Introducing the AI Collaborative (AICO) Platform: A Pilot Implementation in Mechanics of Solids

Dr. Zhuwei Qin, San Francisco State University

Dr. Zhuwei Qin is currently an assistant professor in the School of Engineering at San Francisco State University (SFSU). His research focuses on designing efficient AI computing algorithms and human-centered AI systems for real-world deployment, with applications such as health technology, rehabilitation, and AI education. Dr. Qin serves as the director of the Mobile and Intelligent Computing Laboratory (MIC Lab) at SFSU. Dr. Qin's research endeavors are dedicated to addressing the inherent challenges related to efficiency and robustness in the practical application of deep learning within real-world environments. A central focus of MIC Lab is to achieve computational acceleration for deep learning, including deep neural networks and large language models, on low-power hardware without reliance on heavy compute or storage resources. His research addresses the efficiency, reliability, and security challenges in the algorithm design and system optimization, as well as application development to create intelligent mobile edge computing systems.

Dr. Zhaoshuo Jiang P.E., San Francisco State University

Zhaoshuo Jiang graduated from the University of Connecticut with a Ph.D. degree in Civil Engineering. Before joining San Francisco State University as an assistant professor, he worked as a structural engineering professional at Skidmore, Owings & Merrill

Jennifer Trainor, San Francisco State University
Andre Bouvier, San Francisco State University
Jose Torres, San Francisco State University

Introducing the AI Collaborative (AICO) Platform: A Pilot Implementation in Mechanics of Solids

Abstract

The rapid evolution of generative artificial intelligence (AI) presents both opportunities and challenges for engineering education. While existing AI tutoring systems offer instant feedback and personalized resources, they raise concerns related to transparency, instructor oversight, student over-reliance, and equitable access. To address these challenges, the AI Collaborative (AICO) platform was developed at San Francisco State University, a primary undergraduate and hispanic serving Institution as an open-source, student-centered system that integrates course-specific instructional materials with large language models (LLMs). AICO prioritizes transparency, critical engagement, and instructor agency by grounding AI responses exclusively in instructor-curated content and emphasizing reasoning-focused support rather than direct answer provision.

AICO was piloted during Summer 2025 in a junior-level Mechanics of Solids course, a core requirement in civil and mechanical engineering curricula. Instructors uploaded textbooks, lecture slides, and problem sets into the platform, enabling AICO to generate interactive practice problems, step-by-step solution guidance, and personalized previews and reviews of course topics. Students engaged with AICO through conversational interactions designed to provide adaptive scaffolding, targeted hints, and course-aligned content navigation.

To examine student experiences, post-course reflection questions were administered, including Likert-scale items assessing perceived helpfulness, reliability, satisfaction, and likelihood of recommendation, along with open-ended prompts addressing benefits, limitations, accessibility, and suggestions for improvement. Platform usage logs provided additional contextual insight into how students interacted with the platform. Findings indicate that while many students perceived pedagogical value in AICO's reasoning-focused support, technical performance, accessibility, and usability strongly shaped adoption and overall perceptions. This pilot highlights both the potential and the implementation challenges of instructor-guided, retrieval-augmented AI platforms in high-challenge engineering courses.

Introduction

Engineering education has long recognized the value of personalized, timely instructional support in promoting student learning, persistence, and equity. In core engineering courses with high cognitive demand, such as Mechanics of Solids, students frequently encounter conceptual challenges that require iterative practice, guided feedback, and opportunities to articulate reasoning. However, providing individualized support at scale remains difficult, particularly in institutions serving diverse student populations under constraints related to class size and instructional workload [1]-[3].

Recent advances in generative artificial intelligence (AI), particularly large language models (LLMs), have introduced new possibilities for addressing these challenges [4]. AI-powered tools can generate explanations, practice problems, and feedback on demand, offering flexible and personalized academic support [5]-[8]. As a result, many students have begun using general-purpose AI tools independently. While promising, such tools raise pedagogical and ethical concerns, including limited transparency, lack of instructor oversight, misalignment with course-specific learning goals, risks of over-reliance, and inequities stemming from proprietary or paywalled platforms [9]-[10].

