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Reflecting with AI: Integrating Weekly AI Use Reflections to Foster Critical and Ethical AI Literacy in First-Year Engineering Design

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Abstract

As artificial intelligence (AI) tools become embedded in professional engineering practice, developing students' ability to use these tools critically and responsibly has emerged as a key pedagogical priority. This paper describes the design and early implementation of a low-stakes reflective assignment intended to promote AI literacy within a first-year engineering design course at a small public campus within a large public university system. The Weekly AI Use Reflection activity invited students to post brief weekly reflections describing how they used AI in their coursework (e.g., brainstorming design concepts, troubleshooting SolidWorks models, or developing research questions) and to evaluate the usefulness, accuracy, and appropriateness of AI-generated responses.

To encourage peer learning, participating students also responded to classmates' posts with constructive commentary or follow-up questions, creating an asynchronous dialogue around effective and responsible AI use in engineering contexts. Over ten instructional weeks, students demonstrated greater sophistication in how they applied AI for ideation, problem-solving, and technical communication. Preliminary thematic analysis suggests a shift from passive information-seeking toward more active, metacognitive engagement, with students increasingly positioning AI as a collaborative design support rather than an answer-providing shortcut.

This paper presents the assignment structure, grading approach, and implementation considerations for this scalable, IRB-exempt classroom practice, along with preliminary findings illustrating students' developing AI literacy and reflective judgment. Across the study period, 42 students contributed 148 reflection posts and 94 peer responses. The paper concludes with plans for continued qualitative analysis and future integration of reflective AI activities into broader engineering curricula.

1. Introduction

Artificial intelligence (AI) tools—such as generative text models, image generators, and code assistants—are rapidly becoming embedded in engineering workflows [1]. Professional engineers now routinely use AI for tasks including brainstorming concepts, exploring design alternatives, documenting decisions, debugging code, and conducting background research [2], [3], [4]. As these tools proliferate, engineering programs face an emerging pedagogical challenge: preparing students not only to use AI effectively, but also to evaluate its outputs critically and apply it responsibly within ethical and professional boundaries.

First-year engineering courses are a particularly appropriate context for cultivating these skills. During this early stage, students are forming foundational habits related to design thinking, documentation practices, and information-seeking behaviors. Introducing structured opportunities for reflection around AI use can help normalize transparency, ethical deliberation, and critical evaluation early in the curriculum. This paper describes the implementation of a Weekly AI Use Reflection assignment situated in an introductory engineering design course at a **small public campus within a large public university system**. The assignment encouraged students to articulate how they used AI tools, critique the accuracy and limitations of AI-generated content, and engage in peer dialogue about responsible AI use in engineering contexts. Within this context, AI use was often embedded in design-related tasks such as CAD modeling, prototyping, and visual communication, positioning this work within the broader domain of engineering design learning rather than general AI use alone.

This instructional intervention responds to growing calls for **AI literacy** in engineering education that extend beyond tool proficiency to include ethical awareness, reflective judgment, and metacognitive engagement. Rather than prohibiting AI use or treating it solely as a productivity aid, the assignment positions AI as a collaborative design support whose value and limitations must be actively interrogated by students through reflective practice and peer discourse.

2. Background and Motivation

2.1 AI Literacy in Engineering Education

Recent literature highlights the growing need for engineering graduates to develop competencies in AI-assisted problem solving, human–AI collaboration, and ethical reasoning [5], [6]. As AI tools become increasingly accessible, students are encountering them early in their academic careers, often without structured guidance on how to evaluate AI limitations, biases, or appropriate roles in engineering work. In many undergraduate contexts, AI use is either discouraged through restrictive policies or left largely unexamined, resulting in informal, inconsistent, and sometimes uncritical student practices.

In response, engineering education scholars have called for approaches to AI literacy that extend beyond tool proficiency to emphasize critical evaluation, transparency, and responsible decision-making [7]. These perspectives stress the importance of helping students understand not only how AI tools can support engineering tasks, but also when human judgment, verification, and domain expertise are required to ensure appropriate use.

In this paper, AI literacy is defined as students' ability to use AI tools transparently and effectively while critically evaluating AI-generated outputs for accuracy, appropriateness, and limitations within engineering design contexts. This definition foregrounds evaluative judgment and responsibility as central components of AI literacy, particularly for novice engineers engaging with AI-supported design and problem-solving activities.

2.2 Metacognition and Self-Regulated Learning

Reflection is a well-established mechanism for promoting metacognition and self-regulated learning. Flavell's metacognition framework emphasizes learners' awareness of and control over their cognitive processes, including planning how to approach a task, monitoring progress, and evaluating outcomes [8], [9]. These processes are particularly important for novice learners, who may otherwise focus primarily on task completion rather than on the quality of their reasoning or decision-making.

Complementing this perspective, Zimmerman's self-regulated learning model characterizes learning as a cyclical process involving forethought, performance, and self-reflection [10]. Within this cycle, learners set goals and select strategies, monitor their performance, and reflect on outcomes to adjust future actions. Reflection plays a central role in linking these phases by enabling learners to identify strengths, recognize limitations, and refine strategies over time.

