Systems & Control Transactions

Original Research Article
Peer Reviewed Conference Proceeding
ESCAPE 36 - European Symposium on Computer Aided Process Engineering
Sheffield, UK. 21-24 June 2026

Generative AI in Process Design Instruction: A Survey of Students and Faculty

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ABSTRACT

A survey was conducted of 103 students and lecturers who had recently participated in chemical engineering design courses concerning their opinions on the use of Generative Artificial Intelligence (Gen-AI) in their capstone design education. Participants were at universities in Europe, the Middle East, North America, and South America, from at least eight different language groups. The survey found little difference in responses between students and lecturers, except for uptake, in which students reported higher rates of familiarity and adoption of Gen-AI tools than instructors. Both groups were net-positive generally on the use of Gen-AI in the classroom, reporting relatively high confidence in the ability to assess results, the general positive benefits of using Gen-AI in their chemical process design education, and the likelihood of using them in the future. However, participants reported that their trust in the results of Gen-AI tools was relatively low.

Keywords: Education, Artificial Intelligence, Process Design

INTRODUCTION: A DISRUPTIVE TECHNOLOGY IN EDUCATION

The rapid emergence of Large Language Models (LLMs) and generative artificial intelligence (Gen-AI) tools such as ChatGPT has sparked widespread debate across higher education, particularly in fields traditionally rooted in quantitative rigor and design creativity such as chemical process engineering [1]. Tao et al. [2] provide a framework enabling the efficient application of LLMs in PSE involving three strategies: standardized prompt structure, task decomposition, and iterative generation. They provide several example applications of these strategies, among them process flowsheet visualization, process simulation and HEN synthesis. As a typical example of the capabilities of LLMs in process design, consider the contribution of Vogel et al. [3], who developed an LLM-based methodology for autocompletion of chemical flowsheets.

As an illustrative example, we used ChatGPT to synthesize an ammonia production process (Haber-Bosch type), stipulating air and water as the feedstocks. The chat record is available in the supplementary material for the curious reader. With just a few simple prompts, it synthesized the process with a general block flow diagram, provided some numerical calculations about approximate material requirements based on stoichiometry, provided approximate energy requirements, opportunities for heat exchange (and offered to run a pinch analysis to synthesize the heat exchanger network), safety notes, control system notes, and produced a cost analysis, with plots, including the levelized cost of ammonia as a function of various market and technology assumptions. After each prompt, it provided a list of steps to be conducted next and offered to do many more tasks. It also told us “You’re doing great” after the first prompt. The total computational workload was less than 2 minutes, encompassing a process that would normally take months for a student in a process design course toward the end of many years of engineering study. The potential value of the tool is profound.

Trust in the correctness of Gen-AI results is also a serious concern. The ChatGPT ammonia synthesis example produced 15 pages of results with bold confidence, but with opaque explanations. It could require weeks or even months for an expert to check each and every step of ChatGPT's results and its thought process. The ability to even check or certify the results at all assumes that ChatGPT would be able to sufficiently provide explanations throughout its process and do so in a deterministic way. The probability of some inaccuracy seems high, not just in mistakes in logic or technical knowledge but even basic math and data. For example, in the preparation of this work, the authors found that leading Gen-AI tools generated hallucinated references that did not exist, reported that the molecular weight of air was 18.02 g/mol (which is for water), and said there were two "r's" in the word "strawberry" (in the 5th and 9th positions), all while projecting confidence. This problem is not just due to potential inaccuracies of the LLM, but also due to the lack of or inaccuracies in open data in process systems engineering on which the models are trained [4]. Note, the LLM is purely trained on language-based data without any physics-informed decision layer. That is, the LLM parameters are obtained over a large dataset not only for process engineering but many unrelated areas, even Ozzy Osbourne's hard rock metal lyrics. Contrary to popular belief, ChatGPT is not simply just relying on available online information which it harvests by live lookup but has the capability of at least performing preliminary computations for itself. For the example interaction, ChatGPT explains that it arrives at the numerical values it reports on response to the user prompts by performing stoichiometric material balances and relies on cost exponents for CAPEX estimation, among other simple calculations.

