consult while doing homework. This can be particularly helpful for students, especially when they are working on assignments outside of standard office hours or help session offerings.

> How that affects learning how to learn. I think it benefits me, because, you know, professors and TAs aren't always there or available to respond to an email, "Hey, what do I do at this step?" Whereas AI, I can say, "what do I do with this step?" and it gives me some ideas to work on. [. . .] I find that if you understand the topic well enough to know whether or not it's accurate, it's helpful. If you're so lost that

> you're trying to rely on it to do the whole problem, it's not helpful, because you can't distinguish whether it's right or wrong.

Together, these qualitative insights partially explain a trend observed in the quantitative phase of the mixed methods study highlighting that freshman (or first year) engineering students were less likely to have used GAI technologies than those later in their college careers; students closest to entering the workforce report having more exposure to these technologies [12].

Study Limitations

Challenges Studying a Rapidly Evolving Technology. One of the key challenges experienced by the research team while conducting this work has been the rapidly evolving nature of GAI technologies and public perceptions and use of these tools. While the interview protocol was conceptualized in early Fall 2024, we are finding that, approximately one year later, some of the questions already feel outdated and archaic. At the same time, the mystique surrounding GAIs that was once present is diminishing, as evidenced by students' recognition that their coursework is too complex for GAI to work through without significant prompting. These realizations are beginning to shift the perception of GAIs as a tool that can think for you to one that can simply help with more mundane tasks – similar to the role of a calculator doing arithmetic.

Self-Selection Bias. As we have engaged in qualitative data collection, we have realized that self-selection bias may be occurring in that survey respondents who had not used AI tools and who identified as not intending to use GAIs in their coursework (or other applications) did not volunteer to participate in an interview. As a research team, we are working to investigate if this is because these participants felt as though they could not contribute in valuable ways to the research study or if they genuinely were not interested in participating in an interview. In future work, we will attempt to address this further.

Conclusions and Future Work

These insights lay the foundation for more work examining the existing culture of engineering education and how it shapes students' current use and adoption of GAI tools and as the technology – and our knowledge of it – continues to evolve. While we have identified three factors used by students to determine GAI use and how those decisions are made, future work will continue to examine other influences related to the activity theory framework that shape these decisions. For example, we anticipate that academic policy, whether institution-based or instructor-based, as well as norms of the engineering profession, may influence these decisions. These insights can then be used to further scaffold training for GAI use and allow educators to articulate the role of GAI in the learning process.

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