Research in Engineering Education Symposium (REES)
Regional Conference in Engineering Education (RCEE)
& Research in Higher Education (RHEd)
September 29 – October 3, 2025
Johor, Malaysia

Generative AI in Engineering Design: Implications for Teaching and Learning from Seasoned Instructors

Justin Heiss, Robert Loweth and Udeme Idem
Purdue University, United States
jhess@purdue.edu

ABSTRACT

BACKGROUND & CONTEXT

There has been much interest in Generative AI (GenAI) use throughout higher education, including engineering education. While understandings of appropriate GenAI use in this context are emerging, there are limited understandings of the strengths and weaknesses of GenAI use to support student learning and growth in engineering curricular contexts.

PURPOSE OR GOAL

We investigated how experienced engineering instructors viewed GenAI usage in design teaching. We addressed the question: "How do views of and experiences with GenAI vary across engineering design instructors?" Building from findings, we sought to identify instructional considerations for leveraging GenAI in design education.

APPROACH OR METHODOLOGY

We selected three interview participants from a sample of 17 engineering design instructors who represented a range of views on GenAI use. We identified strengths, weaknesses, opportunities, and threats of GenAI as perceived by each participant and then used thematic analysis to generate semantic themes for individuals and latent themes across participants.

OUTCOMES

Participants described how GenAI can speed up and democratize innovation and act as a collaborator to supercharge abilities but also risks eroding students' critical thinking if over-used. Across participants, we identified three latent themes, such as the productive tension that GenAI can both facilitate idea generation and facilitate knowledge theft.

CONCLUSIONS

GenAI is impacting many facets engineering design teaching and learning in higher education, presenting both opportunities and threats. Instructors can build from the productive tensions and pedagogical suggestions we identified in this study to leverage GenAI in design education to minimize threats while catalyzing opportunities.

KEYWORDS

Generative AI, Engineering Design, Qualitative Analysis.

Introduction

Generative AI (GenAI) use is increasing throughout higher education, accompanied by concerns about societal impacts and academic dishonesty (Hashmi & Bal, 2024). Batista et al. (2024) note that "students, teachers, and researchers consider this technology as a valuable support for their work" as it can "enhance student support, improve teaching efficiency, and facilitate research activities" (p. 24). However, these advantages are tempered by risks pertaining to academic integrity and responsible use, students' educational development, and uncertainty regarding what constitutes human versus AI-generated content and associated plagiarism or related concerns (Batista et al., 2024).

In response to the emergence of GenAI, scholars named strategies for "preparing students for the AI-augmented future" (Hashmi & Bal, 2024, p. 609). Hashmi and Bal (2024) suggested that learners must evolve to "Learners 2.0" to better "understand the ethical implications and functioning of AI" and "use it as a tool to assist and enhance human capabilities, understanding strengths and limitations" (p. 610). Such learners use GenAI while exhibiting transparent and responsible use, and instructors need approaches to promoting the formation of such learners.

While scholars are exploring how best to leverage GenAI in higher education, we still have limited understanding of the strengths and weaknesses of GenAI use, including how these strengths and weaknesses vary by instructional contexts. Thus, in this study, we aim to develop a context-specific understanding of GenAI by addressing the question, "How do views of and experiences with GenAI vary across engineering design instructors?"

Background: GenAI use in higher education

Scholars have highlighted advantages and disadvantages of GenAI use in higher education. For example, GenAI can support inclusive education by offering personalized feedback to learners, adaptive content and language support (Ahmed et al., 2024; Aldreabi et al., 2025; Farrelly & Baker, 2023; Kumar et al., 2024). GenAI can also assist teachers to transform course learning outcomes, pedagogy, and assessment to prepare students for future employment, promote interdisciplinarity, or make learning experiences more student-centred (Al-Samarraie et al., 2024; Chiu, 2024; Farrelly & Baker, 2023; Kumar et al., 2024). However, concerns around GenAI use include academic integrity issues (Ahmed et al., 2024; Aldreabi et al., 2025; Kumar et al., 2024), the replication of bias (Ferrara, 2023), equity issues (Aldreabi et al., 2025; Farrelly & Baker, 2023), and cost barriers (Aldreabi et al., 2025).

Given the possibilities and concerns of GenAI usage, authors suggest that instructors need to proactively address ethical and privacy issues (Aldreabi et al., 2025; Farrelly & Baker, 2023) and biases (Al-Samarraie et al., 2024) through purposeful integration (Chan & Tsi, 2024). It is especially important to *not* lose sight of the human components of teaching and learning. For example, while GenAI can potentially make learning more inclusive and efficient, human teachers possess unique qualities that cannot be replicated by GenAI use (Chan & Tsi, 2024). Further, given the nascency of GenAI and the recognition that students may use GenAI in productive ways that institutions can fail to recognize, Jensen et al. (2024) advocated for elevating the role of student voice when discerning how to use GenAI in higher education.

