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WIP: Enhancing Online Engineering Learning through Reflective and Ethical Generative AI Chatbots

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WIP: Integrating Reflective and Ethical Generative AI Chatbot to Enhance Learning in Online Engineering Education

1. Introduction

Engineering education is fundamentally practice-driven and iterative: students learn by applying concepts across varied problems, articulating assumptions, and evaluating trade-offs. In asynchronous online courses, providing sustained, individualized feedback that supports this type of reasoning is challenging because instructor interaction is necessarily limited [1]. Large language models (LLMs) and conversational agents offer a potential mechanism for scaling formative dialogue, but generic chatbots often provide solutions without pedagogical scaffolding, which can reinforce passive, answer-seeking behavior [2].

Prior research on artificial intelligence, supported learning in engineering education highlights both instructional potential and pedagogical risk, particularly in introductory and online contexts. Early work on intelligent tutoring systems demonstrated that adaptive dialogue and automated feedback can improve engagement and conceptual understanding when aligned with learning objectives and grounded in cognitive theory [3], [4].

Recent work highlights the role of data-driven and analytics-based approaches in improving student engagement and learning in online engineering education [5]-[7]. Studies on LLMs emphasize their ability to support explanation, reflection, and iterative reasoning, yet caution that unstructured use may promote surface learning, shortcut problem solving, and reduce epistemic effort [8], [9]. In higher education, scholars have noted growing concerns about academic integrity and overreliance on generative AI, particularly in foundational courses where students are still developing professional judgment and problem-framing skills [10]-[12]. Advances in artificial intelligence and continual learning systems further support adaptive knowledge representation and scalable instructional design [13]-[16]. In parallel, research emphasizes experiential, simulation-based, and industry-aligned learning environments as essential for developing professional skills and preparing students for complex engineering challenges [17]-[20].

Ethics education research consistently underscores the importance of scenario-based learning, reflective writing, and guided discussion to foster ethical sensitivity, stakeholder awareness, and principled decision-making [21], [22]. Accreditation and professional bodies similarly emphasize that ethical reasoning must extend beyond rule memorization to include contextual analysis and justification [23], [24]. While conversational agents have been explored in higher education to support reflection and metacognition [25]-[27], few studies examine discipline-specific chatbots explicitly designed around professional codes of ethics in engineering. Consequently, there remains a gap in the literature regarding how scaffolded, ethics-focused conversational agents can be integrated into introductory engineering courses to support ethical reasoning without displacing student ownership of analysis, an issue this study begins to address.

This work-in-progress (WIP) reports the design and early implementation of a discipline-specific ethical reasoning chatbot. The chatbot is framed as an “ethics mentor” grounded in the National Society of Professional Engineers (NSPE) Code of Ethics [24], embedded in *Introduction to Engineering* (ENGR 101).

2. Theoretical framework

This design is guided by two complementary foundations: metacognitive reflection and scenario-based ethical reasoning. Reflection supports students in monitoring their thinking, integrating conceptual and procedural knowledge, and evaluating the validity of their solutions.

In engineering education, reflective activities help students surface assumptions, connect mathematical reasoning to physical intuition, and strengthen transfer across contexts [28]. At the same time, reflection is frequently underemphasized due to time constraints and the prevalence of solution-focused instruction, motivating structured supports that can be embedded directly within coursework. Ethical reasoning is also central to professional formation and is stated in ABET student outcomes related to ethical and professional responsibility. Effective ethics instruction requires guided engagement with authentic dilemmas where technical, environmental, human, and societal factors intersect. Scenario-based learning is important as it requires students to justify trade-offs and consider stakeholder perspectives, rather than merely recalling a professional code.

A key implication for generative AI is that conversational fluency is not equivalent to instruction. LLMs are not inherently pedagogical and can provide answers without scaffolding, reinforcing passive learning unless intentionally designed around disciplinary reasoning and structured prompts. Accordingly, the chatbot described in this WIP adopts a discipline-specific design philosophy: it is structured around ethical reasoning practices (issue framing, evidence-based justification, code mapping, and professional action planning) rather than answer generation.

Instruction follows a practice-to-application structure: students first use the chatbot with a practice case to learn the interaction format, then apply the same reasoning structure to a course-adopted, real-world ethical scenario that has been used previously in ENGR 101 as a written ethics assignment. **Figure 1** shows the instructional sequence for chatbot-supported ethical reasoning activities in the Introduction to Engineering ethics module.