In response, there is growing interest in instructor-guided AI systems that foreground pedagogy, equity, and instructional intent. Rather than replacing human instruction, such systems aim to scaffold learning processes, support critical thinking, and remain embedded within course contexts. Open, instructor-controlled platforms offer a promising pathway by enabling faculty to curate content, shape AI behavior, and maintain transparency while providing students with adaptive learning support.

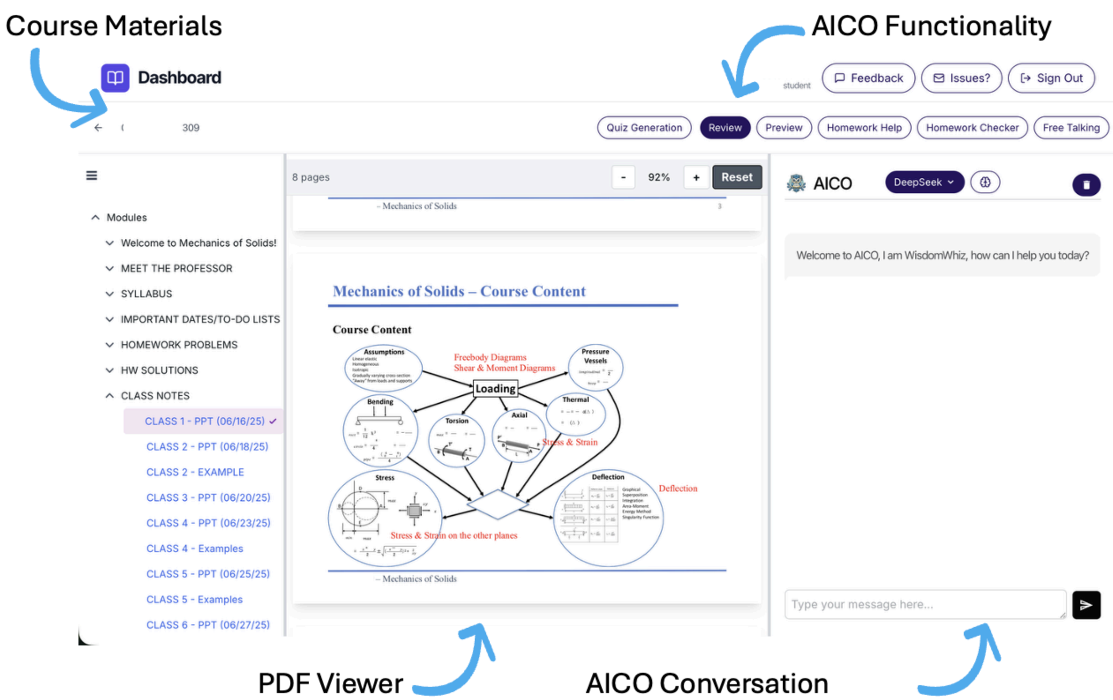

Figure 1. Overview of the AICO platform interface, showing instructor-uploaded course materials (left), integrated document viewer (center), and AI-powered conversational workspace with task-specific learning supports (right).

This paper introduces the AI Collaborative (AICO) platform, an open-source, student-centered AI learning companion developed at San Francisco State University, a primary undergraduate and hispanic serving Institution. AICO integrates instructor-provided materials with a retrieval-augmented generation (RAG) framework to produce course-aligned, reasoning-focused guidance [11]. The platform was piloted in a junior-level Mechanics of Solids course during Summer 2025. This paper describes the platform design, pilot implementation, and preliminary findings from platform usage patterns and post-course student reflections.

Figure 1 provides an overview of the AICO user interface. The platform integrates instructor-uploaded course materials, a document viewer, and an AI-powered conversational interface within a single workspace. Students navigate course content through a structured materials panel, view lecture slides or assignments directly within the platform, and interact with

AICO using task-specific functionalities such as review, preview, homework help, and open-ended conversational guidance. This integrated design supports transparent, course-aligned AI interactions while allowing students to move fluidly between source materials and AI-supported reasoning.