Strengths and weaknesses of GenAI may vary by learning context, and instructors and learners must adapt their approaches to GenAI use accordingly (Ali et al., 2025; Gonsalves, 2025). Engineering design instructors have already begun using, testing, and sharing their uses of GenAI (e.g., Ali et al., 2025; Chacko, 2024), but studies thus far provide limited insight on how curricular context relates to the transferability of findings. For example, how instructors prompt students to use GenAI in introductory coding courses may differ from engineering design courses due to differences in course objectives and GenAI's capabilities. This variation suggests a need to focus on how GenAI is used in distinct engineering educational contexts.

In sum, GenAI presents both challenges and opportunities for higher education, including in the context of design teaching and learning. A balanced approach to addressing AI literacy

https://doi.org/10.52202/086293-0015

and ethical considerations is crucial for ensuring equitable access and positive outcomes for all students (Farrelly & Baker, 2023), but we need a better understanding of context-specific pedagogical needs and strategies for integrating GenAI in engineering design teaching. To begin developing such understandings, we explored the perspectives and experiences of GenAI instructors who have used GenAI in a variety of engineering design teaching contexts.

Methodology

Research Questions and Study Overview

We approached this study from an exploratory, qualitative research paradigm. Exploratory research follows an inductive line of reasoning and seeks to characterize phenomena as they were observed by the researcher to identify initial concepts and relationships to be refined in future research (Foster, 2024). This preliminary study explored interview responses collected from experienced design instructors about their experiences with GenAI. From interviews, we sought to understand the contents and contexts of participant perspectives. The contents of instructor perspectives are relevant for suggesting curricular adaptations to GenAI, while instructor context provides important nuance related to the transferability of these adaptations.

Data Collection

This study used a subset of data from a larger exploration of engineering design instructors' experiences with GenAI. In this larger exploration, we recruited participants through a screening survey distributed to the email list-serv of multiple professional societies. Our survey collected information on prospective participants' design teaching experiences, their self-rated familiarity and skill level with using GenAI, and basic demographic information. We used this information to select 17 instructors to participate in 90-minute interviews, prioritizing respondents who indicated high levels of familiarity and skill in using GenAI while maintaining diversity in our participant sample related to gender and racial identities and institutional context. During interviews, we asked participants to share their experiences teaching engineering design, how they use GenAI in their teaching, and their evaluation of the strengths, weaknesses, opportunities, and threats of using GenAI in engineering design curriculum.

Participant Selection

This study focuses on the experiences of three pseudonymous participants: Angie, Alvin, and Elizabeth. Our selection criteria for these three participants were: (1) High self-rating for GenAI familiarity and skill, (2) Substantial experience teaching design, (3) Diversity of teaching contexts, and (4) Diversity of views related to GenAI. We evaluated the first three criteria based on our screening survey, with Angie and Alvin both strongly meeting these three criteria. We evaluated our fourth criteria through an initial read of participant interview transcripts and preliminary memos describing participant perspectives. We selected Elizabeth for inclusion because she strongly met criteria four and, we felt, under-reported her level of expertise.

Data Analysis

We used thematic analysis (Braun & Clarke, 2006) to characterize the views and experiences of Angie, Alvin, and Elizabeth. We first generated initial codes systematically across the three interview transcripts. We inductively identified excerpts where participants described their GenAI views and their teaching practices related to GenAI. In alignment with our interview protocol, we identified strengths, weaknesses, opportunities, and threats described by each. Following this first coding cycle, we developed themes that captured relationships between coded excerpts. For example, we observed that Angie would describe GenAI weaknesses but then discuss teaching strategies that she used to address those weaknesses. We captured this relationship between GenAI weaknesses and teaching practices as the theme "*students must be taught how to use GenAI effectively given its weaknesses*." We first prioritized semantic themes, or themes that mirrored specific wording in participants' interview excerpts. Next, we developed a limited number of latent themes that captured implicit relationships

between codes or participants. For example, Angie described role-play capability as a strength of GenAI but later mentioned potential for discrimination as a threat of GenAI. While Angie did not explicitly connect these two ideas herself, we felt the juxtaposition of these codes produced an important tension that we described as "*GenAI is a powerful tool for helping students plan by simulating perspectives and scenarios but can also serve as a vector for transmitting discriminatory biases.*" Each author coded one interview transcript individually, and we then collectively developed themes through discussion and review with the other two authors.