This example presents an existential question for chemical engineering design education. From a purely pedagogical perspective, the advantages to the students could include having a tool that guides them through the process, offers ideas and starting points, provides always-available technical support and personalized tutoring, and of course an incredible speed-up in results generation. The sheer rapidity of results could permit students to solve much bigger and deeper problems that are simply impossible to do in in a design course with pre-ChatGPT technology.

The disadvantages and concerns for pedagogy are also myriad. These include the erosion of deep understanding, the outsourcing of critical thinking, and an increased temptation toward plagiarism. The temptation to use them as a replacement for the hard work of personal learning is evident. It is reasonable to surmise that these would lead to very poor educational outcomes and produce insufficiently competent engineers, creating a downward spiral of skill.

Suppose that even if the personal development concerns of the student are mitigated. Since results can be generated so quickly but trust in the results is a major concern, does this mean our chemical engineering design courses should primarily focus on training students to check and certify Gen-AI results rather than the art and science of designing it themselves? Will this be sufficiently motivating to encourage students to enter the process design profession, or even to develop their own skills generally?

To get a better handle on these issues, we conducted a survey of students and lecturers who took or taught capstone chemical process design recently about their opinions and experiences of Gen-AI. The goal is to get the perspective of students and instructors as to where they think the technology is going and how they are using it now. There are no such recent surveys on chemical engineering capstone-level design courses to the author's knowledge.

RECENT RELATED SURVEYS

In a study focusing on Gen-AI usage in a second-year chemical engineering course, Verret [5] polled students on their perceptions on the degree of assistance they received from Gen-AI on assignments related to design, finding that about half of the students polled made no use of AI, and that those that did mostly used it to edit documents, for problem solving, and to critically evaluate information. As for their concerns in reliance of Gen-AI, of those students that used it, the issues that most concerned them centered around the low quality of information obtained, the academic integrity of the information obtained, and the possibility of fabricated, incorrect, or missing citations.

Chans et al. [6] used pre-tests and post-tests that book-ended a four-hour beverage design problem exercise in a chemical engineering product design course. The exercise was primarily a brainstorming session, guided by the lecturer who provided Gen-AI tools and prompts for them to use. They reported a general increase in the students' perceived usefulness of Gen AI-tools but did not find a significant increase in other metrics. The sample size was small (9 students) and there was no control group, so general conclusions cannot be made about the ability of Gen-AI to increase design thinking, creativity, and innovation.

Huang [7] surveyed students in a course in chemical process control for three modules related to coding, Laplace transforms, and PID controller tuning. Students were instructed to engage with ChatGPT during the workshops. Students reported slightly net-positive outcomes in their perceived understanding of the theoretical topics at hand, but strong net-positive responses in understanding how AI can be applied to chemical engineering problems. Students also had negative responses concerning confidence in the AI-generated results and noted they needed more guidance in how to check. Some of these results will be echoed in the results of this survey on process design.

Although not about education specifically, 86 engineers practicing in the UK were asked if they thought ChatGPT should be taught in engineering higher education [8]. Although 82.5% agreed that engineers generally needed training in ChatGPT, only 55.7% felt that it should be explicitly "embedded" in university courses. Although still net-positive, it does not signal a huge push for explicit educational integration. Similar attitudes were found among our student and lecturer survey participants, as explained in the following sections.

