



## The Impact of AI on the Process of Learning to Write

Tamara Tate, Waverly Tseng, Beth Harnick-Shapiro, Daniel Ritchie, Mark Warschauer  
[tatet@uci.edu](mailto:tatet@uci.edu), [waverlyt@uci.edu](mailto:waverlyt@uci.edu), [harnickb@uci.edu](mailto:harnickb@uci.edu), [dr Ritchie@uci.edu](mailto:dr Ritchie@uci.edu), [markw@uci.edu](mailto:markw@uci.edu)  
University of California, Irvine

**Abstract:** As generative AI becomes part of academic and professional writing, understanding how it mediates students' writing processes is critical for the learning sciences. This study examines engineering students' reflections on one such integration in an upper division writing course in spring 2025. Drawing on sociocultural perspectives and the writer(s)-within-community model, we examine how students engage with AI through agency, self-regulation, and AI literacy. Researchers analyzed students' reflections and found three categories of use patterns: intentional users, minimalists, and offloaders. Each of these types of use reflected different levels of agency and self-regulation in the use of AI tools. We also see evidence that regular reflection supported both self-regulation and AI literacy. We discuss implications for designing AI-integrated writing instruction that promotes agentic and critically informed use.

### Introduction

Generative artificial intelligence (AI) is rapidly reshaping how writing is produced in both academic and professional contexts. For students in STEM fields, learning to write effectively now increasingly involves learning to work with AI tools. This shift raises important questions for the learning sciences: how does AI mediate writing processes, and how do students maintain agency and control over their work?

Writing is not simply a linear act of transcription but a complex, recursive process involving planning, drafting, revising, and evaluating ideas (Flower & Hayes, 1981; Graham, 2018). From a sociocultural perspective, writing is also a mediated activity shaped by tools, social interaction, and disciplinary contexts (Vygotsky, 1978; Lave & Wenger, 1991). The writer(s)-within-community (WWC) model (Graham, 2018) extends this view by emphasizing how writers coordinate cognitive processes with social and material resources. In this framework, generative AI can be understood as a powerful mediational tool that has the potential to reshape how writers plan, interpret feedback, and revise text.

However, the educational implications of generative AI depend not simply on whether students use these tools, but on how they use them. Prior work suggests that AI can either scaffold higher-order thinking—supporting ideation, revision, and audience awareness—or enable cognitive offloading that may reduce engagement with key learning processes (e.g., Handa et al., 2025; Gerlich, 2025). These divergent outcomes point to the importance of self-regulation, agency, and AI literacy in AI-mediated writing. In this study, we conceptualize agency as students' ability to direct and make purposeful choices about tool use in relation to their writing goals; self-regulation as the processes of planning, monitoring, and evaluating one's writing and tool use; and AI literacy as the capacity to critically interpret, evaluate, and strategically employ AI-generated output. Together, these constructs provide an analytic lens for understanding how students engage with generative AI as part of their writing process.

To investigate these dynamics, we analyze engineering students' field notebook reflections from an upper-division writing course in which generative AI was available but not required. Unlike prior work, this study captures students' ongoing reflections across multiple writing tasks, offering insight into how AI use unfolds in practice. Through qualitative analysis, we identify three patterns of engagement—intentional use, minimal use, and offloading—which we interpret not as fixed user types but as variations in how students regulate and integrate AI into their writing processes. By examining these patterns through a learning sciences lens, this study contributes to understanding how AI functions as a mediational tool in writing and how instructional design can support students in developing agentic, self-regulated, and critically informed uses of AI.

### Method

#### Setting and participants

This study took place in an upper division writing and communication course at a research university in the western US taught by the third author. The institution is designated as a Hispanic- and Asian American and Native

American Pacific Islander-Serving Institution. The course was required for substantially all engineering students, who are primarily male (72%), with large numbers of first-generation college students (38%), Pell grant eligible students (30%) as well as international students (25%). Students tend to take this class in their final year; for many in their final quarter before graduation. At the beginning of the term, students were provided access and training to use a researcher-developed AI tool (Tate et al., 2025). Students were permitted, but not required, to use the tool (and other generative AI) during the term. As part of course instruction, the instructor advised students on best practices for interacting with generative AI, modeled effective use of the AI tool, and engaged students in discussions on evaluating AI output. The study protocol was approved by UCI’s institutional review board.