Researcher Motivation

As discussed by Braun and Clarke (2006), a crucial component of trustworthiness in thematic analysis is that the researchers transparently describe their research motivation and relation to the subject matter. We initiated this research project following our own experiments integrating GenAI tools into our design courses. We encountered limited guidance around recommended practices for GenAI use beyond basic prompt engineering techniques; thus, our goal in interviewing engineering design instructors was to develop general recommendations that accounted for curricular context. Our own familiarity with GenAI influenced how we identified themes from participant interviews. Collectively, we believe that GenAI can be a powerful tool to support students, but we are aware of many legitimate issues associated with GenAI. Accordingly, we included "Diversity of views related to GenAI" as a participant selection criterion to develop a balanced portrayal of GenAI's possibilities and threats.

Research Validity

We operated in an interpretivist paradigm. Research validity in this paradigm is marked by rich, thick description of participant perspectives grounded in their own words; procedural alignment between methods, findings, and conclusions; and relevance to other contexts and broader literature (Tracy, 2010; Walther et al., 2017). For rich description, we organized our findings into profiles that introduce the context of each participant. We supported each theme with block quotes to illustrate participant perspectives as completely as possible. We provided tables of strengths, weaknesses, opportunities and threats for each participant for greater transparency. For procedural alignment, we aimed to examine perspectives in sufficient depth to illuminate nuances within and across perspectives. Such nuances provide crucial context that is relevant to understanding transferability of findings. To ensure findings resonated with participants, we shared this report with all three member checks and solicited their feedback for accuracy and to identify potential anonymity or privacy concerns. Lastly, related to relevance, we identified more themes than we could report. We curated our findings to emphasize themes that related to other literature and that were transferable, at minimum, to our own teaching experiences.

Findings

Profile 1: Angie

Angie (she/they) has over 20 years of experience teaching engineering design. Her department, in which she is a leading faculty member, emphasizes co-op experiences and real-world projects as foundational components of engineering learning. One of Angie's research interests is how higher education responds to societal shifts, such as the advent of GenAI. Angie encourages her students to use GenAI tools such as ChatGPT and CoPilot to support their design projects and provides prompt engineering resources so that students use GenAI tools effectively. Angie uses these curricular experiences to illustrate the ethics of GenAI use for students and to prepare them for their future work. As Angie described:

> *We consistently approach AI as a tool. Just like your calculator is a tool, your smartphone is a tool, SOLIDWORKS is a tool, AI is a tool. We talk explicitly about, "What are the ethics of using this tool? How can you use this tool, so it actually helps you?" One example we give is if you're a PE [professional engineer] and you've got some junior engineers who are doing work that is coming to you to put your PE stamp on, you wouldn't just automatically accept it. You would… make sure that putting your name on it is appropriate. You have to do the same thing with AI.*

https://doi.org/10.52202/086293-0015

Table 1 summarizes Angie's SWOT responses. One key theme from Angie's interview, related to opportunities, was that GenAI can speed up and democratize innovation. In her words:

> *If you look at the Star Trek movies and TV shows where they have AIs that are making it able for people to really slingshot forward and push the bounds of what we're able to create, there's huge opportunities with AI to be able to do that. There're huge opportunities with AI to make this all more accessible, bringing a broader set of participants into what we're doing.*

Table 1: Summary of Angie's SWOT Responses

Strengths	**Weaknesses**
• Modify text to suit different audiences. • Aid effective planning by simulating conversations and scenarios. • Support case study implementation by simulating multiple different identities. • Generate examples that are beyond the prompter's immediate expertise.	• GenAI doesn't create, it predicts. • Lack of critical thinking, particularly regarding whose ideas or perspectives are embedded in AI responses. • Over-reliance on GenAI. • Inhibition of students' innovative potential. • Lack of GenAI output fact-checking or validation.
Opportunities	**Threats**
• Innovate and iterate faster. • Democratize access to designing or education. • Discover elements of the hidden curriculum. • Expose engineers to a broader set of perspectives.	• Ownership of data input into GenAI models, specifically by for-profit companies or foreign governments. • Discrimination against real people due to biases in AI training data. • Transmission of AI biases to the prompter.