CHEMICAL PROCESS DESIGN SURVEY

Given the recent emergence and rapid spread of Generative AI tools, their role in process design curriculum is still developing. To gain a first overview on current practices as well as a comparison between the associated perceptions of lecturers and students, we conducted a survey of students and lecturers in chemical engineering design programs between December 4, 2025 and January 25, 2026. It consists of questionnaires distributed to chemical engineering students as well as their instructors, asking about familiarities with Gen-AI tools, current use, view on opportunities and challenges in their application, as well as opinions on recommended future development. The lecturers and students received parallel questionnaires, covering the same topics, but with different wordings appropriate to the role of the survey participant. The survey was open to the public and taken via an internet website. It was announced through direct email of colleagues, posts on relevant professional network websites and listservs, and in multiple languages. Responses were received from participants in Catalan-, Danish-, Dutch-, English-, French-, German-, Hebrew-, Portuguese-, and Spanish-speaking institutions or countries, whose chemical engineering design courses are either conducted in the relevant national/regional language or in English. The survey itself was conducted in English. The question sets and the associated raw data are posted in the supplementary material.

Demographics of Survey Participants

Participants were asked for their current university and status as a lecturer or student. Participants who selected "Student currently taking a course in chemical engineering design, or have done so, or expecting to take it over the next year" are classified as a Student (S), with 81 responses. Participants who selected "Lecturer currently teaching chemical engineering design, has taught it recently, or is expecting to teach it in the next year" are classified as a Lecturer (L), with 22 responses. 1 participant selected the "Neither of the Above" option and was discarded from the analysis.

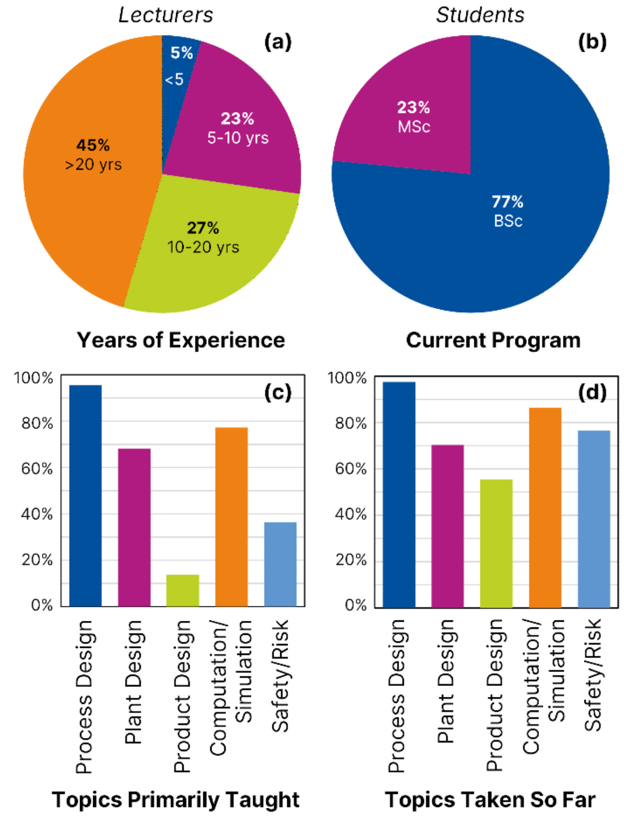

Figure 1. Participant demographics. (a) Years of experience in chemical process design instruction of lecturers; (b) The current level of the degree program of student participants; (c) The topics primarily taught by lecturers; (d) The topics studied by students. (N=103)

Questions 1 and 2 asked participants about the relevant areas of chemical engineering design that they either teach (L) or have taken so far (S). Students were asked about their current degree program, and lecturers were asked about the numbers of years of experience they have teaching process design. Participants were presented with multiple-choice lists. A summary of the results is shown in Figure 1. The vast majority of the lecturer participants had at least 5 years of experience, with almost half having at least 20. With regard to the topic involvement, few lecturers selected product design, but the question specifically asked what instructors *primarily* teach. Conversely, most student respondents indicated they had studied product design previously. This disparity in responses could simply mean that instructors do not consider product design to be a primary aspect of their instruction, but students are exposed to it nevertheless.

