

Impact of Structured AI Implementation on Student Confidence and Instructor Interactions in an Undergraduate Geotechnical Engineering Course

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Dr. Vincent Bongioanni is an innovator in integrating artificial intelligence into higher education. He formed the "AI in Higher Ed" research group under the United States Air Force Academy's Center for Excellence in Teaching and Learning. He leads a cross-disciplinary team investigating the transformative potential of generative AI (gAI) in academic settings. His work focuses on identifying both the challenges and opportunities presented by AI technologies in education.

Dr. Bongioanni's research aims to develop best practices for AI integration that enhance student learning experiences while addressing potential pitfalls. His team explores innovative ways to leverage AI to foster deeper engagement, critical thinking, and problem-solving skills among students. Additionally, they investigate methods to streamline instructional processes, potentially reducing faculty workload without compromising educational quality.

As a faculty member in the Department of Civil and Environmental Engineering, Dr. Bongioanni brings a unique perspective to AI integration in STEM fields. His work not only contributes to the academic discourse on AI in education but also has practical implications for preparing future military leaders for an increasingly AI-driven world.

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Abstract

This study investigated how structured AI implementation affects student-instructor interactions and student perceptions in an undergraduate geotechnical engineering course. The research compared an intervention group that was highly encouraged to use AI and received structured AI guidance with a control group with no formal AI integration or encouragement. Through pre- and post-course surveys, findings revealed that structured implementation helped maintain student confidence in using AI as a learning tool, while students without guidance showed decreased confidence. Statistical analysis of final grades showed no significant differences between groups, suggesting that while the implementation approach influenced student perceptions, it did not directly impact academic performance. Students across all sections expressed concerns about AI's reliability for technical calculations and the balance between AI assistance and traditional learning methods. The results indicate that while implementation approach significantly influences both student confidence and classroom dynamics in technical courses, careful consideration must be given to how these changes translate to measurable learning outcomes.

Introduction

The rapid advancement of artificial intelligence (AI) technologies is transforming higher education, presenting both opportunities and challenges for engineering education. Despite AI's potential to enhance teaching and learning practices, its adoption in higher education has been limited by institutional resistance to innovation and adherence to traditional teaching methods. This resistance persists even as evidence mounts for AI's potential to support diverse learning approaches and provide personalized assistance to students. The integration of AI in engineering education requires careful consideration of both pedagogical strategies and implementation methods. As Mollick and Mollick¹ emphasize, effective AI implementation demands "challenging but well-proven pedagogical strategies that require extensive work to implement." This study examines two contrasting approaches to AI implementation in an undergraduate civil engineering course - one providing structured guidance and active encouragement for AI use versus one allowing but not actively promoting AI integration - to understand their effects on student confidence and instructor interactions.

Recent research has highlighted several potential benefits of AI integration in higher education.

Wang et al.² found that AI can provide “personalized and timely assistance” while supporting diverse learning approaches. Additionally, Alqahtani et al.³ note that AI tools can help instructors “be more consistent and systematic... helping to reduce subjectivity and bias” while providing “feedback to students more quickly, allowing them to spend more time on other important tasks.”

However, the implementation of AI in engineering education also presents significant challenges. Crompton and Burke⁴ emphasize the need to integrate AI education into university curricula while increasing “academic understanding” of AI. This integration must be thoughtful and strategic, as Allen⁵ notes that “adding AI technology without revising processes will deliver only a tiny fraction of the potential improvements, if any.” A key gap in current research concerns how structured AI implementation affects the dynamics between students and instructors in technical courses. While existing literature addresses AI’s potential benefits, less attention has been paid to how different approaches to AI integration influence student-instructor interactions and student confidence in using AI for technical problem-solving. This gap is particularly notable in engineering education, where the complexity of technical content adds an additional layer of consideration to AI implementation.