Angie described many weaknesses of GenAI, coupled with actionable solutions to these weaknesses. To take advantage of GenAI's opportunities, Angie suggested that students must be taught how to use GenAI effectively given its weaknesses. For Angie, GenAI was only a predictive language generator, and potential weaknesses included students' failing to verify GenAI outputs or overly relying on GenAI to produce new ideas. As in the case with other engineering tools, Angie suggested that GenAI's weaknesses provide opportunities for teachable moments that students must develop an awareness of and reflexive response to:

> *I'm trying to get [students] to create an intuition that they will catch [clearly erroneous answers] before they move it forward. That, 'hey, wait a minute, this doesn't make sense… Is this truly solving the root cause of the problem?'*

We identified a tension between the strengths and threats of GenAI identified by Angie: GenAI is a powerful tool for helping students plan by simulating perspectives and scenarios but can also serve as a vector for transmitting discriminatory biases. For instance, in discussing strengths, Angie stated that:

> *One of the huge strengths is the ability of the AI to take on different identities. I can ask it to be a client [or] a project manager. I can ask it to be from a particular industry or a particular discipline of engineering and respond to the same situation, but from multiple identities.*

Despite these opportunities, when discussing threats, Angie described cases where issues with the training data lead to discriminatory outcomes. As an example, she referenced a situation where Amazon trained an AI to screen applications from managerial candidates, with the result being that the AI rejected all women candidates immediately because its training set was based on the resumes of current managers that were mostly men. As Angie concluded:

> *There're choices being made by whoever is creating and training the particular model. And if we don't understand the implications of those [choices] then we may fall victim to interpretations, to limitations, and to biases without realizing that they're there.*

Thus, for Angie, students and instructors should always critically evaluate the information generated by GenAI to protect against possible discriminatory or biased AI outputs. This is critical for Angie because such biases can be harder to recognize than simple factual errors.

Profile 2: Alvin

Alvin (he/him) has nearly 20 years of experience teaching design to engineering students. He is both a coordinator of first-year courses and an instructor of these courses. The first semester course at Alvin's university introduces students to engineering design with instructors choosing the topical focus (Alvin's focus is robotics). Building on his teaching, Alvin's research explores how to leverage educational technologies in engineering education, including the development and testing of AI systems for teaching and learning. He frames this part of his research as "learning about AI and learning with AI" and then bringing those learnings into his own teaching practices. Alvin sees GenAI as a powerful tool. As he shared:

> *There's huge power in this new technology. And so I'm super interested then in the impact that that has on both us understanding it, so what are the educational trajectories that help us wrap our heads around what is GenAI as a subfield of AI? […] How can I use this now crazy powerful hammer to, what nails can I hit with it? And what benefits does that get to me?*

Table 2 summarizes Alvin's SWOT responses. Alvin emphasized one strength throughout his interview: GenAI can act as a collaborator to supercharge abilities. As Alvin shared, "I love the idea that the GenAI can be another teammate and a collaborator in that [teaching or learning] process and can bring something to the table."

Table 2: Summary of Alvin's SWOT Responses

Strengths	**Weaknesses**
• Supercharge abilities, thus enabling one to work beyond their capacities. • Generate ideas and images quickly and rapidly. • Edit or "smooth" content. • Provide quick, immediate feedback. • Psychologically safe learning support. • Reduce human bias	• Hallucination risks and inaccuracies. • Uncertainty regarding how to prompt AI well • Lack of critical interpretation of outputs. • Failure to learn important materials. • Hinder development of communication and collaboration skills. • Reinforce human biases or stereotypes. • Variation in use across instructors.
Opportunities	**Threats**
• Force instructors to clarify fundamental values for teaching and learning. • Prepare students for future careers. • Equalize the learning experience.	• Hinder learning through culling reliance. • User overconfidence can lead to lack of awareness of users' actual skills. • False information being acted upon.

Notably, Alvin referred to GenAI as a collaborator, or more than a tool. Alvin suggested that when one (i.e., instructor or student) works alongside GenAI appropriately, GenAI can enable "people to bat way above their abilities." As Alvin elaborated:

> *With this collaborator, this partner as an individual, I can do things that are supercharged way beyond what I would be able to do without [GenAI], right? I can write code that's way more complex than anything I personally understand... I can generate things faster and more in depth.*

While Alvin consistently reinforced the "supercharging" affordance of GenAI, he strived to scaffold student learning to mitigate GenAI's weaknesses such as hallucinatory or biased outputs. As he shared, "When I don't scaffold the experience to teach [students] how best to use [GenAI], they might get bad results out, and… come away with a misunderstanding of the power of the tool." Without such scaffolding, students may use GenAI in uninformed or uncritical ways that may expose them and others to potential threats.