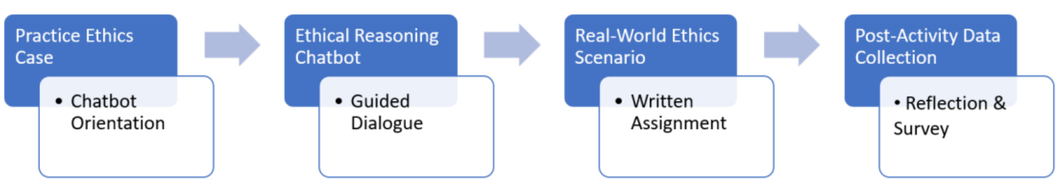

Figure 1: Instructional sequence for chatbot-supported ethical reasoning activities in the *ENGR 101*.

3. Preliminary results

The chatbot is implemented in ENGR 101 as part of the Engineering Code of Ethics module through a custom web application embedded within the course learning management system. Students complete the chatbot activity within the course environment and submit the resulting transcript as their assignment artifact. The chatbot follows an assignment-aligned sequence intended to generate a submission-ready reasoning trace. First, students summarize the case (stakeholders and central dilemma) and the chatbot probes for missing elements to ensure a sufficiently detailed starting point. Next, it supports "engineer role framing" by prompting students to identify likely engineering responsibilities and constraints (e.g., scope, client pressure, schedule/budget, and regulatory requirements). Students then select at least two NSPE Fundamental Canons they judge relevant and justify why they apply using specific case details; if students struggle, the chatbot provides limited hints but does not choose for them.

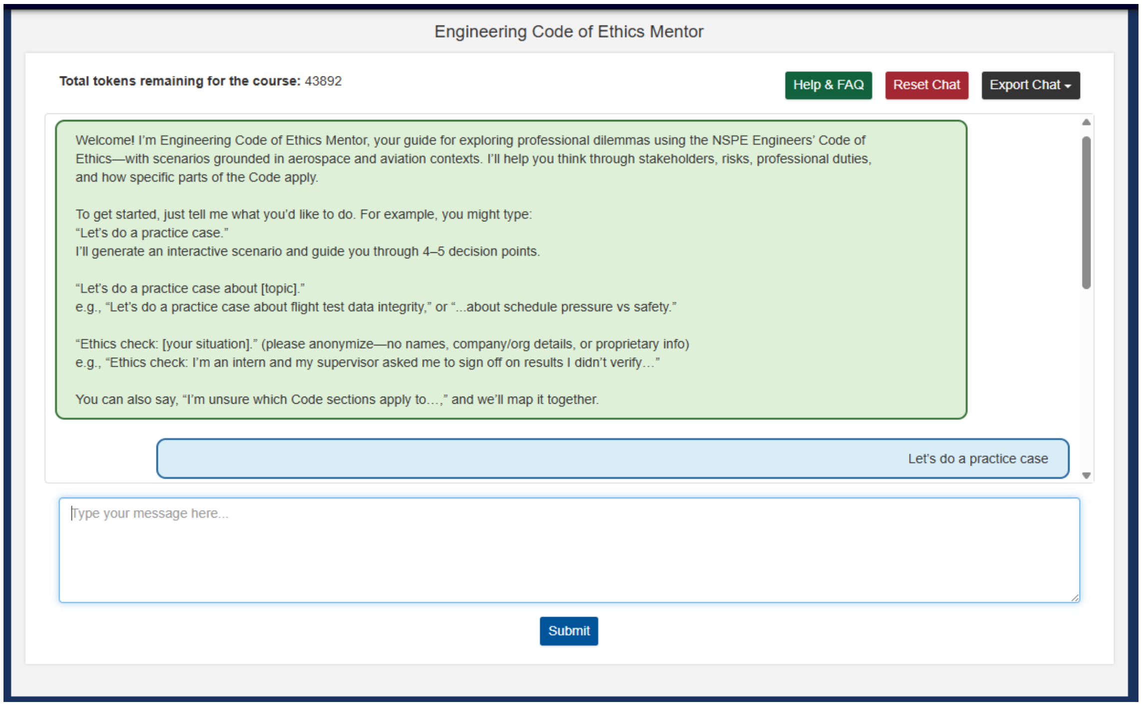

Figure 2: The screenshot of the chatbot used in the *ENGR 101* course, Ethics Module

Figure 2 shows the chatbot environment for Engineering Code of Ethics, implemented in ENGR 101. The core analytic portion is an iterative *Ethics Map*. For each canon selected, students articulate (1) what the provision requires or prohibits in their own words, (2) which case facts connect to that duty, and (3) what engineers might have done or failed to do, explicitly noting where evidence is insufficient. To preserve student ownership, the chatbot uses open-ended questions and nudges; when students ask for a single correct answer, the chatbot redirects them toward constructing a defensible argument grounded in the NSPE Code and case evidence. The final stages focus on professional decision-making and reflection, including communication, documentation/escalation if overruled, and boundaries around refusal to approve or seal work.