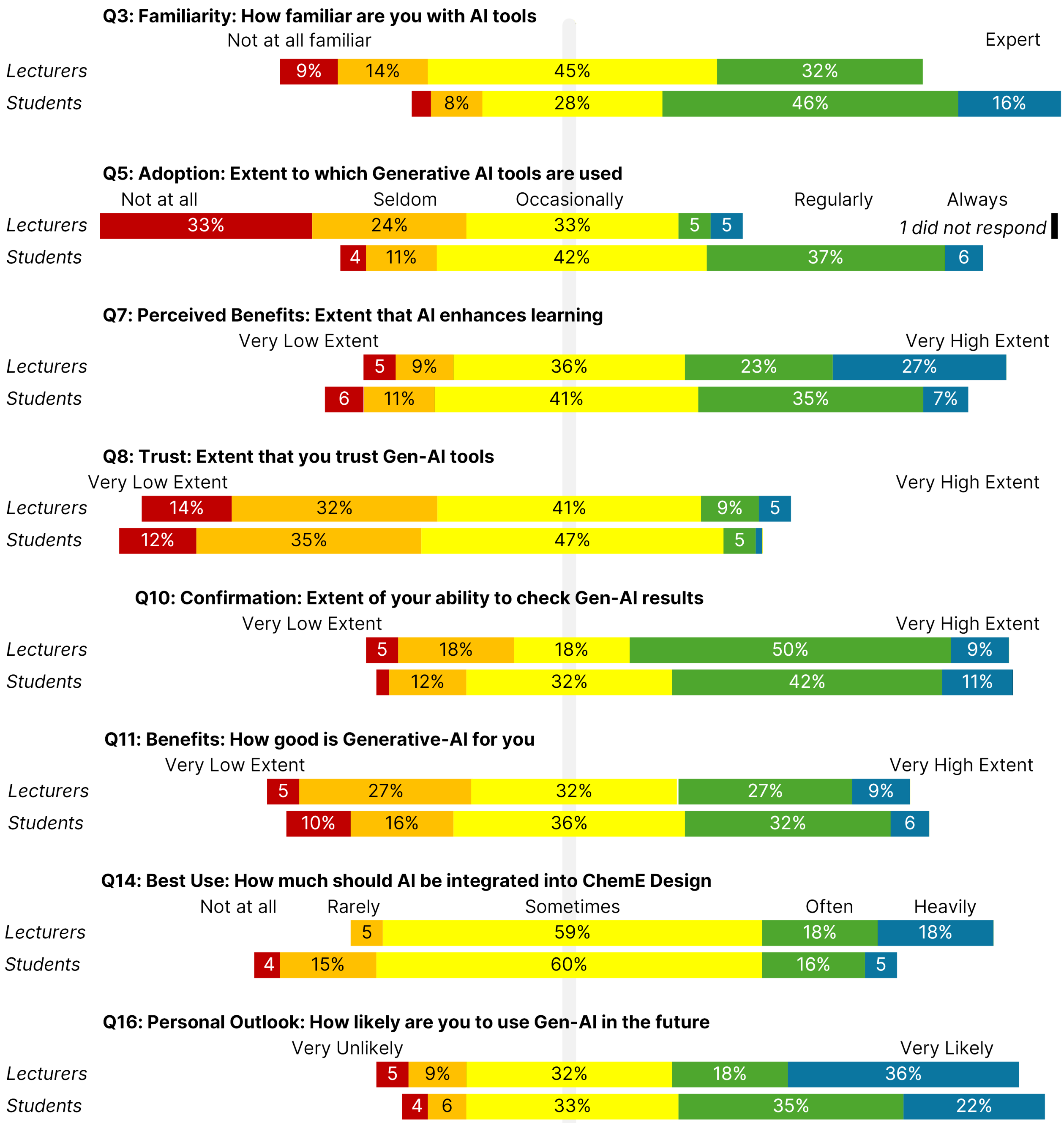

Figure 2. Resposes to Likert scale questions (Q3, Q5, Q7, Q8, Q10, Q11, Q14, Q16). *N=103*

Because the question asking participants to state their university had a free text field for an answer, not all responses could be accurately understood (because of acronyms and initials), so these are not included in the formal analysis.