Together, these theories help explain how novices develop more expert-like approaches to problem solving. In engineering contexts, novice students often exhibit answer-seeking behaviors, while more expert practitioners engage in strategic reasoning, evaluate information sources, and iteratively refine solutions. Structured reflective activities support this transition by making students' decision-making processes explicit and by encouraging monitoring, evaluation, and adjustment of strategies during authentic engineering tasks.

Weekly AI use reflections provide repeated opportunities for students to practice metacognitive monitoring and self-regulation in the context of AI-assisted design work. By requiring students to evaluate AI-generated output, articulate their reasoning, and reflect on how AI influenced their design decisions, the activity encourages students to regulate their reliance on AI across different tasks rather than accepting AI responses uncritically.

2.3 Ethical Reasoning and Responsible AI Use

Ethical reasoning and professional responsibility are core outcomes emphasized in engineering education. Recent calls from engineering education organizations and professional bodies (including ASEE, IEEE, and ABET) highlight the growing importance of ethical AI literacy as AI tools become increasingly embedded in engineering practice[11], [12]. These calls emphasize that engineering graduates must be prepared not only to use AI tools effectively, but also to do so with transparency, verification, accountability, and professional judgment.

Within engineering design contexts, responsible AI use requires careful evaluation and verification of AI-generated outputs. Because AI systems can produce responses that are plausible yet inaccurate, incomplete, or biased, uncritical reliance on AI poses ethical risks that extend beyond academic integrity to professional responsibility for design decisions and downstream consequences. Developing habits of transparency and verification is therefore essential when AI is used to support engineering design decisions, analysis, modeling, or technical communication.

Prior research in engineering and other technical disciplines suggests that reflective activities can foster ethical awareness by prompting learners to examine their decision-making processes and the implications of their actions [13]. By asking students to explicitly document how AI tools are used, evaluate the appropriateness and reliability of generated content, and justify final design choices, reflection supports ethical reasoning in authentic technical contexts. Integrating AI-focused reflection into engineering design courses helps students develop professional norms for responsible human–AI collaboration and reinforces expectations aligned with accreditation and professional standards.

2.4 Peer Learning and Sociocultural Theory

Sociocultural theories of learning, grounded in Vygotskian perspectives, emphasize the central role of social interaction and discourse in knowledge construction and professional identity development [14]. From this view, learning is not solely an individual cognitive process, but is shaped through participation in shared practices, dialogue, and negotiation of meaning within a community. Discourse functions as a key mechanism through which learners articulate reasoning, encounter alternative perspectives, and internalize disciplinary norms.

Within engineering education, peer interaction and reflective dialogue have been associated with students' development of engineering identity and professional reasoning [15]. Opportunities to discuss problem-solving strategies, design decisions, and tool use allow students to make their thinking visible, compare approaches, and align their practices with disciplinary expectations. Such interaction is particularly valuable for novice learners, who benefit from exposure to peers' reasoning and from observing how others navigate uncertainty and ambiguity in engineering tasks.

Peer feedback in reflective assignments can provide a structured and formative environment for this type of sociocultural learning [16]. When students respond to classmates' reflections, they engage in questioning, elaboration, and strategy sharing that extends learning beyond individual reflection. In the context of AI use, peer replies create a low-pressure space where students exchange prompting strategies, compare tools, and collectively negotiate appropriate roles for AI in engineering work. Through this dialogic process, norms around verification, judgment, and responsible AI use are reinforced, supporting disciplinary sensemaking and community-oriented learning.

2.5 Reflection as a Tool for Ethical and Critical Engagement

Reflective writing has long been recognized as an instructional strategy for supporting metacognition, self-regulated learning, and ethical awareness in engineering education[17]. Across these perspectives, reflection functions as a mechanism that makes students' reasoning visible, prompting them to examine how decisions are made, what information is relied upon, and how alternative actions might lead to different outcomes.

When reflection is focused specifically on AI use, it creates a routine practice of transparency and accountability. Asking students to document what they asked an AI system, how they evaluated the response, and how the output influenced their final decisions encourages both critical evaluation and ethical awareness. Rather than treating AI use as implicit or invisible, reflective documentation foregrounds students' responsibility for judgment, verification, and decision-making in AI-supported work.

In this study, reflection serves as the central pedagogical mechanism linking metacognitive regulation, ethical reasoning, and peer-mediated learning. By embedding reflective prompts within authentic engineering design tasks, the Weekly AI Use Reflection activity positions critical and ethical AI engagement as an integral part of everyday engineering practice rather than as a separate or abstract consideration.

2.6 Gap Addressed by this Work

Despite the rapid growth in the availability and classroom adoption of generative AI tools, engineering education research has limited empirical documentation of how first-year engineering students use AI during routine design coursework, how they evaluate AI-generated outputs, and how these practices evolve over time within authentic course sequences. Existing discussions and review-based work on AI in engineering education frequently emphasize institutional policy, academic integrity, curricular integration frameworks, or tool capabilities [18], [19], while comparatively fewer empirical studies examine students' self-reported decision-making processes during everyday course activities, particularly in early-stage design contexts such as ideation, CAD troubleshooting, prototyping, and technical communication.