Figure 3 shows the month-by-month percentage of ethics discussion in ENGR 101 students scoring ≥80%, comparing 2022–23, and 2024–25, (before and after emergence of AI) with the y-axis constrained to 70–100% to emphasize variation. Across both academic periods, student performance remains consistently high, generally clustering in the upper-80s to mid-90s range. The 2022–23 line shows relatively stable performance across months, with a slight dip in the spring and fall terms but overall limited variability. In contrast, 2024–25 exhibits greater month-to-month fluctuation, including a noticeable decline in early spring followed by recovery in later terms. Overall, the figure highlights that while high achievement is sustained in both periods, 2024–25 displays increased variability compared to the more stable pattern observed in 2022–23, a difference that becomes more apparent with the tighter y-axis scaling.

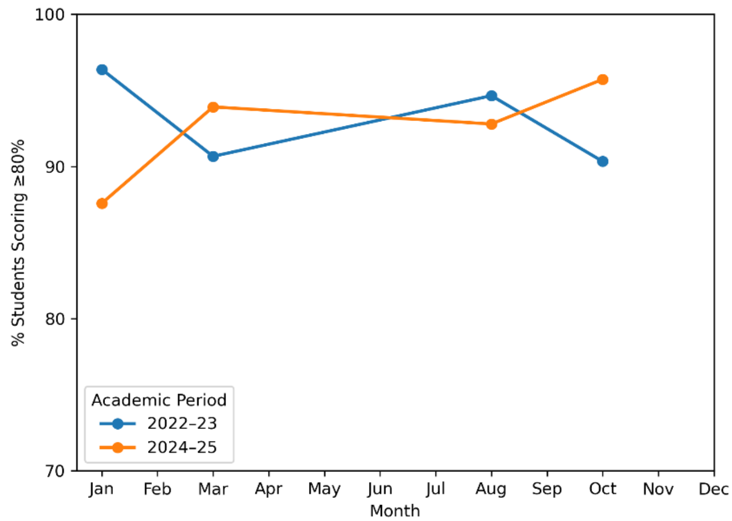

Figure 3: The month-by-month percentage of Ethic Discussion in *ENGR 101* for students scoring ≥80%, before and after emergence of AI

Because the project is in an initial phase, preliminary results are necessarily focused on feasibility and on the planned evaluation strategy rather than validated learning gains. The instructional design enables an exploratory comparison of student responses to the same ENGR 101 ethics scenario under two conditions: (1) prior offerings without chatbot guidance (baseline) and (2) current offerings with chatbot support (intervention). Performance will be evaluated using the existing assignment rubric emphasizing ethical issue identification, stakeholder recognition, justification using ethical principles or professional codes, and clarity/coherence of reasoning. Student perceptions will be collected via a short voluntary survey with Likert-scale and open-response prompts designed to capture whether the chatbot influenced ethical trade-off thinking and stakeholder awareness.

4. Conclusions

This WIP introduces a discipline-specific ethical reasoning chatbot integrated into an online Introduction to Engineering ethics module. The design addresses a core limitation of generic LLM chatbots, answer generation without learning scaffolds, by structuring ethical reasoning as a guided process: case framing, role and constraint identification, explicit mapping to NSPE canons, iterative justification through an *Ethics Map*, and professional action planning. Grounded in metacognitive and scenario-based ethics frameworks, the chatbot is intended to function as a learning partner that preserves student ownership of the argument while extending formative dialogue into asynchronous settings. Next steps include implementing the planned descriptive comparison between baseline and chatbot-supported cohorts using rubric-based scoring, qualitative review of written responses, and analysis of anonymized transcripts and survey feedback to identify patterns in how students frame issues, justify decisions, and incorporate stakeholder considerations. Findings will inform iterative refinement of prompt structure, scenario framing, and integration timing to strengthen how conversational scaffolds support ethical reasoning in introductory engineering education.

References

[1] Thorpe, M. (2002). Rethinking learner support: The challenge of collaborative online learning. *Open Learning: The Journal of Open, Distance and e-Learning*, *17*(2), 105-119.

[2] Hu, Y. H., Yu, H. Y., & Hsieh, C. L. (2025). Can pedagogical Agent-Based scaffolding boost information Problem-Solving in One-on-One collaborative learning with a virtual learning companion?. *Education and Information Technologies*, 1-28.

[3] Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *The Journal of the Learning Sciences*, *4*(2), 167–207.

[4] VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational psychologist*, *46*(4), 197-221.

[5] Barari, G., & Sanders, B. (2025, June). Application of FLASH to Forecast Student Engagement in Online Engineering Courses. In *2025 ASEE Annual Conference & Exposition*.