Responses to AI-Related Questions

The following questions ask participants about their opinions concerning Gen-AI in chemical process design. Recipients were asked to respond using a 1 to 5 Likert scale, where 1 indicates “to a very low extent/I never use, ” to 5 indicating “to a very high extent/I always use.” Responses are summarized in Figures 2, 3, and 4. Comments on individual questions follow.

- ***Q3: The degree to which S/L are familiar with Gen-AI.*** L averaged 3.00, while S averaged 3.66. Z-test value is 2.97, indicating S feel significantly more familiar with Gen-AI tools than L.

- ***Q4: Which specific Gen-AI tools are used?*** The most commonly used tools are ChatGPT (91% of L, 95% of S) and Copilot (L: 50%, S: 43%). Responses are summarized in Figure 3.

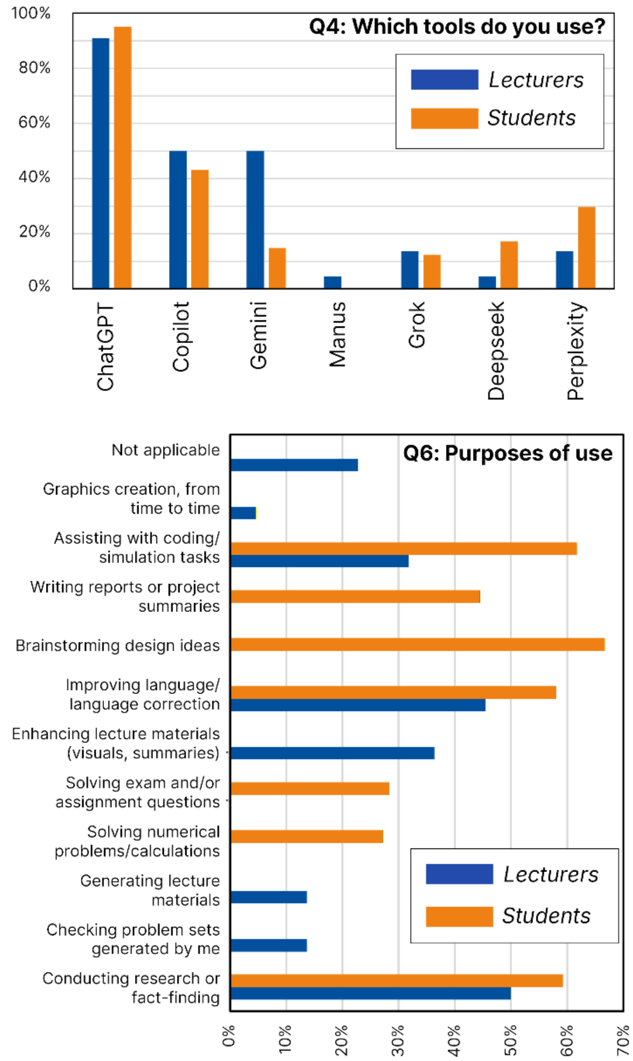

Figure 3. Responses to Q4 and Q6. *N*=103

- ***Q5: The extent to which Gen-AI tools are used in the design courses.*** The average L response was 2.14, close to "I seldom use, " while the average S response was 3.31, equivalent to more than "I use them occasionally." Note that one third of L do not use Gen-AI in their design courses at all. Statistically the two distributions score a Z-test value of 4.47, meaning that the students use Gen-AI tools quite significantly more than the lecturers do. These responses are consistent with those received for Q3 given that both questions indicate higher uptake in the S class.
- ***Q6: For which purposes are Gen-AI tools used?*** Most popular use for S is "brainstorming" (67%), while this usage scores 0% for L. Perhaps the lecturers do not consider brainstorming with AI to be brainstorming, and students include AI into teamwork and they of course do. Next most popular for S is "Assisting with coding/simulation tasks" (62%), while this scores only 32% for L. Of the rest, both use if for "Conducting research or fact-finding" (L:50%, S: 59%), and for "Improving language/language correction" (L: 45%, S: 58%).
- ***Q7: The extent of perceived benefit of Gen-AI in the process design courses***. Both L and S average about the same (L: 3.59, S: 3.26), and perceptions are statistically indistinguishable. The large majority of participants indicate that there are at least some benefits.
- ***Q8: The degree to which S/L trust Generative-AI in their process design courses.*** Both L and S average about the same (L: 2.59, S: 2.48), and perceptions are statistically indistinguishable. This finding can be surprising, but this same result was found by Đerić et al. [9] whose recent study designed to address this specific point also found no statistical difference between students and lecturers in their level of trust in Gen-AI. Trust skews heavily negative for both L and S.
- ***Q9: The degree to which lecturers favour results given by Generative-AI over other sources***. The question was removed from the analysis due to a technical issue with the survey tool.
- ***Q10: The extent of the perceived ability of S/L to check the results of Gen-AI.*** Both L and S average about the same (L: 3.41, S: 3.47), and perceptions are statistically indistinguishable. Both groups self-reported a relatively high confidence in their ability to determine the correctness of the output given by Gen-AI. This could partially explain why students have a relatively high adoption rate of Gen-AI tools, despite a relatively low level of trust in its output. This however would not explain why lecturers have a relatively low adoption rate of Gen-AI in their courses, since they too have high a self-perception of their own ability to determine correctness.
- ***Q11. The degree to which S/L believe Gen-AI is a "net good" for their education***. Both L and S average the same (L:3.09, S: 3.09), and perceptions are statistically indistinguishable.
- ***Q12: Which are the benefits of using Gen-AI tools?*** Highest scores were for "Getting explanations in simpler terms" (L:59%, S: 54%). Other but less mentioned benefits included "Saving time of assignments" (L:41%, S: 44%), "Bridging gaps in prior knowledge" (L:36%, S: 28%), and "Improving creativity" (L:36%, S: 25%).

- ***Q13: Which are the greatest risk and challenges of using Gen-AI tools?*** Similar perception of L and S with the highest scores being for "Over-reliance on AI /Becoming too dependent on AI" (L:91%, S: 80%), "Inaccurate or misleading outputs" (L:73%, S: 73%), and "Students bypassing fundamental steps" (L:64%, S: 59%).