Platform Design and Pilot Implementation

Institutional Context and Course Setting

The AICO platform was piloted at a primary undergraduate and hispanic serving Institution with a diverse student population that includes many first-generation college students and students from historically underrepresented groups in engineering. The pilot was conducted during the Summer of 2025 in a junior-level Mechanics of Solids course required for both civil and mechanical engineering majors. The course is a prerequisite for multiple upper-division courses and is widely regarded as high-challenge due to its conceptual rigor, mathematical demands, and emphasis on abstract reasoning.

The accelerated summer format compressed a full semester of content into a shorter instructional period, intensifying cognitive demands and limiting opportunities for individualized instructional support. This context provided a meaningful testbed for exploring whether an AI-supported learning platform could supplement instruction without diminishing student agency or instructional rigor.

AICO Platform Design and Architecture

AICO was designed as an open-source, instructor-guided AI learning platform grounded in principles of transparency, pedagogical alignment, and equitable access. The platform was intentionally framed as a *learning companion* rather than an autonomous tutor, with the goal of supporting reasoning, reflection, and sense-making.

Key design principles included:

- Instructor control over all instructional content ingested by the system
- Bounded AI behavior grounded exclusively in course-specific materials
- Emphasis on scaffolding and explanation rather than answer generation
- Attention to accessibility and equity in supplemental academic support

AICO employs an RAG architecture that integrates LLMs with instructor-curated course materials [11]. Prior to the course, instructors uploaded textbooks, lecture slides, and problem sets, which were processed and indexed to form a course-specific knowledge base. When students submitted queries, relevant content was retrieved from this knowledge base and provided to the LLM as contextual grounding. This approach ensured that AI responses were aligned with course notation, terminology, and instructional intent, while reducing risks associated with hallucination or misalignment common in general-purpose AI tools. By constraining responses to instructor-approved materials, AICO enhanced transparency and instructor oversight.

The front-end provided a web-based conversational interface through which students could preview content, practice problems, and request guided explanations. Interactions were designed to be iterative, encouraging follow-up questions and reasoning exploration. The back-end managed content ingestion, retrieval, AI response generation, and system orchestration. Logging mechanisms were incorporated to support analysis of platform usage patterns, which are reported in this study.

Results

This section presents findings from platform usage patterns and post-course student reflections, including Likert-scale survey responses and open-ended qualitative reflections.

Platform Usage Patterns

AICO automatically logged anonymized usage data, capturing how students interacted with the platform, including frequency of access, timing relative to instructional activities, and types of interactions (e.g., homework help, review, conversational guidance). Usage data were analyzed descriptively to characterize patterns of engagement rather than to evaluate learning outcomes.

Although detailed analytics are not exhaustively reported, usage logs provide important contextual insight for interpreting student perceptions described in Sections 3.2 and 3.3.

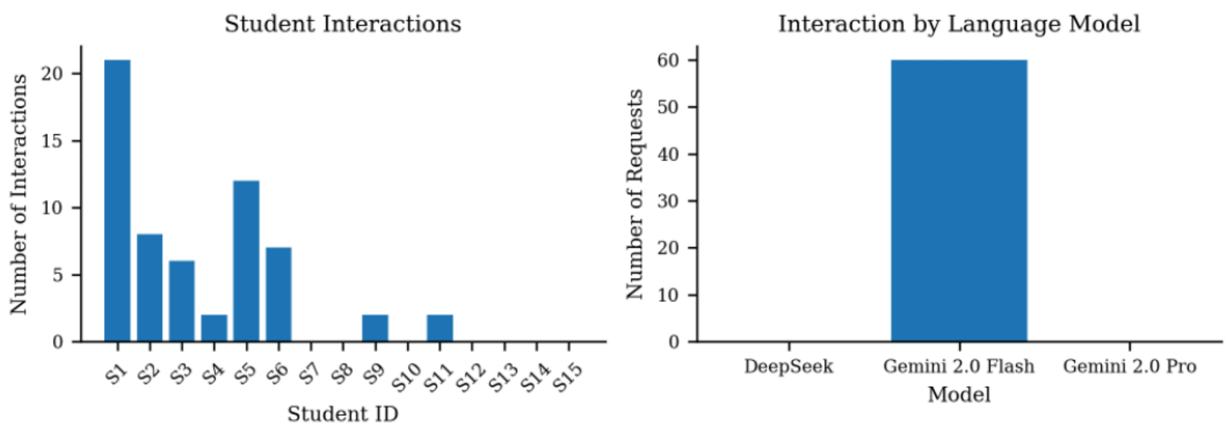

Figure 2. Distribution of student–AI interactions. (Left) Number of interactions per student. (Right) Distribution of requests across language models, showing exclusive usage of Gemini 2.0 Flash in this study.