In addition, while recent conceptual and review-based studies acknowledge the importance of socially shared regulation and peer interaction in AI-supported learning environments [20], [21], relatively few empirical studies have closely examined peer discussion spaces as a learning mechanism through which students exchange AI use strategies, negotiate norms, and develop evaluative judgment in authentic engineering coursework.

This study addresses these gaps by analyzing low-stakes weekly reflection posts and peer replies collected in a first-year engineering design course. The analysis provides descriptive and thematic insight into students' evolving AI use practices, evaluation criteria, and peer-mediated sensemaking within a naturalistic instructional setting, laying the groundwork for deeper qualitative analysis in future work. To clarify the alignment between instructional design, reflective documentation, and analytic focus, Figure 1 illustrates how the Weekly AI Use Reflection functions simultaneously as a pedagogical scaffold and as a data source for examining students' developing AI literacy. Accordingly, this work is positioned as an exploratory, descriptive study that documents emerging patterns in first-year students' AI use and peer-mediated sensemaking, rather than as a summative evaluation of learning outcomes.

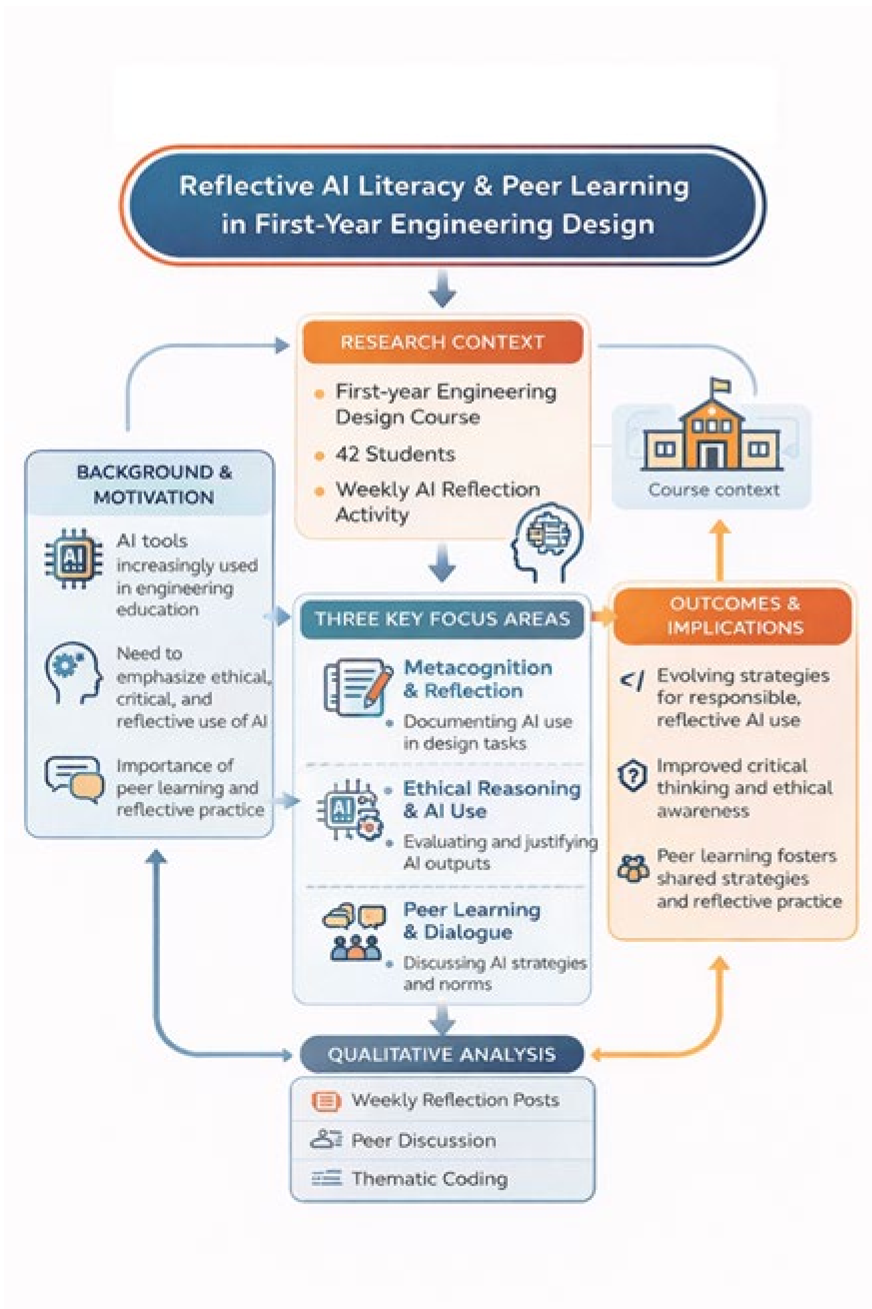

Figure 1 - Overview of the Weekly AI Use Reflection intervention and analytic focus

3. Methods

3.1 Study Design and Context

This study examines students' documented use of AI tools in EDSGN 100: Introduction to Engineering Design, a first-year, semester-long engineering design course offered in person at Penn State Abington, a Commonwealth Campus of The Pennsylvania State University. The course was delivered during the Fall 2025 semester across two sections with a total enrollment of 42 students and emphasizes hands-on, team-based design projects addressing defined design opportunities. Instruction focuses on iterative design processes, computer-aided design (CAD) modeling using tools such as SolidWorks and AutoCAD, technical communication, and professional skills including teamwork, ethical decision-making, creativity, and consideration of sustainability and societal impact. Students are expected to prepare for class through assigned readings, instructional videos, homework, and active participation in group discussions, maintain complete design documentation, and complete a final team-based design project.