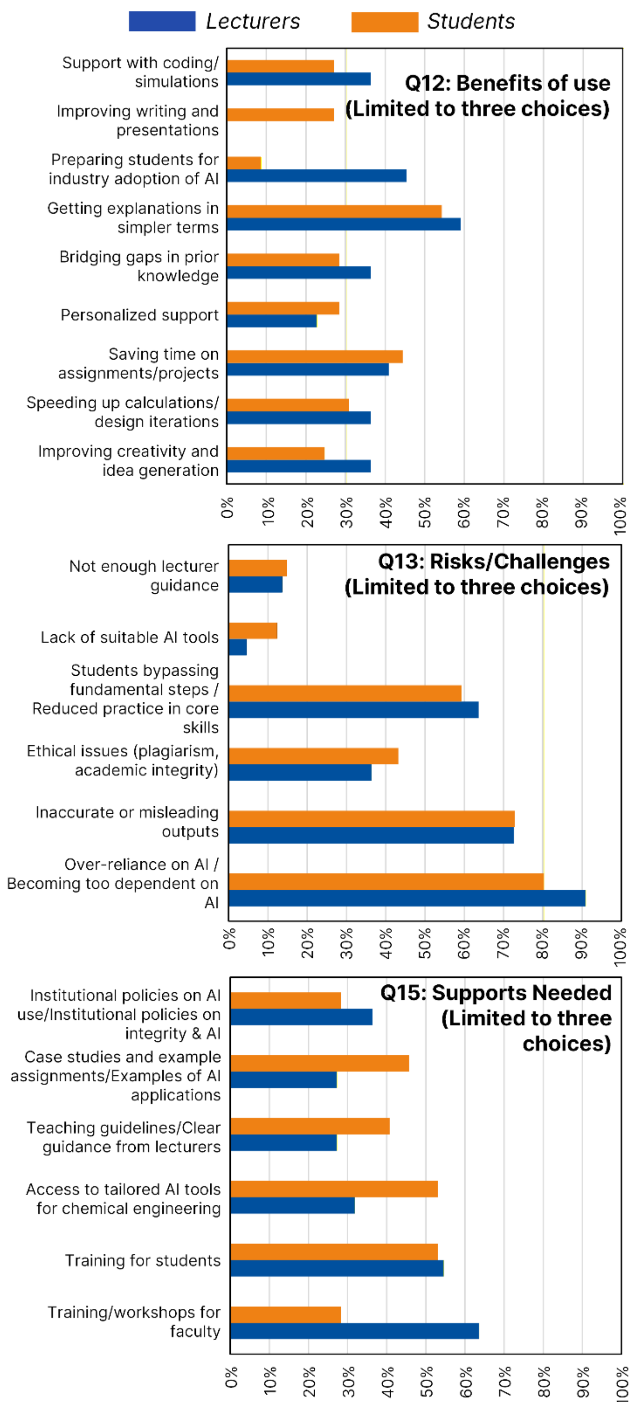

Figure 4. Responses to Q12, Q13, and Q15. *N*=103

- ***Q14. How much should AI be integrated into process design?*** L average response is 3.50, while the average response for students is lower at 3.04. Note that L are more enthusiastic about the introduction of Gen-AI in design education than students, and the difference in perception is statistically significant (Z-test = 2.31). This could in part be due to self-selection bias in those who chose to answer the survey. These results mirror the survey results of engineering employers [10] who also had a middle-of-the-road opinion that ChatGPT (specifically) should be integrated into engineering higher education.

- ***Q15: What kind of support is needed for Gen-AI usage?*** L opinion that support is needed most for training for faculty (64%) and students (55%). S think that support is needed most for "Training for students" and "Access to tailored AI tools for chemical engineering" (both 53%) and for Case studies and examples (46%). It would appear that students have put more thought into integrating Gen-AI than have the lecturers.

- ***Q16. How likely are you to use generative AI in future?*** Both L and S average about the same (L:3.73, S: 3.65) that were the highest scores in the survey, with perceptions being statistically indistinguishable.

Open-ended Responses

One question allowed responders to make closing remarks. Here are a few of the more noteworthy comments from the lecturers:

- "The whole purpose of education is to get students to think for themselves, and to understand the principles of engineering science well enough that they can either do their own calculations (using generic tools such as Excel) or check calculations made using specialist computer software. They need a good level of fundamental understanding so they can look at a design and answer the questions "does this make sense?" and "is this a feasible and safe design?" This requires development of an internal structure of knowledge, and my experience of AI is that it is devoid of any understanding of the structure of knowledge. Another major issue with AI is hallucinating references. **If you can't tell where the underlying information is coming from, how can you trust the output?