Figure 2 (Left) shows substantial variability in engagement. While 8 of 15 students who enrolled in the class (53.3%) registered and interacted with AICO at least once, interaction counts were unevenly distributed, with a small subset of students accounting for most interactions. Such skewed adoption patterns are common in optional educational technology pilots and suggest that engagement was influenced by access conditions, perceived usefulness, and individual study practices. Figure 2 (Right) shows that Gemini 2.0 Flash, the default language model configured within AICO, was used for all recorded student interactions during the pilot, despite the availability of alternative models such as Gemini 2.0 Pro and DeepSeek. No student-initiated model switching was observed.

This pattern suggests that students relied on the default system configuration rather than actively selecting among model options. Rather than indicating a lack of interest in alternative models, this behavior more likely reflects students' focus on efficient task completion within a time-constrained academic context. As the platform was positioned as a supplemental learning tool, students appeared to prioritize timely access to guidance over experimentation with different underlying AI models.

Importantly, this finding documents an aspect of system use and transparency rather than student preference or model performance. The consistent use of a single model during the pilot ensured that variability in student experiences was not driven by differences in language model selection, supporting controlled interpretation of the results reported in this study.

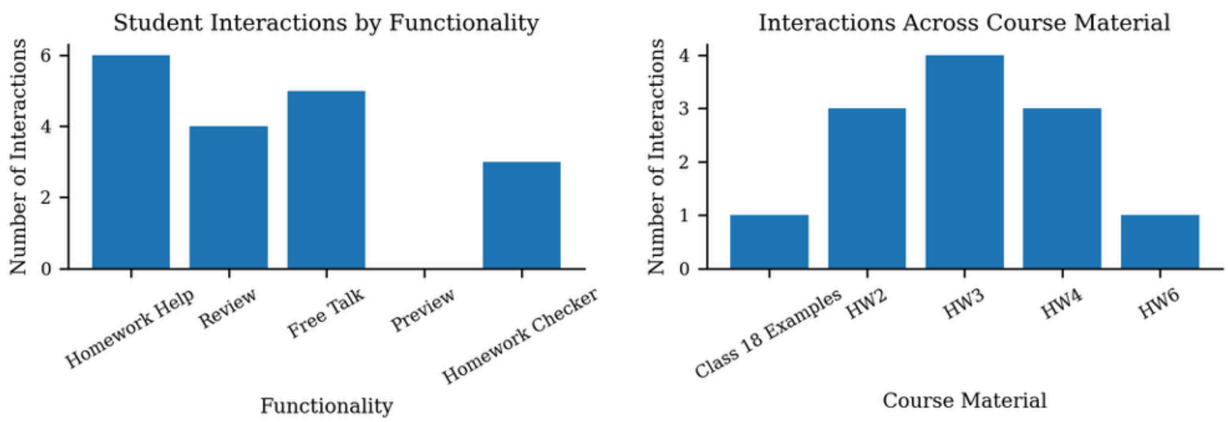

Figure 3. Distribution of student interactions by functionality and course material. (Left) Frequency of interactions across system functionalities. (Right) Distribution of interactions across course materials, with the highest engagement observed for HW3.

As shown in the left figure of Figure 3, interactions reveal a mixed distribution of student engagement across the platform's features, with problem-solving features being most utilized. While Homework Help was the most utilized single functionality (6 interactions), there was also significant engagement in non-task-specific areas, specifically Free Talk (5 interactions) and Review (4 interactions). The Homework Checker saw moderate use (3 interactions), whereas the Preview features were not utilized. This spread suggests that while students frequently sought direct problem-solving assistance, they nearly as often used the platform for open-ended dialogue and retrospective learning.

As shown in the right of Figure 3, the majority of student interactions with AICO were associated with homework assignments, with the highest engagement observed for Homework 3 and Homework 4, followed by Homework 2. In contrast, relatively few interactions were recorded for lecture examples or other non-homework materials.