## Field notebooks

Students were assigned to keep a field notebook over the quarter to regularly document their experiences using generative AI tools in their course activities and assignments. Specifically, students were asked to “Record a reflection on the writing and oral communication processes as you move through the assignments in the course. Do the tools support or hinder the writing or communication goals?” Students were encouraged to provide clear objective observations; include details to document the process; assess the level of effort required for the assignment; indicate which tools that were useful and how they were employed; and identify any barriers to success and explore how they might be overcome in the future. Entries were expected to be about 100 words. Because AI use was optional, the dataset may overrepresent students more inclined toward AI use.

## Data analysis

Field notebooks were uploaded into Dedoose and coded by the first author. Coding was done using an inductive, grounded theory approach throughout (Charmaz, 2006), with codes emerging directly from participant responses as well as more focused codes based on our early research on effective use of generative AI in writing (Miles & Huberman, 1984; Tate et al., 2025). Codes included writing stages (planning, drafting, revision, editing), AI use types (e.g., ideation, feedback, offloading), and regulatory behaviors (e.g., evaluation, comparison). The third author provided a participant check from the instructor’s perspective to ensure that we were appropriately interpreting the classroom experiences, and the second author provided insight based on extensive classroom observations and interviews conducted during the term for the larger project.

## Findings and discussion

### Patterns of AI use across the writing process

Students (n=35) reported using generative AI across multiple stages of writing, most frequently for feedback (n=33), planning (n=29), and revision (n=27), and less often for drafting (n=24) and editing (n=14). AI was also used for reading (n=16) and research (n=18). While most students described AI as helpful in at least one instance (n=32), many also reported choosing not to use it for specific tasks, particularly when they wanted to preserve opportunities for independent effort or peer interaction.

### A typology of AI-mediated writing as a variation in regulation

We identified three patterns of engagement (Table 1)—intentional use, minimal use, and offloading—which are best understood as differences in self-regulation and agency in tool use, rather than fixed user categories.

**Table 1.**  
*Patterns of AI engagement*

	N	Typical Use	Regulation	Role of AI	Grade in Class
Intentional	15	Planning, feedback, revision	High: iterative evaluation, selective adoption	Scaffold for thinking and revision	Mostly A-/A
Minimal	8	Occasional brainstorming, none	High: selective non-use based on task needs	Optional / unnecessary tool	Mostly A-/A
Offloading	7	Drafting, outlining, summarizing, research	Lower: early reliance, limited evaluation	Substitute for cognitive effort	Mixed A-C

**Intentional use: regulated tool integration.** Students in this group (n=15) demonstrated active control over when and how to use AI. They typically generated initial ideas independently, used AI to refine or evaluate

those ideas, and iteratively assessed AI output before incorporating it into their writing. These students frequently used AI for feedback, revision, and planning, often treating it as a collaborator or tutor or using it to provide their audience’s perspective, “After getting some [human] feedback I turned to some AI, I gave the AI the prompts of the assignment and asked it to pretend it was the professor and basically tell me how it would react to my email and what could be improved. This helped a lot in refining my email and eventually gave me a pretty good grade on the assignment.” From a learning sciences perspective, these patterns reflect metacognitive regulation of tool use. Students monitored the usefulness of AI output, compared it with their own ideas or human feedback, and made deliberate decisions about whether to adopt or reject suggestions. This aligns with the WWC model, in which writing involves coordinating cognitive processes with available tools. Here, AI functioned as a mediational resource that supported higher-order processes such as audience awareness, argument development, and revision—without displacing student agency.

**Minimal use: agentic non-adoption.** A smaller group of students (n=8) reported limited or no use of AI. These students often expressed confidence in their existing writing practices or a preference for relying on their own effort, “[Tool] was used during the peer review process, which was fairly amusing, but I did not end up using it in my part of the writing.” In some cases, they acknowledged potential usefulness of AI but chose not to engage with it. Importantly, this pattern reflects selective and agentic non-adoption, rather than absence of capability. From a regulatory perspective, these students exercised control by determining that AI was unnecessary for their goals. This suggests that AI literacy includes not only effective use of tools but also informed decisions about when not to use them. However, because these students engaged less with AI, it remains unclear whether they are developing the evaluative skills needed to navigate AI-supported writing in future contexts.