While Alvin was a strong proponent of GenAI use, he recognized that GenAI use can hinder the development of important foundational skills. Alvin described GenAI weaknesses and threats related to replacing learning and encouraging cognitive laziness. He viewed it as instructors' responsibilities to capitalize on, or restrict, GenAI use in ways that are appropriate to their teaching and learning goals. For instance, Alvin teaches first-year students in the fall and spring. The fall course emphasizes engineering design, and the spring course involves introductory computing. Alvin encourages broad use of GenAI in the design course but discourages GenAI use in his computing course because GenAI can quickly provide correct

https://doi.org/10.52202/086293-0015

answers that students can quickly find, thus foregoing the struggling that Alvin views as necessary for developing coding skills. Alvin thus encourages educators to identify their teaching values and ensure that AI is used in ways to elevate those values. As he shared:

> *What is it I value here? Is it getting the right answer? If so, then yeah, by all means [use GenAI]. But that's not what we believe in education. The right answer wasn't the point. The point was the journey that you went through to get there and the friction and the decisions you had to make. If GenAI is a tool that's doing all of that for you, then we don't like that interplay between those two things [production vs. learning]. It's really making us wrestle with what are the assignments that we're giving, what are the structures? What are the rules and regulations that we're providing the students? What access are we giving them? What access are we restricting?*

Profile 3: Elizabeth

Elizabeth is an associate teaching professor with 10 years of design teaching experience who works at a mostly-commuter, minority-serving institution with a high rate of first generation students. She coordinates and teaches a first-year engineering design course, wherein students observe the built world, iteratively prototype, and learn to collaborate. She encourages students, especially first-generation and international learners, to trust their creativity and lean into their voice. As she shared, this is especially pertinent given the rise of GenAI use, especially among specific groups of students for certain tasks:

> *My perception is that my international students who are… self-conscious about their English usage are heavily relying on AI for any writing assignment I give them. […] There's a weekly self-reflection on, "How did I do as a student? How did I participate on my team? What methods were the most useful to us as a team this week that we learned?" And my perception is about 50% of my international students are heavily relying on ChatGPT or something similar to write those for them rather than trust my comment that I'm not grading this for grammar.*

Table 3 summarizes Elizabeth's SWOT responses. A core theme from Elizabeth's interview was that while GenAI can be useful for brainstorming and stakeholder simulations, there is a risk that over-reliance can erode students' critical thinking and ownership of ideas. Elizabeth identified strengths associated with GenAI in design learning, such as AI's capacity to role-play stakeholders for interview practice and act as a brainstorming aid to jumpstart ideas. However, she suggested that GenAI's generic responses can stifle creativity and lead to overreliance where "students trust AI over their judgment." As a result, Elizabeth advocates for cautious and critical GenAI integration, where students question biases and retain agency in their design processes. As she described:

> *I think the most effective use of AI and design work is when we ask the AI to behave like a stakeholder and we interrogate it a bit. I think that turning to AI to figure out how to word part of a report or a presentation, [that's] okay, but it better be a fairly unobtrusive level, meaning your voice comes back in, your thoughts are given primacy, or maybe you give it a rough draft and it helps you smooth it out or fix the grammar or something. But I still want the central critical thinking to come from the students. I want my students to stay curious and stay imaginative, and anything from AI that deadens that, I'm going to fight.*

Table 3: Summary of Elizabeth's SWOT Responses

Strengths	Weaknesses
• **Role-play stakeholders.** • **Aid brainstorming to generate initial ideas.** • **Aid interviewing activities by developing and practicing protocols.** • Visualization concepts, particularly to help non-artists develop digital prototypes. • Refine text, specifically for non-native English speakers. • Handles administrative tasks (e.g., notes).	• Provide generic responses. • Lack novelty and imagination. • Stifle creativity and critical thinking. • Lack of trust in one's own judgements coupled with overlying on GenAI. • Introduction and reflection of biases • Copyright concerns and potential rise of legal issues, particularly for image creation. • Loss of student agency and voice.

Opportunities	Threats
• Generate case studies. • Provide virtual teaching assistance 24/7. • Focus interpretation of technical plotting and graph designs. • Improve designs, in general. • Introduce multiple voices and perspectives.	• Perpetuate and reinforce biases. • Tech divisions, particularly if/as dominant demographics adopt GenAI faster. • GenAI autonomous decision-making. • Ethical harm, particularly resulting from unchecked optimization and standardization.

Elizabeth also suggested that GenAI's weaknesses, if left unchecked, can contribute to serious downstream threats. Students may unintentionally internalize biases evident in GenAI outputs. Additionally, Elizabeth talked at length about the potential for a new tech divide where white men, who are already overrepresented in LLM training data, develop a systemic skill advantage given their potentially greater propensity to use GenAI. Elizabeth likened this situation to university makerspaces, where white men often feel more comfortable in the space and thus have an advantage in learning to use fabrication tools. Elizabeth explained:

> *That divide is happening again with the introduction of AI technologies. Most people who are like, "Cool, I'm going to try this," come from dominant demographics. And then people who are like, "Oh no, I don't want to get in trouble. Maybe it's not allowed... I shouldn't even risk it." Those are from my minority and vulnerable populations. This guy's been using it on the side since high school [and] you [a minoritized individual] won't even touch it. That just created a new tech divide, in terms of comfort level or knowing how to iterate with the thing [GenAI]. If we don't attend to it as instructors, if we're not giving opportunities to use it in productive ways that don't turn into a crutch, then the more vulnerable students are the ones who are having the biggest disservice in the process.*

Themes across Participants

We next identified themes from data by looking across interviews. One common theme was that **GenAI can make education more accessible**. Participants described how GenAI can provide feedback to students faster than professors or can answer questions that students may feel uncomfortable asking professors. Angie described how students can use GenAI to "discover elements of the hidden curriculum," such as asking "why something is happening" with a "low stakes entity [i.e., GenAI]." Elizabeth elaborated on similar ideas:

> *My colleagues are looking at AI to create custom TA chatbots for their classes. I think that has a lot of potential. I can't tell you how many times I wake up the next morning, and I see a panicked email from a student from the night before. And of course, I didn't see that. I was asleep. I do see a lot of opportunity [to] custom[ize] learning, but it's going to require thoughtful development.*

The potential for GenAI to boost accessibility is tempered by GenAI's weaknesses. While GenAI can provide 24/7 mentoring, the information provided by GenAI may be inaccurate. By asking class-related questions to GenAI, students may develop an unhealthy overreliance. Given concerns that not all groups leverage GenAI for learning in equal ways, Alvin suggested it was critical to identify "who has access to these tools?" and "how is that [access] propagating existing power dynamics and relationships between people, tools, technology, society, etc?"

Another theme discussed across participants was the possibility that GenAI facilitates knowledge theft. Participants expressed concerns regarding the ownership of the data within the large language models [LLMs] on which GenAI depends. Elizabeth described how concept visualization for prototypes is a notable strength of GenAI, but worried that "[LLMs] have stolen a bunch of intellectual property," including "current imagery and things they didn't have a legal right to incorporate." While theft may include stealing *others'* intellectual property, there is also the risk that an LLM absorbs one's own knowledge during use, leading to unsanctioned access to GenAI users' intellectual property. As Angie shared when describing proprietary information: "There's also threats in terms of AI model choice, and who owns what? Are you giving away anything proprietary based on the questions that you're asking a particular AI?" Similarly, Elizabeth worried that "when you type into the AI, you're giving it your intellect."

https://doi.org/10.52202/086293-0015

Discussion

We analyzed interviews with three participants to determine how their views of and experiences with GenAI aligned and varied. In summary, Angie felt that GenAI was a powerful tool with the potential to speed up and democratize innovation, although she noted weaknesses that purposeful pedagogy can offset. Alvin described how GenAI can supercharge innovation but cautioned that GenAI use can hinder students' development of foundational skills. Elizabeth advocated that students should only use GenAI in ways that preserve their critical thinking and creativity. She worried that failure to support equitable training around GenAI use could result in a new tech divide. Collectively, participants discussed how GenAI can make education accessible but can complicate knowledge generation and learning.

A key observation across participants was that effective use of GenAI in design education must account for specific course characteristics such as the types of tasks that students are performing, how instructors assess learning, and course values related to learning. While there is no one-size-fits-all set of GenAI guidelines that will apply across all course contexts, our findings indicate tensions between participant-identified strengths/opportunities and weaknesses/threats. We frame these tensions as productive as they enable purposeful strategizing to elevate positive aspects of GenAI use in engineering design education while mitigating negative facets. In this section, we first describe each productive tension. We next offer instructional considerations to guide curricular responses given these tensions.

Productive Tensions

Each participant identified strengths of and opportunities for GenAI integration in engineering design teaching and learning, but participants also identified associated weaknesses and threats. We frame these conflicting perspectives on GenAI use as "productive tensions" to highlight how such conflicts (1) operate in concert and (2) may not have a singular best solution or response (Cheville & Heywood, 2016; Klassen & Case, 2022). Framing these tensions as "productive tensions" further draws attention to how engaging with each tension can lead to the "production of new ideas or modalities of thinking" (Cheville & Heywood, 2016, p. 5), such as creative approaches to GenAI use that align with curricular contexts and needs.

Tension 1: GenAI can both enhance learning and disable learning.

Alvin saw GenAI as supercharging abilities. Angie and Elizabeth each discussed how GenAI could support student learning by role-playing stakeholders in case studies. However, Alvin expressed concern that unconstrained GenAI use could hinder foundational learning, and Elizabeth worried that GenAI use could stunt creativity and critical thinking. Nonetheless, participants felt that appropriate instructional scaffolding could mitigate student learning-related weaknesses and threats.