Consistent with the course syllabus, generative AI tools were permitted on an assignment-level basis, with specific guidance provided for each activity. The course AI policy emphasized student ownership of work, critical evaluation and verification of AI-generated content, adherence to academic integrity standards, and responsible AI use, including appropriate citation and avoidance of uploading copyrighted instructional materials.

Students primarily used general-purpose generative AI tools such as ChatGPT, Co-Pilot, and Google Gemini to support tasks including brainstorming, troubleshooting, and technical communication. These tools were not integrated directly into CAD environments; rather, students used them externally to support design-related problem solving, such as interpreting errors, generating ideas, or organizing information.

Throughout the semester, the instructor explicitly encouraged students to use AI as a supportive design and learning tool—such as for brainstorming design ideas, clarifying constraints, or troubleshooting modeling challenges—while emphasizing the importance of verification, iteration, and reflective evaluation of AI-generated outputs. AI use was framed as a collaborative aid rather than a substitute for student reasoning, and students were regularly reminded to document and critically assess how AI influenced their design decisions.

Within this instructional context, the study adopts an exploratory, classroom-embedded design, using students' weekly reflective discussion posts as qualitative data to examine emerging patterns in AI use, evaluation, and self-regulated learning.

3.2 Instructional Intervention: Weekly AI Use Reflection

The Weekly AI Use Reflection assignment was designed to promote intentional, transparent, and metacognitive use of AI tools in a first-year engineering design course. Rather than treating AI as a prohibited or purely instrumental resource, the assignment framed AI as a learning support tool whose effectiveness and limitations must be critically evaluated by students.

Across ten instructional weeks, students were invited to participate in brief, low-stakes reflective posts (minimum 3–4 sentences) in an asynchronous discussion forum. Participation in the reflection activity was optional and offered as bonus participation credit, allowing students to engage without academic penalty. The assignment was offered as bonus participation to encourage authentic, low-pressure reflection on AI use without penalizing students who were still developing confidence or familiarity with AI tools. In each reflection, participating students were asked to explicitly document their use of AI by identifying the specific course-related task for which the tool was used, describing the prompt or input provided to the AI system, summarizing the AI-generated response, and evaluating the usefulness of that response—whether helpful, partially useful, or unhelpful—along with a brief justification for their evaluation. An optional prompt encouraged students to reflect on how the experience might influence their future learning or problem-solving strategies.

To support peer learning and accountability, participating students were also encouraged to respond constructively to at least one classmate's post each week. Peer replies were expected to extend discussion by asking follow-up questions, offering contrasting experiences, or identifying transferable strategies, rather than providing superficial agreement. This structure encouraged exposure to diverse AI use cases and fostered a shared classroom discourse around effective and ethical AI use.

The assignment was intentionally structured as low-stakes bonus participation, with each weekly reflection contributing up to 0.1% toward the final course grade (10 reflections totaling up to 1%). Because the activity functioned as bonus credit, reflections were not required for course completion. Grading emphasized specificity, completeness, and peer interaction rather than correctness of AI use, reducing performance pressure while encouraging honest reflection.

From a research perspective, the Weekly AI Use Reflection served a dual purpose. Pedagogically, the activity was designed to support students' development of metacognitive awareness and self-regulated learning by requiring them to articulate how they used AI tools, evaluate the usefulness and limitations of AI-generated outputs, and reflect on how AI influenced their engineering design decisions. At the same time, the assignment encouraged critical evaluation of AI responses within authentic design tasks, reinforcing responsible and reflective AI use while generating rich qualitative data on students' learning processes. Students were informed that their reflections were part of regular coursework and graded solely as optional participation. Responses could be analyzed anonymously for engineering education research purposes, with no identifying information, grades, or personal data disclosed. This consent language was embedded directly in the assignment description to ensure transparency and ethical data use.

3.3 Data Sources

The data analyzed in this study consist of student-generated discussion posts collected from a Canvas-based discussion assignment associated with the Weekly AI Use Reflection activity in a first-year engineering design course. The dataset includes all original reflection posts and all peer responses submitted by students who chose to participate in the optional discussion over the semester examined.

Data were exported directly from Canvas in a format that preserves the native threaded discussion structure. In this system, each contribution, whether an original reflection or a reply, is displayed as a discrete entry with explicit author identification and timestamp metadata. Peer responses appear visually nested beneath the post to which they respond, preserving conversational context and making author attribution unambiguous. This structure allows clear differentiation between students who authored reflections and those who responded to peers, without relying on inferred boundaries or aggregation across posts.

Because the discussion interface records each contribution independently, the dataset captures both individual reflections on AI use and interactive peer engagement surrounding those reflections. Instances where posts were deleted by students are explicitly marked by the system (e.g., "Deleted by [student name]") and were retained in the dataset as structural indicators of participation without recoverable content. The chronological ordering of posts and replies was preserved in the export, enabling analysis of interaction sequences as they unfolded during the course.