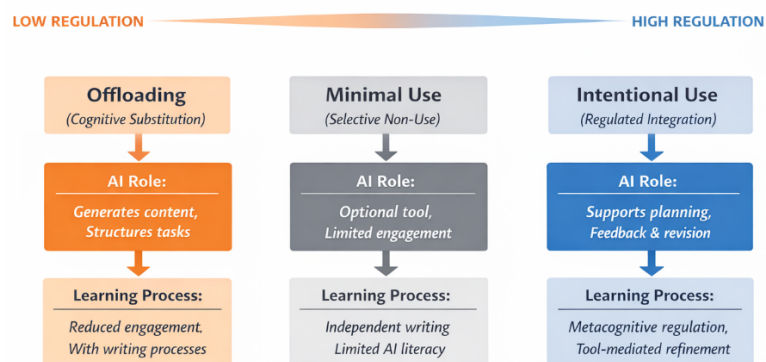
**Offloading: reduced regulation and cognitive substitution.** A third group of students (n=7) frequently used AI to generate content, structure assignments, or summarize readings, often at early stages of the writing process. In these cases, AI may have been used to replace rather than support key cognitive activities such as ideation or comprehension. Time constraints and lack of confidence were commonly cited as reasons for this reliance, “The use of the AI definitely helped reduce the time it took to finish the assignment.” These patterns suggest reduced self-regulation, where AI use substitutes for, rather than scaffolds, engagement with the writing task. While some students still modified AI-generated output, their process often began with AI rather than their own ideas. From a sociocultural perspective, this reflects a shift in how the mediational tool is taken up: instead of extending the writer’s capabilities, the tool assumes a more directive role in shaping the work. Although some students in this group demonstrated emerging awareness of AI’s limitations, their use patterns raise concerns about diminished opportunities for developing writing expertise.

### Cross-group comparison: AI as a mediational tool shaped by regulation

Across these groups, the key difference lies not in whether AI was used, but in how students regulated their interaction with it. Intentional users integrated AI into a cycle of planning, monitoring, and evaluation; minimalists exercised control through selective non-use; and offloaders relied on AI in ways that reduced engagement with core writing processes. As shown in Figure 1, the key distinction across groups lies in how students regulate AI use, which shapes whether AI functions as a substitute for or scaffold of writing processes. These findings suggest that generative AI does not have a uniform effect on learning to write. Instead, its impact depends on how it is incorporated into students’ self-regulatory practices. In this sense, AI functions as a mediational tool whose role is shaped by the writer’s agency: it can either support writing practices or displace critical aspects of them.

**Figure 1**

*AI as a mediational tool across levels of regulation*



## Reflection as a mechanism for developing regulation and AI literacy

Students' field notebook reflections provide evidence that structured reflection can support the development of self-regulation and AI literacy. Many students described becoming more deliberate in their use of AI over time, including questioning the accuracy of outputs, evaluating alignment with their intent, and adjusting their prompting strategies, "While AI supported my writing process by offering suggestions and saving time, I also learned the importance of critical thinking and personal revision to ensure accuracy and authenticity." In several cases, students explicitly noted that AI use prompted deeper engagement with their writing, as they had to assess whether suggestions "made sense" and aligned with their goals, "using AI didn't just make things easier. It actually made me more careful. I started questioning whether the suggestions made sense, whether they fit what I wanted to say, and whether they were supported by good evidence. These tools helped a lot, but the biggest learning came from being deeply involved in the topic and thinking hard about how to communicate it well." Reflection may be functioning as a mediating practice that helps students maintain agency in AI-supported writing environments. We also saw that some students linguistically distanced themselves from AI by referring to it in the third person. This pattern suggests emerging norms around authorship and responsibility, and highlights the tension between using AI as a tool and maintaining ownership of one's work. Such positioning may reflect students' attempts to reconcile institutional expectations with evolving practices of AI-assisted writing.