** Every month or two, I see stories in the press or elsewhere about lawyers getting fined because their pleadings (generated by AI) contain either references to completely fabricated cases, or the real cases quoted don't support the arguments made in the pleading. Because lives are at stake in engineering, similar issues are much more serious in our field. We wouldn't just lose money…"

- "While **AI is a great help in numerous aspects**, ranging from the simple improvement of text quality to providing significant assistance in solving complex problems, it is also true that, currently, it frequently introduces changes that modify the meaning of texts, makes incorrect assumptions, and tends to attempt to fulfil the request, sometimes even at the expense of 'falsifying' some results. In many instances, **locating these errors is not trivial** (even for experts), **which poses a significant risk**, particularly for students. In my prompts, I often add phrases such as 'do not invent anything, ' 'justify all your steps, ' 'always include the source from which you obtained the data, ' and even then, I do not always succeed. Generally, it is a tremendous tool that must be leveraged at all levels (i.e., research and teaching), but as in all cases, the responses must be analyzed with a critical spirit, and this applies to both experts and novices."
- "The main point to be explored**: the different way students and instructors use Generative AI and ask it questions** (I'm reluctant to use the term "prompt engineering" to refer to understanding the problem and asking the right questions in the precise way by understanding the rules of grammar and logics, which is the real issue)."
- "There are clear differences between architecture/programming AI and Instantiation on AI application. Those differences are not clear for the university staff, and consequently students don't learn about it. Another question is the theoretical overlooking about ethical aspect without ethical day-by-day practices by the staff. A third urgent question is how the students will learn and practice the **Law of Unintended Consequences** on pervasive AI."