For analytic purposes, each post and reply was treated as a discrete unit of data, with author attribution used to group contributions by participant across weeks. This approach supported both micro-level analysis of individual AI use episodes and macro-level examination of within-student patterns over time, while retaining the social and conversational dimensions of the discussion environment.

All data were analyzed in de-identified form. These data provide insight into both students' individual reflective processes and the peer-mediated exchange of strategies and experiences related to AI use. Student names were replaced with pseudonyms prior to coding and reporting, and no grades or identifying academic records were included in the research dataset. Reflection posts were graded for participation based on completeness and specificity; however, grading was conducted prior to de-identification and was not used as part of the research analysis.

3.4 IRB Status and Ethical Considerations

This study was conducted under an existing Institutional Review Board–approved protocol that permits the analysis of student coursework for engineering education research purposes. The protocol was approved as Exempt under Category 1 (normal educational practices). All analyses were conducted using de-identified student work, and participation in the research component did not affect student grades.

3.5 Analytical Approach

Data were analyzed using reflexive thematic analysis following Braun and Clarke's framework, with an iterative coding process that combined inductive and deductive approaches. Reflexive thematic analysis was selected due to its flexibility and suitability for examining patterns of meaning in students' reflective writing and peer discourse. Analysis focused on identifying patterns in how students described their use of AI tools, evaluated AI-generated outputs, and engaged with peers around AI-related strategies. Both original reflection posts and peer replies were included to capture individual sensemaking as well as interactional dimensions of learning.

Analysis proceeded through multiple cycles. First, all reflections and peer replies were read in full to develop familiarity with the dataset and to document preliminary patterns through analytic memos. Next, an initial coding framework was developed inductively from the data and refined using concepts from the literature on metacognition, self-regulated learning, and technology-supported learning. Codes were applied iteratively, with attention to patterns within individual students' reflections over time and similarities and differences across participants.

In the final stage, related codes were clustered into higher-level themes that captured salient dimensions of students' AI engagement. Theme development emphasized coherence, distinctiveness, and alignment with the research questions. An audit trail including coded excerpts and analytic memos was maintained throughout the process to support rigor and transparency. AI-based tools were used to support data organization and exploratory pattern identification; all coding decisions and interpretive judgments were made by the researchers.

3.5.1 Initial Open Coding (First-Cycle Coding)

During the first analytic cycle, inductive open coding was applied to students' weekly reflection posts and associated peer replies to capture descriptive features of AI engagement as documented by students. Codes were used to label elements such as the type of course-related task for which AI was used, the AI tool referenced, students' stated evaluations of usefulness or difficulty, challenges encountered during use, and forms of peer interaction evident in replies.

Both original reflections and peer responses were coded to support analysis of individual sensemaking as well as interactional learning processes within the discussion environment.

Analytic memos were maintained throughout this cycle to document recurring observations, note variation across tasks and tools, and support refinement of the coding framework for subsequent analytic stages.

3.5.2 Axial Coding (Pattern Identification)

In the second analytic cycle, axial coding was used to examine relationships among the descriptive codes generated during open coding and to develop more interpretive, process-oriented categories. This phase focused on identifying how students engaged with AI tools across tasks and time, including patterns in how students refined prompts, evaluated AI-generated outputs, compared responses across sources, and used AI to support troubleshooting or debugging.

Coded segments were compared within and across students' weekly reflections and peer replies to examine how these engagement strategies co-occurred with different tasks, tools, and forms of peer interaction. Categories were iteratively refined through comparison of coded excerpts and analytic memos, supporting development of coherent groupings that reflected recurring dimensions of students' AI-related learning processes. These categories informed subsequent theme development reported in the Findings section. A condensed version of the final codebook, including operational definitions and example excerpts, is provided in Appendix A.

3.5.3 Planned Second-Cycle Coding

In the next phase of the study, the full dataset will be coded using the refined codebook developed during axial coding to further strengthen analytic rigor. A second researcher will independently code a subset of the dataset in a subsequent phase of analysis to examine consistency and support reflexive discussion of the coding framework. Theme refinement and consolidation will be undertaken following Braun and Clarke's reflexive thematic analysis framework to strengthen the robustness of the final themes.

3.6 Researcher Positionality

The course instructor served as the primary researcher. To address potential bias associated with this dual role, all reflections were de-identified after grading, analytic memos were used to support reflexivity, and a second researcher was planned to participate in subsequent coding cycles. This positionality was explicitly acknowledged as part of reflexive qualitative methodology.

3.7 Validity, Trustworthiness, and Reliability

Analytic rigor was supported through triangulation of reflection posts, peer replies, and analytic memos, as well as peer debriefing with engineering education colleagues, contributing to the credibility and trustworthiness of the findings.