## Conclusions

This study examined how engineering students integrated generative AI into their writing processes. Rather than treating AI use as a binary of adoption or non-adoption, our findings show that the key distinction lies in how students regulate their interaction with AI. Across the three observed patterns—intentional use, minimal use, and offloading—AI functioned as a mediational tool whose role shifted from supporting metacognitive engagement to substituting for core writing processes.

By situating these patterns within a sociocultural and writer(s)-within-community framework, this study contributes to learning sciences research by demonstrating that AI-mediated writing is fundamentally shaped by agency and self-regulation. When students actively plan, evaluate, and adapt AI output, the tool supports higher-order processes such as revision, audience awareness, and rhetorical decision-making. In contrast, when AI is used to replace early-stage thinking or comprehension, opportunities for developing writing expertise may be reduced. Importantly, students who chose not to use AI at all also exercised agency, suggesting that AI literacy includes the capacity to make informed decisions about both use and non-use.

These findings have implications for the design of AI-integrated writing instruction. First, structured reflection appears to play a critical role in supporting students' metacognitive awareness of both their writing and their AI use. Second, instruction should explicitly model not only how to use AI effectively, but also how to evaluate its output and determine when it is appropriate to engage with it. Third, AI tools and pedagogical approaches should be designed to scaffold regulation rather than automate production, supporting students in maintaining ownership over their writing processes.

The study also highlights emerging tensions around authorship and accountability, as some students linguistically distanced themselves from AI in their reflections. This suggests that norms for acceptable AI use in academic writing are still evolving and may shape how students position themselves as writers.

Several limitations should be noted. Because AI use was optional, the dataset may overrepresent students who were more inclined toward engagement with AI or reflection, limiting generalizability. In addition, the analysis relies on self-reported reflections rather than direct observation of writing processes. Future work could triangulate reflections with writing artifacts, AI interaction logs, or interviews to better understand how students' practices develop over time. We also realize that as communities of writers create expectations of appropriate (and inappropriate) AI use in writing, we may well see a shift in best practices. Even now we see a suggestion that perhaps AI use is not acceptable even when permitted as shown by the passive voice in reflections. Tracing what is and is not acceptable in various settings will be important, particularly for instructors of disciplinary writing attempting to apprentice students into a particular profession.

Overall, this study suggests that the impact of generative AI on learning to write depends not on the presence of the tool, but on how it is taken up within students' regulatory practices. Designing learning environments that support agentic, reflective, and critically informed use of AI will be essential as these tools become increasingly embedded in academic and professional writing contexts. We highlight the need for both strong self-regulation when integrating generative AI into their writing process and AI literacy to do so effectively.



## References

- Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Sage.
- Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, 32(4), 365–387. <https://doi.org/10.2307/356600>
- Gerlich, M. (2025). AI tools in society: Impacts on cognitive offloading and the future of critical thinking. *Societies* 15, no. 1: 6. <https://doi.org/10.3390/soc15010006>.
- Graham, S. (2018). A revised writer(s)-within-community model of writing. *Educational Psychologist*, 53(4), 258-279.
- Handa, K., Bent, D., Tamkin, A., McCain, M., Durmus, E., Stern, M., Schiraldi, M., Huang, S., Ritchie, S., Syverud, S., Jagadish, K., Vo, M., Bell, M., & Ganguli, D. (2025, April 8). Anthropic education report: How university students use Claude. Anthropic. <https://www.anthropic.com/news/anthropic-education-report-how-university-students-use-claude>
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation* (1st ed.). Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>
- Miles, M. B., & Huberman, A. M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational Researcher*, 13(5), 20-30.
- Tate, T. P., Harnick-Shapiro, B., Ritchie, D. R., Tseng, W., Dennin, M., & Warschauer, M. (2025). Incorporating generative AI into a writing-intensive undergraduate course without off-loading learning. *Discover Computing*. <https://doi.org/10.1007/s10791-025-09563-9>
- Vygotsky, L. S. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.

## Acknowledgments

This work has been supported by funding from the National Science Foundation (2315294) and the California Learning Lab AI Grand Challenge.