This pattern indicates that student engagement with AICO was primarily centered on applying course concepts to assigned problems, rather than interacting extensively with lecture slides or class notes. Taken together with the functionality-level analysis, these findings suggest that students used AICO as a supplemental tutoring resource outside of class, while continuing to rely on the instructor and in-class instruction for learning core concepts.

Likert-Scale Results: Perceived Helpfulness, Reliability, Satisfaction, and Recommendation

Students first responded to four Likert-scale items (1 = strongly disagree, 5 = strongly agree) assessing their overall perceptions of the AICO platform:

- Helpfulness: The AICO provided helpful guidance for solving problems or understanding concepts.
- Reliability: The AICO gave consistent and accurate responses during my usage.
- Satisfaction: I am satisfied with my overall experience using the AICO.
- Recommendation: I would recommend AICO to other students in similar courses.

These items were intended to provide a high-level snapshot of students' experiences with AICO across instructional and usability dimensions. Across all four items, responses exhibited substantial variability, reflecting uneven student experiences during this pilot implementation.

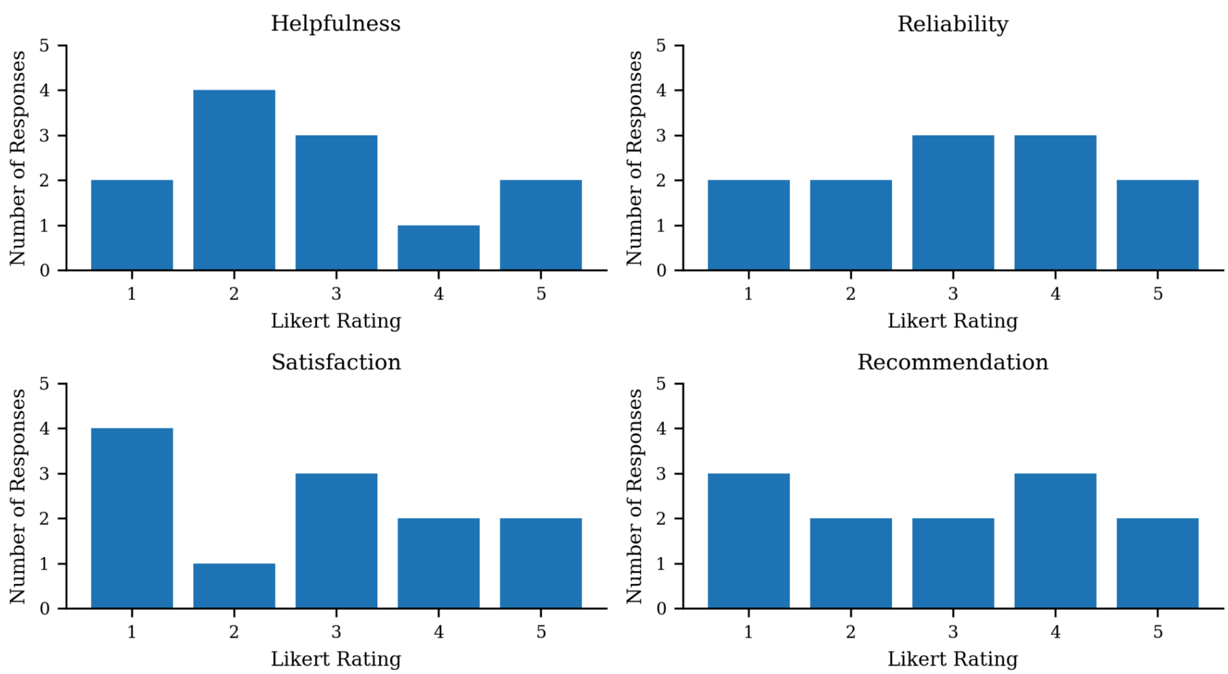

Figure 4. Student perceptions of the AICO system based on post-study survey responses (n = 12). Distributions of Likert-scale ratings are shown for (a) Helpfulness, (b) Reliability, (c) Satisfaction, and (d) Recommendation.