Tension 2: GenAI can both facilitate idea generation and facilitate knowledge theft.

All participants identified the rapidity of idea generation as a major strength of GenAI that had the potential to accelerate innovation. However, intellectual property with regards to GenAI use is a grey area. In the absence of broader guidelines to prevent knowledge theft, instructors have an ethical responsibility to present this tension to students and find ways to mitigate it.

Tension 3: GenAI can both support inclusive education and amplify discrimination and misinformation.

Participants described creative ways that students are using GenAI to support their own course engagement and that instructors are using GenAI to provide on-demand resources for students. However, GenAI is subject to myriad biases ranging from algorithmic bias programmed into the AI to confirmation biases wherein "an AI system is used to confirm pre-

existing biases…held by its creators or users" (Ferrara, 2023, p. 3). Yet, most sources of bias are outside of instructor control. Angie's response to this tension was to help then trust students to use good judgment to weigh the advantages and disadvantages of different AI models and make appropriate decisions about which models to trust.

Pedagogical Suggestions

Given these productive tensions, there is a need for purposeful integration of GenAI that elevates its strengths while mitigating its risks. We offer three such suggestions here.

First, instructors should identify prerequisite knowledge, skills, and attitudes (KSAs) students must possess before using GenAI for specific tasks. While GenAI can enhance student learning, participants felt that students needed an appropriate foundation of knowledge, skills, and attitudes (KSAs) to use GenAI effectively. Lacking sufficient knowledge of a given problem, students may fail to discern if GenAI provides inaccurate responses. Accordingly, instructors need to first identify which foundational KSAs their students have and which KSAs they need to use GenAI appropriately. Thereafter, instructors should design developmentally appropriate instructional approaches and scaffolds to ensure students can learn and discover how best to use GenAI in developmentally appropriate ways (see Munir et al., 2025 for a more thorough description of how GenAI can support student advancement throughout their Zone of Proximal Development).

Second, instructors should identify ethical perspectives their students should have when using GenAI. Our participants emphasized that appropriate GenAI use may vary by specific task, but there were pervasive perspectives that each participant expected their students to bring. For example, participants suggested that students should be critical of every GenAI output given that GenAI outputs are potentially inaccurate and based on myriad biases. Students must recognize that leveraging GenAI outputs require extra work, be it by confirming output accuracy through alternative sources or re-contextualizing outputs to a specific problem.

Third, instructors should provide specific course guidance for student use of GenAI to ensure attainment of student learning goals. While participants were generally against rigid and universal policies for GenAI use, they each provided instructional guidance regarding where and how to use GenAI *while noting* that such guidance could vary by instructional task. Design instructors should identify: (1) which tasks students can use GenAI, (2) why GenAI usage is acceptable for that task, and (3) how best for students to then use GenAI. Instructors might start by identifying salient questions (perhaps building from those provided in many of our participants' block quotes), bringing them to their classroom, and engaging students in conversations about GenAI use for specific tasks or assignments.

Limitations and Future Work

This study reflects an in-depth qualitative analysis of three experienced design instructors' perspectives. Our select sample afforded a nuanced thematic description of participants' experiences and perspectives; however, instructors in curricular contexts other than those of our three participants may have different experiences or perspectives with Gen AI. In the future, we will synthesize all 17 instructors' perspectives to represent a broader range of instructional contexts and instructor diversity, including GenAI use cases, GenAI expertise, disciplinary backgrounds, and other demographic factors. Ideally, future work will also visually depict the interplay between tensions to guide others in navigating producing tensions.

Conclusion

We explored the experiences and perspectives of three seasoned engineering design instructors who had introduced GenAI into their design teaching and learning. Our findings include strengths, weaknesses, opportunities, and threats of GenAI use in this domain identified by each participant, along with themes representing key insights from participant interviews. Based on our findings, we identified productive tensions related to learning, data

https://doi.org/10.52202/086293-0015

security, and discrimination that capture important instructor considerations when leveraging GenAI tools in engineering design teaching and learning. Instructors interested in using GenAI may use our findings as inspiration, and researchers may use our findings as a basis to deepen understandings and considerations for GenAI use in light of existing productive tensions.

