BOARD # 250: Integrating Generative AI into an Upper Division STEM Writing and Communications Course (IUSE)

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Writing and communication are crucial to engineers, taking up more than half their working hours [1] [2]. However, too few engineers have the writing and communication skills requisite for today's information society [3]. Within this context, new generative artificial intelligence (AI) tools such as ChatGPT and other large language models ("AI writing tools") pose both opportunities and challenges for helping engineering students become better writers and communicators.

Working in partnership with the lead instructor of the existing undergraduate engineering writing and communication course (second author), we sought to provide guidance on the ethical and effective use of generative AI for writing and increase students' AI literacy. As part of this project, we are iteratively developing, implementing, and evaluating a pedagogically-informed AI writing tool, which provides students scaffolded access to generative AI and researchers access to the student–AI interaction data. In parallel, we are creating professional development to support instructors' use of the curriculum, tool, and instructional resources for integrating AI writing tools into undergraduate writing-intensive courses. We conducted design-based implementation research (DBIR) during the 2023-24 academic year on the incorporation of AI writing tools for scientific communication centered on teacher instruction, student learning, and problems of teaching practice as identified by practitioners, students, and researchers [4]. Through iterative cycles of DBIR, we explored best practices for teaching and learning the use of AI writing tools in scientific communication; integrated these practices into the products; evaluated the impact on students' development as writers; and improved the project's products. For this paper, we focus on two research questions: 1) What emerging best practices do we see instantiated for using generative AI productively in academic writing; and 2) What emerging best practices do we see instructors using to integrate AI into their writing-intensive courses?

Methods
Setting
The University of California, Irvine (UCI) is federally designated as a Hispanic-Serving Institution and an Asian American and Native American Pacific Islander-Serving Institution. UCI engineering and computer science majors are 42% Asian, 15% Hispanic, 13% White, and 2% African American. Students are overwhelmingly male in this field (72%). 30% of these students qualify for the Pell Grant and 38% are first-generation college students. The Engineering Department requires an upper-division professional communication course designed to provide students with the tools to plan, research, organize, write, and edit various forms of oral and written technical communication that they will need as professionals. The course is a graduation requirement for almost all engineering majors and complies with the requirements of the campus for upper-level writing courses. Students must produce 4,000 words or more of finished work.

Participants
The second author is the lead instructor of the course and participated in implementing the instructional resources and tool as they evolved across the academic year. In the first quarter, Fall 2023, Harnick-Shapiro implemented curriculum and pre-made prompts that students could use with ChatGPT's free version. In Winter 2024, she piloted the minimum viable product developed by the team, which contained premade prompts and provided access to GPT-4.0. In Spring 2024, 3 additional course instructors were provided with the tool and curricular materials for use at their discretion. Each instructor taught at least two sections of approximately 20 students each.

Tool

Our digital writing tool (redacted) allows students to interact with generative AI—specifically a large language model ("LLM")—through pre-designed, embedded prompts that guide the interaction between students and AI (Figure 1).

Figure 1.
Description of the key components of the digital tool, PapyrusAI, created for this project.

What is PapyrusAI?
PapyrusAI is a web-based tool built on top of a commercially available AI model (currently, GPT-4o) that:
● Scaffolds and supports improvement in student writing through assistance with the process of writing, such as planning and revision activities;
● Includes embedded prompts to facilitate a conversation between the student and AI that guide the student through research-based best practices for learning writing;
● Provides teacher control over the types of interactions permitted for students for each assignment, allowing gradual change of usage over time (e.g., by assignment);
● Enhances privacy protection compared to individual AI access options; and
● Comes with instructional resources to support teacher and student use and AI literacy.

Results

Based on our work with instructors over the past year, we have noted emerging best practices for using generative AI productively in academic writing and for integrating generative AI into writing-intensive courses. We caution that there are likely many different patterns emerging that are productive, but these are the patterns found in our context at this time as generative AI is becoming increasingly available to students and instructors.

Prompting

We recommend that instructors emphasize an *iterative prompting strategy* with prompting as a multi-stage process, beginning with a "good enough" prompt followed by iterative refinement until the user's needs are met by the AI output.

Good enough prompting. We are finding that students benefit from some explicit instruction on prompting techniques. Instructors need to provide some foundational information to ensure that all students are prepared to be successful at prompting, because there is no baseline education for this in the current K-12 curriculum. For example, students should be explicitly taught that using "personas," giving the AI a role to play, can be very helpful in giving the model a great deal of information efficiently. They should understand that details and context, perhaps an example or two, can improve the quality of the AI's output. Clear instructions on what is needed, the goal of the output, and perhaps the steps suggested to get there will increase the likelihood of the output being usable. But most importantly, students need to understand that they should just write *something*.