[6] Barari, G., & Sanders, B. (2024, February). The effectiveness of virtual environments for increasing engagement in engineering technology courses. In *2024 CIEC*.

[7] Barari, G., Janke, C., & Lin, Y. (2026). Integrating T-shaped competency models in interdisciplinary aviation and engineering education. Collegiate Aviation Review International, 44(1), 136–159. Retrieved from https://ojs.library.okstate.edu/osu/index.php/CARI/article/view/10584/9344

[8] Hennekeuser, D., Vaziri, D. D., Golchinfar, D., Schreiber, D., & Stevens, G. (2025). Enlarged education–exploring the Use of Generative AI to support lecturing in Higher Education. *International Journal of Artificial Intelligence in Education*, *35*(3), 1096-1128.

[9] Wang, D., Liu, Y., Jing, X., Liu, Q., & Lu, Q. (2025). Catalyst for future education: An empirical study on the Impact of artificial intelligence generated content on college students' innovation ability and autonomous learning. *Education and Information Technologies*, *30*(8), 9949-9968.

[10] Sevnarayan, K., & Potter, M. A. (2024). Generative Artificial Intelligence in distance education: Transformations, challenges, and impact on academic integrity and student voice. *Journal of Applied Learning and Teaching*, *7*(1), 104-114.

[11] Bittle, K., & El-Gayar, O. (2025). Generative AI and academic integrity in higher education: A systematic review and research agenda. *Information*, *16*(4), 296.

[12] Eaton, S. E. (2023). Academic Integrity in the Age of Artificial Intelligence.

[13] Barari, N., & Barari, G. (2025). Continual learning models in aviation systems. *The Collegiate Aviation Review International*, *43*(1).

[14] Barari, N., & Kim, E. (2021, November). Linking sparse coding dictionaries for representation learning. In 2021 International Conference on Rebooting Computing (ICRC) (pp. 84-87). IEEE.

[15] Barari, N., Lian, X., & MacLellan, C. J. (2024). Incremental concept formation over visual images without catastrophic forgetting. *arXiv preprint arXiv:2402.16933*.

[16] Barari, N., Kim, E., & MacLellan, C. (2025). Explaining Robustness to Catastrophic Forgetting Through Incremental Concept Formation. *arXiv preprint arXiv:2510.23756*.

[17] Janke, C., Lin, Y., & Barari, G. (2025). BOARD# 15: From drones to airplanes, Lessons learned from uncrewed aviation for teaching innovative and sustainable electric aviation propulsion. In *Proceedings of the 2025 ASEE Annual Conference & Exposition*. American Society for Engineering Education.

[18] Ward, T., Jenab, K., Ortega-Moody, J., Barari, G., & Molina Acosta, L. D. C. (2025). Virtual classrooms, real impact: A framework for introducing virtual reality to K–12 STEM learning based on best practices. *Applied Sciences*, *15*(21), 11356. https://doi.org/10.3390/app152111356

[19] Siebold, K., & Barari, G. (2026, February). Enhancing Undergraduate Engineering Education through HLA-Based Simulation Exploration Experience (SEE). In *2026 CIEC*.

[20] Barari, Ghazal, and Karl Siebold. "Curriculum Alignment through the Industry Pulse Platform." In *2026 CIEC*. 2026.

[21] Herkert, J. R. (2000). Engineering ethics education in the USA: Content, pedagogy and curriculum. *European journal of engineering education*, *25*(4), 303-313.

[22] Harris, C. E., PRITCHARD Jr, M. S., & RAY W JAMES, E. E. (2019). *Engineering ethics concepts and cases*. Cengage Learning, Inc..

[23] ABET. (2023). *Criteria for accrediting engineering programs*. ABET.

[24] National Society of Professional Engineers (NSPE). (2019). *Code of ethics for engineers*.

[25] Yusuf, H., Money, A., & Daylamani-Zad, D. (2025). Pedagogical AI conversational agents in higher education: a conceptual framework and survey of the state of the art. *Educational technology research and development*, *73*(2), 815-874.
[26] Du, Q. (2025). How artificially intelligent conversational agents influence EFL learners' self-regulated learning and retention. *Education and Information Technologies*, 1-67.
[27] Winkler, R., & Söllner, M. (2018, July). Unleashing the potential of chatbots in education: A state-of-the-art analysis. In *Academy of management proceedings* (Vol. 2018, No. 1, p. 15903). Briarcliff Manor, NY 10510: Academy of Management.
[28] Barari, G. Basu, D. Lin Y., and Ortega-Moody, J. (2026). Evaluating Large Language Models in Engineering Education: A Multi-Course Assessment Across Bloom's Taxonomy, in *IEEE Access*, doi: 10.1109/ACCESS.2026.3686339.