4. Descriptive Overview of AI Use and Peer Interaction

An initial thematic review of 25 first-year engineering student reflections suggested emerging shifts in students' AI engagement associated with the weekly reflective structure. Across weekly reflections, students reported using AI tools for a wide range of course-related tasks, including idea generation, writing support, research assignments, coding, concept selection, image generation, presentation preparation, and, in isolated cases, 3D printing support. Use of AI for CAD-related tasks (e.g., SolidWorks) was frequently described as challenging, with students noting difficulty interpreting errors or following step-by-step instructions. In response, several students reported experimenting with alternative AI tools, such as Google Gemini, which they perceived as more effective for certain tasks.

Peer interaction was also prominent in the discussion environment. Students frequently engaged with classmates' reflections by asking follow-up questions, comparing tools, and validating or refining AI use strategies. In several cases, students reported adopting strategies encountered in peers' posts in subsequent work. Explicit consideration of ethical issues related to AI use was not prominent at this stage, as reflections primarily focused on functional task support. Overall, peer interaction emerged as a recurring feature of students' documented AI use over time, and these descriptive patterns provided the foundation for subsequent thematic analysis.

4.1 Development of Metacognitive and Self-Regulated Learning Behaviors

Across weekly reflections, students commonly demonstrated a shift from using AI as a one-step answer provider toward more active, self-regulated engagement with AI tools. Early reflections frequently described AI use for low-risk, efficiency-oriented tasks such as summarization, grammar correction, or initial idea generation, with outputs often accepted with minimal modification. Over time, however, students increasingly described monitoring AI output, adjusting their interactions, and making selective decisions about when and how AI should be incorporated into their work. This progression appears to align with the sequencing of course assignments, which moved from early-stage brainstorming and project ideation to prototyping, final design decisions, and presentation preparation. As design tasks became more complex and consequential, students' reflections suggested more deliberate and evaluative AI use, indicating that the timing and structure of course activities may have shaped how students engaged with AI across the semester.

Students' responses to AI output varied systematically by task type. For creative or exploratory tasks—such as brainstorming, image generation, or presentation design—students often engaged in iterative prompting to refine outputs until they aligned with project goals. For more technical tasks, including SolidWorks modeling, coding, and prototyping, students described testing AI-generated suggestions in practice and rejecting outputs that were vague, impractical, or incompatible with software or physical constraints. In contrast, for highly structured, low-risk tasks such as citation creation in specific formats, students frequently treated AI output as a time-saving aid for generating or formatting references, with minimal discussion of the citation process in their reflections. Across these contexts, AI was framed as support for exploration rather than an authoritative source, with students emphasizing their own judgment in determining whether outputs were usable. These task-dependent differences illustrate how students adapted their AI use in response to both task demands and prior outcomes, reinforcing the role of reflective judgment in regulating AI engagement.

Students also articulated clear criteria for evaluating AI usefulness, frequently referencing efficiency, clarity, feasibility, and alignment with design constraints. Reflections indicated that AI was perceived as valuable when it reduced cognitive or time burdens, expanded the design space, or supported organization and planning, but less useful when it produced generic, misleading, or unimplementable results. Across the dataset, multiple students described refining prompts, switching AI tools, or narrowing AI use to specific stages of the design process in response to earlier experiences, indicating growing awareness of how to regulate AI use over time. Importantly, this pattern of strategic adjustment was evident across varied student trajectories, including those who expanded AI use into new contexts, those who became more selective after encountering limitations, and those who explicitly articulated boundaries around when AI was or was not appropriate. Collectively, these patterns suggest that students increasingly positioned themselves, not AI, as the primary decision-makers, demonstrating core features of metacognitive monitoring and self-regulated learning. The structured weekly reflection format appeared to support this development by prompting students to regularly evaluate, adjust, and justify their AI use across the semester.

4.2 Emergence of Ethical and Professional Awareness

In addition to changes in how students regulated their AI use, reflections revealed emerging ethical and professional awareness related to responsibility, accuracy, and appropriate reliance on AI-generated output. Although ethical considerations were not prominent in early reflections, later entries increasingly demonstrated that students viewed AI use through a lens of accountability rather than convenience. Rather than framing AI as an authority, students positioned themselves as responsible for evaluating correctness and ensuring that AI-supported decisions met engineering standards.

Students frequently described the need to verify AI-generated information before implementation, particularly for technical or safety-relevant tasks. This included testing AI-suggested solutions in software environments, rejecting outputs that could not be implemented successfully, and acknowledging limitations in AI-generated explanations. In these instances, students emphasized that AI could assist with ideation or structure but could not replace their own understanding or judgment. Such statements reflect an emerging recognition that responsibility for accuracy and consequences remains with the engineer, not the tool.

Notably, students' verification practices were primarily focused on functional feasibility rather than on source transparency. When AI was used to generate information from facts or background content, reflections seldom indicated that students independently traced claims to original sources or examined the provenance of information, unless inaccuracies became apparent during implementation. This suggests that verification was often triggered by practical breakdowns rather than by concerns about information origin.

In a related but distinct pattern, several students described using AI to generate citations by specifying a desired format (e.g., IEEE), yet reflections rarely addressed whether the resulting citations were reviewed for formatting accuracy or fidelity to the original sources. This reliance on AI for procedural correctness indicates that while students recognized the importance of citation conventions, responsibility for technical compliance was frequently delegated to the tool without further evaluation.