The survey has highlighted what appears to be a student body that at least perceives itself to be significantly more familiar with Gen-AI tools than their teachers, with about a third of the professors not using Gen-AI in process design education at all (Q3 and Q5). As both students and lecturers agree that Gen-AI will be utilized at an increasing extent in process design education (Q16), it would appear to be incumbent on lecturers to increasing integrate these tools into their teaching. Perhaps a good summary would be that offered by of one of the lecturers, who commented that:

- "We need to get on with it, or we will be left behind. But, one year before official retirement, I am not the professor to do this anymore ;-)"

Limitations to the Methodology

The limitations of the survey should be considered in its interpretation. The number of lecturers who participated was not as high as would be preferred, and subject to self-selection bias since those who both hear about and choose to participate may be skewed toward a class of people who are connected to the outreach networks used in participant recruiting. The number of student responses was sufficiently high but varied widely by institutions. Although many institutions were represented by at least one student participant, a few universities had large response rates, likely due to direct encouragement by the class instructor. Thus, responses of the S class as a whole will be skewed toward these universities. Much larger sample sets and participation rates would allow greater confidence in the S class and would allow us to create profiles representative of the institutional level.

CONCLUSIONS

The emergence of generative AI represents a fundamental shift in the environment in which process design is taught and practiced. Tools capable of producing flowsheets, calculations, code, and technical text within seconds are no longer peripheral aids but active participants in the design process. The results presented in this paper confirm that their use is already widespread among students and that adoption is likely to increase further in the near future.

The survey reveals a clear asymmetry between students and lecturers. Students report significantly greater familiarity with generative AI and make more frequent use of it in design courses, particularly for brainstorming and coding support. Lecturers, in contrast, remain more cautious and in many cases have not yet integrated these tools into their teaching. Despite this difference in usage, both groups express remarkably similar views regarding the perceived benefits, the limited level of trust in AI-generated results, and the risks of over-reliance and inaccuracy. This shared ambivalence suggests that the central challenge is not whether AI will be used, but how it can be used responsibly.

The pedagogical opportunities are substantial. Generative AI can provide cognitive scaffolding, personalized explanations, and exposure to alternative design options that may enrich creativity. At the same time, the risks identified—erosion of core engineering skills, propagation of errors, and threats to academic integrity—cannot be ignored. Process design education has always aimed to develop judgment, accountability, and the ability to verify results; these goals become even more critical in an AI-assisted context.

The findings point to several priorities. First, educators need support and training to engage confidently with these technologies. For example, both students and lecturers may need detailed training in effective prompt engineering. This approach is currently in development in other areas of chemical engineering [10]. Second, assessment methods must evolve to emphasize critical evaluation and transparent workflows rather than final answers alone. Third, students must be explicitly taught how to question and validate AI output as part of professional responsibility.

Generative AI should not replace the need for sound engineering reasoning, but it will reshape how that reasoning is exercised. The task ahead is to integrate these tools in ways that strengthen, rather than weaken, the intellectual foundations of process design education.

SUPPLEMENTARY MATERIAL

The supplementary material can be downloaded at https://PSEcommunity.org/LAPSE:2026.0006

DECLARATION OF AI

ChatGPT and Co-Pilot were used as described in the work. A small portion of the manuscript text was generated by ChatGPT, verified, and modified by the authors.

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