Being the boss. After the initial conversational turn, the tool allows students to converse freely with the AI. Instructors need to stress the importance of students asserting agency by not simply accepting the initial AI output but continuing the turns to ensure that the AI output is useful.

Students need to be explicitly told to "talk back" to the AI and interrogate its output, asking for elaboration, clarification, expansion, or revision for example (this is consistent with evolving research on AI conversations, see [5] [6]. Students may need some explicit modeling and practice of this co-creation process. To effectively cause the AI to refine its output, students also need to have some knowledge of what output they need and what it should contain. This requires both content knowledge and critical thinking.

Corroborating and interrogating
Corroborating the accuracy of the AI output is a critical skill that fits naturally in the existing instruction, as students must check their sources in their writing regardless of AI use. AI use provides additional motivation to engage in this essential step and builds students' muscle to corroborate information in other contexts as well. Verifying the accuracy of AI output is a low-stakes way to practice these skills.

Thinking first
We recommend that students "think first" before turning to the LLM. While not necessary in every instance, we want instructors to be explicit about the cost of not doing so. Students need to understand that the AI only works from the information provided to it and that students will never be able to share all the relevant information that they have (even if the students themselves do not always recognize the importance of the information). We also remind them that humans tend to believe fluent language and to continue down a line of thought once they begin it, making it less likely for them to come up with divergent and creative ideas beyond the AI's output. Building the habit of thinking first will support student agency when using AI.

Reflecting
Our instructors valued reflection prior to our project and continue that practice in working with the AI. All of our instructors in some way have the students reflect at key points in the writing process on the role of AI and its impact on both the writing process and product. This reflection provides an opportunity for students to remain consciously in charge of their use of the AI. They are prompted to consider how effective the AI was when they used it, how it helped or hindered their writing process, and how they might (or might not) use it differently next time.

Integrating generative AI into writing-intensive courses
Synthesizing what we have seen worked—and did not work—this past year, we have learned some things about how to infuse generative AI into the curriculum. First, we note that our implementations were in *already designed courses*—instructors were disrupting existing, functional courses. Ultimately, when possible and especially when developing new courses, we believe intentional use of AI should be considered as part of the course design and, where determined to be supportive of student learning objectives, woven through the course in appropriate ways. To begin with, we found it helpful to ensure that the DBIR team understood and centered the student learning objectives for the course. Generative AI should not overtake the course goals, but rather enhance or supplement pre-existing content and activities.

Once these learning objectives are at the forefront, instructors can use the principles of backward design [7] to create or interrogate existing activities, assessment, and content to ensure that they are supporting the objectives. When attempting to determine what role the AI should play,

instructors can consider what is unnecessary for the student to do, what cannot be done due to a lack of resources (e.g., multiple rounds of teacher feedback), what is within the AI's capacity, and what is ethical for the AI to do. These factors will influence when and how AI might be infused throughout the course. We encourage instructors to start with the uses of AI that are the easiest to implement and most likely to effectively harness the AI's strengths—what we term the low-hanging fruit.

Discussion

Incorporating AI into the teaching and learning of writing is disrupting practices that have long been in place. Emphasizing that students should think first, reflect, and use iterative prompting emphasizes the human's role in co-creation [8]. The *person* retains agency and does the critical thinking necessary to guide the process and the ultimate output. This allows educators to ensure that students have the opportunity to learn the essential skills of writing and thinking, while also becoming proficient, knowledgeable users of this new writing tool. Similarly, infusing generative AI into the curriculum in a pedagogically sound manner requires the instructor to retain agency over the process of determining appropriate uses of AI and centering student learning objectives. By doing so, students do not shortcut their necessary learning (see, for instance, the contrary example in [9]), but are introduced to the use of generative AI in a scaffolded, supported learning environment.

Conclusion

We already see widespread adoption of AI in business and the world at large [10]. Banning or ignoring AI writing tools will fail to prepare our undergraduates for the professional world where such tools will be both embraced and valued. Indeed, AI literacy is a requisite for both future employment and civic engagement [11] in today's and tomorrow's world. Though the long-term impact of generative AI on writing instruction is difficult to foresee, we start from the premise that these AI writing tools are both flawed and fallible, due to their algorithmic biases and technical shortcomings [12], but that they also have powerful affordances, including the ability to assist the large numbers of scientists and engineers around the world who need to publish and present their work in English but are not native speakers of the language. Students from lower socioeconomic backgrounds often have less opportunities to use digital tools in authentic, productive, and creative ways [13] [14]. AI literacy is especially necessary for minoritized students, who already face a lack of access and participation in technology-related fields and are more likely to fall prey to misinformation and unfair decisions made by AI [15]. Thus, learning if, when, and how to effectively use generative AI as part of a writer's process is a key new part of literacy. If we can help students build effective habits and understanding of AI's affordances and limitations, they will be better prepared for their future.

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