Ethical awareness also appeared in students' selective acceptance of AI output. Reflections indicated that students were more cautious when AI outputs influenced design feasibility, physical constraints, or testing protocols, and more willing to accept AI assistance for lower-risk tasks such as formatting, organization, or summarization. This differentiation suggests developing professional discernment about where AI use is appropriate and where uncritical reliance could pose risks. In several cases, students explicitly described revising or abandoning AI-generated suggestions after identifying inaccuracies, vagueness, or misalignment with project requirements.

While explicit references to academic integrity or formal ethical guidelines were limited, students' reflective reasoning demonstrated implicit ethical growth grounded in professional responsibility. Across the dataset, students increasingly articulated that AI-supported work required human oversight, validation, and accountability. These patterns indicate that ethical and professional awareness emerged not as abstract principles, but through practical engagement with AI's limitations and the consequences of applying AI-generated output in engineering contexts.

4.3 Peer Learning as a Mechanism for Disciplinary Sensemaking

Peer interaction played a central role in shaping how students interpreted, evaluated, and legitimized the use of AI within the course. Through weekly peer replies, students engaged in an ongoing, socially mediated process of sensemaking around appropriate AI use in engineering contexts. Rather than functioning solely as individual reflections, the discussion environment supported the comparison of experiences, the exchange of strategies, and the collective negotiation of norms related to AI-supported work.

Students frequently used peer replies to inquire about prompting strategies, tool selection, and troubleshooting approaches. These interactions often prompted students to reconsider their own AI use, including adopting alternative prompting methods, exploring new AI tools, or applying strategies observed in classmates' posts to subsequent assignments. In several instances, peer replies prompted metacognitive reflection, as students compared prompting strategies and recognized how differences in question framing influenced the scope and usefulness of AI-generated responses. Peer interaction also supported observational learning, as students identified previously unconsidered AI uses and adopted concrete strategies—such as organizing AI output in bullet form for later synthesis—after reviewing classmates' examples and follow-up explanations. In this way, peers served as informational resources that expanded students' awareness of how AI could be used across different tasks and stages of the design process.

Peer replies frequently extended beyond affirmation to include follow-up questions, strategy suggestions, and reflections on shared challenges (e.g., prompting trial-and-error, tool selection, feasibility testing, and visualization choices), indicating that students collectively negotiated effective and responsible AI use through dialogue.

Peer interactions also functioned as a site for critical evaluation and validation. Students commonly responded to classmates by questioning the feasibility or accuracy of AI-generated suggestions, affirming cautious decision-making, or reinforcing the importance of verification. Such exchanges contributed to the normalization of reflective and responsible AI use, as students implicitly communicated expectations around testing, judgment, and accountability. Rather than relying on instructor directives alone, students encountered these norms through peer discourse, which helped legitimize careful and selective AI engagement.

Importantly, peer-mediated sensemaking extended beyond technical strategies to include broader reflections on AI's limitations and appropriate boundaries. Students acknowledged shared frustrations with unclear or impractical AI outputs and recognized that others encountered similar challenges. This collective recognition appeared to reduce overreliance on AI by situating AI use as a common problem-solving tool—one that required human oversight—rather than a shortcut or authority. Across the dataset, peer interaction consistently supported students' developing understanding of AI use as a socially situated practice shaped by disciplinary expectations and collective experience.

5. Discussion

This study examined how a low-stakes, structured weekly reflection activity supported first-year engineering students' engagement with AI tools. Collectively, the findings suggest that reflective documentation—paired with peer interaction—can foster meaningful development in students' metacognitive regulation, ethical awareness, and socially mediated sensemaking around AI use in engineering design contexts.

5.1 Pedagogical Implications for AI-Supported Engineering Education

Findings from Section 4.1 indicate that students' AI use evolved toward more strategic and self-regulated engagement, particularly as task demands increased over the semester. Rather than treating AI as an answer-providing shortcut, students increasingly monitored output quality, adjusted prompts, tested feasibility, and selectively incorporated AI support based on task demands. Similar patterns of strategic and selective AI engagement have been reported in AI-integrated design studios, where students increasingly treated AI as a collaborative tool requiring human judgment rather than as an answer-providing shortcut[22]. From a pedagogical perspective, this suggests that requiring students to regularly articulate how and why they used AI can scaffold metacognitive regulation, even in early-stage engineering coursework [23], [24].

Importantly, this shift occurred without direct instruction on "how to use AI correctly" in this course, indicating that the reflective structure itself may play a critical role in supporting responsible AI engagement [25], [26].This trajectory aligns with observations from professional knowledge-work settings, where users develop evaluative, judgment-driven AI practices through hands-on use rather than formal instruction, learning to verify outputs and recognize limitations through experience [27], [28].

The emergence of ethical and professional awareness (Section 4.2) further underscores the value of reflective practices. Students did not typically frame ethics in abstract terms or explicitly reference policy; instead, ethical reasoning emerged through practical decision-making, such as verifying outputs, rejecting misleading suggestions, and acknowledging personal responsibility for correctness and consequences. This aligns with professional engineering norms, where ethical judgment is often enacted through practice rather than formal declarations [29].