Helpfulness: Across all four items, student responses exhibited substantial variability, reflecting uneven experiences with the platform during the pilot implementation. For helpfulness, approximately 25% of students selected ratings of 4 or 5, indicating agreement that AICO provided useful guidance for problem solving or conceptual understanding, while 25% selected the neutral midpoint. Importantly, half of the students (50% or 6/12) selected ratings of 1 or 2, highlighting that perceived usefulness was not uniform across the class. This variability, inferred from the qualitative reflections and usage patterns, reflects differences in students' levels of engagement with the platform, access conditions, and familiarity with interacting effectively with

AI-based systems. As suggested by the usage patterns and open-ended reflections, students who engaged more frequently or were able to navigate the platform successfully tended to report greater perceived usefulness, whereas students who encountered technical barriers or had limited opportunity to develop effective questioning strategies reported less benefit.

Reliability: Perceptions of reliability showed a similar distribution. While 41.7% of students agreed or strongly agreed that AICO provided consistent and accurate responses, 33.4% selected ratings of 1 or 2, indicating concerns about consistency or accuracy. This pattern aligns with qualitative reflections in which students reported occasional errors, inconsistent values across problems, or misalignment with course formulas. These reliability concerns likely reflect a combination of technical limitations present during the pilot implementation, including system instability, session persistence issues, and challenges associated with grounding AI responses consistently in course-specific materials. As described in the open-ended reflections, some students encountered situations where formulas differed from those emphasized in class, which may have contributed to lower perceived reliability.

Satisfaction: Responses related to overall satisfaction were polarized: 33.4% of students selected the lowest rating (1), indicating significant dissatisfaction, while an equal proportion (33.4%) selected ratings of 4 or 5, reflecting a positive experience for this subset of users. The remaining students selected neutral or low-moderate ratings, reinforcing the mixed nature of student experiences during this early-stage deployment.

Recommendation: Finally, willingness to recommend AICO to peers mirrored the patterns observed in helpfulness and satisfaction. Approximately 41.7% of students selected ratings of 4 or 5, indicating they would recommend the platform, while an equivalent proportion (41.7%) selected ratings of 1 or 2, expressing hesitation or disagreement. This distribution, supported by the qualitative reflections, suggests that the recommendation was closely tied to whether students were able to access and effectively use the platform without technical barriers.

Q&A Reflections: Student Experiences, Challenges, and Suggestions

Following the Likert-scale items, students responded to a set of open-ended questions designed to contextualize and deepen understanding of their survey responses. These questions prompted students to describe (1) moments when AICO was especially helpful, (2) frustrations, errors, or limitations they encountered, and (3) suggestions for how AICO could better support their learning.

Thematic analysis of these Q&A reflections revealed several recurring patterns. Students who were able to engage successfully with the platform described benefits such as step-by-step problem breakdowns, support for checking work and confirming formulas, and assistance in locating relevant course materials. In contrast, many students identified challenges related to system performance, device compatibility, workflow friction, and occasional inaccuracies or inconsistencies in AI-generated responses. Students' suggestions for improvement focused primarily on reducing processing time, improving reliability and interface design, enabling access to multiple materials simultaneously, and supporting more seamless integration of personal notes or handwritten work.

- **Reflection Question 1: Can you describe a moment when AICO was especially helpful?**

Students most often described AICO as helpful when they were stuck during problem-solving or when reviewing completed work. Reflections emphasized the value of step-by-step guidance, confirmation of formulas and calculations, and support in locating relevant course materials. These responses suggest that AICO functioned effectively as a reasoning-focused learning companion, particularly during moments of conceptual uncertainty.

Table 1. Perceived Pedagogical Benefits of AICO

Theme	Representative Student Quote
Step-by-step breakdown & targeted explanations	*"Breaking down problems step by step"*
Checking work, troubleshooting, & formula confirmation	*"After completing the homework, AICO was helpful for checking my answers to the problems. If it was incorrect, this was helpful for troubleshooting."* *"It was good at explaining examples or certain parts of a problem I was struggling with."*
Content navigation and resource orientation	*"It confirms the formulas I use and the calculations. It also tells me where to find the content im looking for."*

- **Reflection Question 2: Were there any frustrations, errors, or limitations you noticed?**

Students identified technical performance and accessibility as the most significant barriers to effective use. Long loading times, limited mobile-device compatibility, and inefficient workflows discouraged sustained engagement. Some students also reported inaccuracies or inconsistencies in AI-generated responses, which reduced trust in the platform. These limitations often outweighed perceived pedagogical benefits for affected students.