References

Ahmed, Z., Shanto, S. S., Rime, M. H. K., Morol, M. K., Fahad, N., Hossen, M. J., & Abdullah-Al-Jubair, M. (2024). The Generative AI Landscape in Education: Mapping the Terrain of Opportunities, Challenges and Student Perception. *IEEE Access*, *12*, 147023–147050. https://doi.org/10.1109/ACCESS.2024.3461874

Al-Samarraie, H., Sarsam, S. M., Ibrahim Alzahrani, A., Chatterjee, A., & Swinnerton, B. J. (2024). Gender perceptions of generative AI in higher education. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/JARHE-02-2024-0109

Aldreabi, H., Dahdoul, N. K. S., Alhur, M., Alzboun, N., & Alsalhi, N. R. (2025). Determinants of Student Adoption of Generative AI in Higher Education. *Electronic Journal of e-Learning*, *23*(1), 15-33. https://doi.org/10.34190/ejel.23.1.3599

Ali, S. F., Rege, A. S., Ponniah, S. A., Ehsan, H., & Anwar, S. (2025). *Role of generative AI in enhacing pre-college engineering design thinking (Work in Progress)*. Paper presented at the ASEE Annual Conference & Exposition, Montreal, Canada.

Batista, J., Mesquita, A., & Carnaz, G. (2024). Generative AI and higher education: Trends, challenges, and future directions from a systematic literature review. *Information*, *15*(11), 676.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Chacko, A. S. (2024). *Exploring design education in the age of Generative Artificial Intelligence: Opportunities and challenges*. Georgetown University].

Chan, C. K. Y., & Tsi, L. H. (2024). Will generative AI replace teachers in higher education? A study of teacher and student perceptions. *Studies in Educational Evaluation*, *83*, 101395. https://doi.org/10.1016/j.stueduc.2024.101395

Cheville, A., & Heywood, J. (2016). From problem solvers to problem seekers: The necessary role of tension in engineering education. Paper presented at the ASEE Annual Conference & Exposition,

Chiu, T. K. (2024). Future research recommendations for transforming higher education with generative AI. *Computers and Education: Artificial Intelligence*, *6*, 100197. https://doi.org/10.1016/j.caeai.2023.100197

Farrelly, T., & Baker, N. (2023). Generative Artificial Intelligence: Implications and considerations for higher education practice. *Education Sciences*, *13*(11), 1109.

Ferrara, E. (2023). Fairness and bias in artificial intelligence: A brief survey of sources, impacts, and mitigation strategies. *Sci*, *6*(1), 3.

Foster, C. (2024). Methodological pragmatism in educational research: from qualitative-quantitative to exploratory-confirmatory distinctions. *International Journal of Research & Method in Education*, *47*(1), 4-19. https://doi.org/10.1080/1743727X.2023.2210063

Gonsalves, C. (2025). Contextual assessment design in the age of generative AI. *Journal of Learning Development in Higher Education*. (34).

Hashmi, N., & Bal, A. S. (2024). Generative AI in higher education and beyond. *Business Horizons*, *67*(5), 607-614. https://doi.org/10.1108/jarhe-02-2024-0109

Jensen, L. X., Buhl, A., Sharma, A., & Bearman, M. (2024). Generative AI and higher education: a review of claims from the first months of ChatGPT. *Higher Education*, 1-17. https://doi.org/10.1007/s10734-024-01265-3

Klassen, M., & Case, J. M. (2022). Productive tensions? Analyzing the arguments made about the field of engineering education research. *Journal of Engineering Education*, *111*(1), 214-231.

Kumar, S., Rao, P., Singhania, S., Verma, S., & Kheterpal, M. (2024). Will artificial intelligence drive the advancements in higher education? A tri-phased exploration. *Technological Forecasting and Social Change*, *201*, 123258. https://doi.org/10.1016/j.techfore.2024.123258

Munir, M. T., Li, B., Carter, S., & Hussain, S. (2025). Engineering education's Odyssey with ChatGPT: Opportunities, challenges, and theoretical foundations. *International Journal of Mechanical Engineering Education*, 03064190251337477.

Tracy, S. J. (2010). Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. *Qualitative inquiry*, *16*(10), 837-851.

Walther, J., Sochacka, N. W., Benson, L. C., Bumbaco, A. E., Kellam, N., Pawley, A. L., & Phillips, C. M. (2017). Qualitative research quality: A collaborative inquiry across multiple methodological perspectives. *Journal of Engineering Education*, *106*(3), 398-430. https://doi.org/10.1002/jee.20170

Acknowledgements

We sincerely thank the instructors who participated in this study, especially the three instructors who we featured in this work. This material is based upon work supported by the National Science Foundation under Grant No. 2417252. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or Purdue University.

Copyright Statement

Copyright © 2025 Justin Hess, Roberth Loweth, and Udeme Idem: The authors assign to the Research in Engineering Education Network (REEN) and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full, and this copyright statement is reproduced. The authors also grant a non-exclusive licence to REEN to publish this document in full on the World Wide Web (prime sites and mirrors), on portable media and in printed form within the REES and RCEE & RHEd 2025 proceedings. Any other usage is prohibited without the express permission of the authors.

https://doi.org/10.52202/086293-0015