Pedagogically, these findings suggest that embedding AI use within authentic design tasks—that require students to test feasibility, make trade-offs, and take responsibility for outcomes—may be more effective for fostering ethical awareness than standalone AI ethics instruction [30]. Prior work similarly indicates that ethical and professional awareness is most effectively cultivated when ethical considerations are integrated into authentic, task-based AI use, enabling learners to develop agency and responsibility through engagement with the real consequences of AI-supported decisions [30]

Peer interaction, examined in Section 4.3, played a central role in extending learning beyond individual reflection. Through peer replies, students exchanged strategies, questioned assumptions, and collectively negotiated norms for appropriate AI use. Prior work in dialogic AI-supported learning environments shows that peer interaction plays a central role in shaping how students move from instrumental AI use toward more reflective, judgment-driven engagement, as they exchange strategies, question AI outputs, and renegotiate appropriate human–AI roles through interaction [31] . These interactions positioned AI literacy as a socially situated practice, shaped by disciplinary expectations and community dialogue rather than individual experimentation alone [20], [21]. For instructors, this highlights the importance of designing AI-related assignments that leverage peer discourse, allowing students to learn not only from AI tools, but also from each other's successes, challenges, and judgments [32], [33].

5.2 Design Principles for Reflective AI Integration

Taken together, the findings suggest several preliminary design principles for integrating AI into engineering education. First, low-stakes, recurring reflection encourages experimentation while reducing pressure to optimize or conceal AI use. Second, prompting students to evaluate AI output, rather than merely report use, supports metacognitive and ethical development. Third, structured peer engagement transforms individual AI use into collective sensemaking, reinforcing disciplinary norms. Finally, task-embedded AI use, particularly in design and prototyping contexts, naturally surfaces questions of feasibility, responsibility, and judgment.

These design principles align closely with prior research on AI integration in engineering education, which emphasizes the importance of embedding AI use within authentic, task-based, and socially mediated learning environments [18], [19], [34]. Recent reviews and conceptual frameworks highlight that students develop metacognitive regulation, professional judgment, and ethical awareness most effectively through hands-on interaction with AI tools, supported by reflection and peer dialogue, rather than through standalone instruction or prescriptive guidelines [19], [21], [35]. Across this literature, low-stakes experimentation, evaluation of AI outputs, and collaborative sensemaking are consistently identified as mechanisms through which learners move from instrumental use toward responsible, judgment-driven engagement with AI [34], [35], [36]. Together, these findings reinforce the view that intentional pedagogical framing, rather than sophisticated tools or rigid restrictions, is central to fostering meaningful AI literacy in engineering education [18], [19], [36].

5.3 Limitations and Future Work

Several limitations should be considered when interpreting the findings of this study. Because the findings reported here reflect preliminary thematic analysis conducted by the course instructor as primary researcher, full inter-coder comparison has not yet been completed and represents an important next step for strengthening analytic rigor. While analytic memos, de-identification procedures, and audit trails were used to support reflexivity and transparency, subsequent phases of this work will incorporate independent coding and reflexive comparison to further refine themes and enhance trustworthiness.

Second, self-selection bias is an inherent limitation. Because the Weekly AI Use Reflection assignment was optional and offered as bonus participation credit, students who chose to participate may have been more motivated, reflective, or already inclined toward intentional or responsible AI use than their peers, and the dataset may therefore overrepresent students with higher engagement in metacognitive reflection.

In addition, this study reflects preliminary patterns derived from qualitative analysis of student reflections within a single course context. Findings should therefore not be interpreted as causal claims nor as broadly generalizable across courses or institutions, but rather as exploratory insight into how students describe and negotiate AI use within a specific instructional and social setting.

Future work will extend this analysis through more comprehensive second-cycle qualitative coding, including inter-rater comparison, and will examine longitudinal trajectories of individual students' AI use across the semester to better understand how reflective practices and peer interaction evolve over time. Subsequent studies will also explore the extent to which reflective and peer-mediated AI practices transfer to other engineering contexts and may examine how explicit instruction on AI ethics interacts with reflective and discussion-based approaches to shape students' AI use, metacognitive awareness, and decision-making practices.

6. Conclusion

This study examined how a structured, low-stakes reflection activity can support students' engagement with AI tools in a first-year engineering design context. The Weekly AI Use Reflection assignment offers a scalable and adaptable approach for fostering critical and responsible AI literacy by prompting students to document, evaluate, and reflect on their AI use while engaging with peers' experiences, situating AI use within authentic engineering practice rather than as a shortcut or purely instrumental aid.

Analysis of student reflections and peer interactions suggests that students used AI across a wide range of engineering tasks and developed increasingly intentional, evaluative strategies over time. Patterns related to verification, troubleshooting, and accuracy checking were associated with metacognitive regulation, while peer comparisons, prompting strategies, and collaborative reasoning highlighted the role of peer-mediated learning; although explicit ethical reflection was limited early on, instances of transparency, bias awareness, and responsible use emerged as meaningful elements of students' reflections.

Taken together, these findings indicate that reflective and discussion-based AI activities can support students in moving beyond surface-level tool use toward more deliberate, context-aware engagement with AI. While this work presents preliminary findings from a single course context, it demonstrates the potential of structured reflection and peer dialogue to scaffold students' developing AI literacy and promote responsible AI use in early engineering education.

7. References

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