Table 2. Reported Technical and Usability Challenges of AICO

Theme	Representative Student Quote
Loading delays & system instability	*"The main frustrations ive had was just the loading times. It wont even start to respond until a lecture pulls up, and it takes a solid 10-15 minutes to pull up at times, if at all"*
Device compatibility & access	*"I do not have consistent access to a computer and mainly use an iPad/tablet/iPhone. Unfortunatly, it doesn't load on iPad as quickly as a computer if at all."* *"The only time I tried the platform was to check a homework question but my frustration is that I had to take a scan of my written homework with my phone send it to my laptop, download the pdf and then upload it to the platform which felt like it took an eternity which is why I decided to not use it again since I felt if I just went over the homework myself I could probably find any errors in the time it took*

	for me to do all of that."
Errors & misalignment with course materials	*"AICO would sometimes get values mixed up from different problems. Even after trashing the conversation. Also some of the Formulas suggested are different from the book. once supplied with correct formulas it agreed on the mistake."*

- **Reflection Question 3: Do you have any suggestions for how AICO could better support your learning?**

Student suggestions focused primarily on improving performance, usability, and flexibility, rather than altering the instructional interaction model. Students expressed interest in faster response times, more stable session handling, improved navigation, and the ability to integrate personal notes or handwritten work. These recommendations highlight design priorities for scaling AI-supported learning tools in engineering contexts.

Table 3. Student Recommendations for Enhancing AICO Functionality

Reduce processing time and improve reliability	*"If it started each conversation new. Sometimes it would time out and the break down of each conversation would start over. Other times it would keep values from previous problems."* *"I would really like to see faster load speeds, or uses without the selective files clicked/ loaded up."*
Access to multiple materials simultaneously	*"Been able to access multiple notes at the same time to compare lectures. Lets say there were two slides for the same class and one had step one and the other step two. I'd like for the platform to access both simultaneously so it can provide and break down both slideshows at the same time."*
Interface polish and usability improvements	*"I think ironing down the interface and reliability of the platform would be best. I think the platform is slightly unpolished"* *"Just to be more convenient since at least when I used it felt like a hassle"*
Ability to upload personal notes	*"I would like to be able to upload my own class notes"* *"Introduce a feature whete you can scan your own work and the platform can tell you where you made a mistake in the problem solving. That would make the platform really easy to use for studying and incentivize it to be used for weekly homework's"*

Results Synthesis

Taken together, platform usage patterns, Likert-scale responses, and qualitative reflections indicate that while some students perceived pedagogical value in AICO's reasoning-focused, course-aligned support, technical performance, accessibility, and usability constraints strongly shaped adoption and overall perceptions during this pilot implementation. These findings underscore the importance of aligning AI-supported instructional design with robust technical infrastructure to realize equitable benefits in high-challenge engineering courses.

Discussion and Implications

Platform usage patterns provide critical context for interpreting student perceptions. Homework-centered engagement and uneven adoption help explain the variability observed in Likert-scale responses and qualitative reflections.

Students who accessed AICO successfully described benefits aligned with constructivist learning principles, including scaffolding, sense-making, and support during problem-solving impasses. At the same time, technical and access barriers limited engagement for some students, highlighting that pedagogical value is inseparable from infrastructure and usability.

From an equity perspective, findings highlight both promise and risk. AICO functioned as a low-pressure, always-available support for some students, while others faced barriers related to device access and performance. Notably, student suggestions focused on improving usability and reliability rather than altering the instructional model, indicating acceptance of the instructor-guided, reasoning-focused approach.

Limitations and Future Work

This study has several limitations that should be considered when interpreting the findings. First, the pilot was conducted in a single course with a small sample size, which limits the generalizability of the results. Second, the analysis focused primarily on student-reported perceptions and usage patterns rather than direct measures of learning outcomes. Third, technical performance and usability issues identified during the pilot constrained engagement for some students and likely influenced both adoption and reported experiences.

Importantly, feedback from this pilot directly informed subsequent platform improvements. In Fall 2025, several technical refinements were implemented to address issues raised by students, including improvements to system response time, session stability, and overall interface reliability. These changes were designed to reduce workflow friction, improve accessibility across devices, and support more consistent AI interactions. Early internal testing following these updates indicates improved system responsiveness and reduced latency during common use cases such as homework help and conversational guidance.

Building on lessons learned from this pilot, AICO is being expanded to a larger-scale deployment across four engineering courses in Fall 2025, spanning multiple disciplines. This expanded implementation incorporates student feedback from the Mechanics of Solids pilot and provides an opportunity to examine adoption, usage patterns, and perceptions across a broader instructional context. Data collection in these courses will enable more robust analysis of engagement trends and support future evaluation of learning-related outcomes.

Future work will continue to refine the platform's technical infrastructure and instructional integration, incorporate detailed analyses of platform usage logs, and explore assessment strategies that link AI-supported engagement to student learning and persistence. More broadly, ongoing research will examine how instructor-guided, retrieval-augmented AI platforms can be designed and scaled to support equitable, transparent, and student-centered learning in engineering education.

Conclusion

This pilot study examined the implementation of AICO, an instructor-guided, retrieval-augmented AI learning platform, in a junior-level Mechanics of Solids course. Findings suggest that while AICO can support reasoning-focused learning and provide equitable supplemental support for some students, technical performance and accessibility are critical determinants of adoption and perceived value. Future work will refine platform infrastructure, incorporate usage analytics, and expand evaluation across courses to further explore the role of transparent, instructor-driven AI in engineering education.

Acknowledgment

This work was supported by the California Education Learning Lab through the SCAPE project. The views expressed are those of the authors and do not necessarily reflect those of the funding agency.

References

[1] D. Lim Yankowitz, "Meeting People Where They Are: Personalized Learning to Foster Inclusion & Equity," Ph.D. dissertation, 2022.
[2] N. Kucirkova, L. Gerard, and M. C. Linn, "Designing personalised instruction: A research and design framework," *British Journal of Educational Technology*, vol. 52, no. 5, pp. 1839–1861, 2021.
[3] B. Hui, "A Personalized Learning Approach to Support Students with Diverse Academic Backgrounds," in *Proc. 2023 IEEE Frontiers in Education Conf. (FIE)*, Oct. 2023, pp. 1–9.
[4] C. K. Lo, "What is the impact of ChatGPT on education? A rapid review of the literature," *Education Sciences*, vol. 13, no. 4, p. 410, 2023.
[5] J. Jabbour, K. Kleinbard, O. Miller, R. Haussman, and V. J. Reddi, "SocratiQ: A Generative AI-Powered Learning Companion for Personalized Education and Broader Accessibility," in *Proc. Workshop on Computer Architecture Education*, 2025, pp. 1–10.
[6] J. A. Chudziak and A. Kostka, "Ai-powered math tutoring: Platform for personalized and adaptive education," in *International Conference on Artificial Intelligence in Education*. Cham: Springer Nature Switzerland, 2025, pp. 462–469.
[7] A. Baillifard, M. Gabella, P. B. Lavenex, and C. S. Martarelli, "Effective learning with a personal AI tutor: A case study," *Education and Information Technologies*, pp. 1–16, 2024.
[8] P. Bassner, E. Frankford, and S. Krusche, "Iris: An AI-Driven Virtual Tutor For Computer Science Education," *arXiv preprint arXiv:2405.08008*, May 2024.
[9] L. Yan, L. Sha, L. Zhao, Y. Li, R. Martinez‑Maldonado, G. Chen, X. Li, Y. Jin, and D. Gašević, "Practical and ethical challenges of large language models in education: A systematic scoping review," *British Journal of Educational Technology*, vol. 55, no. 1, pp. 90–112, 2024.
[10] J. F. Price and S. Grover, "Generative AI in STEM Teaching: Opportunities and Tradeoffs," Community for Advancing Discovery Research in Education (CADRE), 2025.
[11] Z. Guo, L. Xia, Y. Yu, T. Ao, and C. Huang, "Lightrag: Simple and fast retrieval-augmented generation," *arXiv preprint arXiv:2410.05779*, Oct. 2024.