The integration of AI in geotechnical engineering has expanded rapidly, with applications in predicting material properties, modeling soil behavior, and optimizing construction. As Liu et al.⁶ note, AI effectively handles non-linear relationships and uncertainties in geotechnical materials. Baghbani et al.⁷ highlight its widespread use, particularly artificial neural networks (ANN), support vector machines (SVM), adaptive neuro-fuzzy inference systems (ANFIS), and deep learning, across key areas like rock mechanics, tunneling, and foundations. However, while research shows AI’s potential in professional practice, there remains a critical gap in understanding how to effectively integrate these tools into engineering education. This gap is particularly notable given that AI applications in geotechnical engineering now span physical properties, mechanical properties, constitutive models, and other technical characteristics that form the core of undergraduate geotechnical engineering curricula.

This study addresses these gaps by examining how structured integration of AI tools in an undergraduate geotechnical engineering course affects student-instructor interactions and student perceptions of learning outcomes. Specifically, this research investigates:

1. How does explicit instruction and encouragement in AI use affect student-instructor dynamics and interactions?
2. How does providing structured guidance on AI use, compared to allowing but not actively promoting AI use, influence student confidence in using AI for technical problem-solving?

By focusing on these questions within the context of a core civil engineering course, this study seeks to provide practical insights for engineering educators considering AI integration while maintaining the technical rigor essential for engineering education.

Methods

This comparative study investigated the impact of structured AI implementation in the *Introduction to Geotechnical Engineering* course during Fall 2024. The course covered

engineering properties of soils, soil classification, compaction, hydraulic conductivity, consolidation, shear strength, and introductory concepts of slope stability and foundation design.

The study included 34 students across three course sections. Two sections (n=20) served as the control group, where AI use was permitted but received no formal integration or guidance in course instruction. One section (n=14) served as the intervention group, receiving structured guidance on AI implementation and encouragement to use AI inside and outside the classroom throughout the semester. The course implementation incorporated specific measures to ensure consistency in instruction and assessment across these sections. Two instructors participated in course delivery, with one instructor teaching the two control sections and the other teaching the intervention section. Assessment standardization was achieved through a structured approach: homework assignments utilized student self-assessment based on instructor-approved solutions, complemented by metacognitive reflections. For examinations, the instructors systematically divided grading responsibilities, with each instructor blind-grading specific questions across all three sections to maintain consistent assessment standards.

The intervention for the intervention group consisted of six structured AI-focused activities implemented throughout the semester to integrate AI into their classroom experience. In the first five lessons, students received foundational instruction on AI, exploring its origins, benefits, and basic principles of generative AI. Throughout the course, they participated in hands-on activities: analyzing and correcting errors in AI-generated solutions, creating practice problems and solutions for exam preparation using AI, and employing AI for real-time problem-solving guidance during lessons. Additionally, they used AI for note-taking (verified by instructors) and incorporated AI into technical writing assignments. In contrast, the control group received standard course instruction without this structured AI intervention; AI use was neither encouraged nor prohibited for them.

Pre- and post-course surveys were administered including both quantitative components using a 7-point Likert scale (Table 1) and qualitative open-ended responses. These surveys assessed prior AI experience, attitudes, and perceived impact on learning (see Table 2 in the Appendix), with each survey worth 10 points of the course's 2,000 total points.

Rating	Response Category
1	Strongly disagree
2	Disagree
3	Slightly disagree
4	Undecided/Unsure
5	Slightly agree
6	Agree
7	Strongly agree

Table 1: Likert Scale for Quantitative Questions

Survey responses were analyzed between groups (control and intervention pre- and post-course) and within groups (pre- to post-course for control and intervention) using non-parametric

methods appropriate for ordinal data. The Mann-Whitney U Test (also known as the Wilcoxon Two Sample test) was selected specifically because the Likert scale data is ordinal rather than interval-scaled, meaning the distances between response categories cannot be assumed to be equal. This test is particularly appropriate for comparing responses between control and intervention groups when the data does not meet the assumptions required for parametric tests, such as normal distribution. The significance level was set at $\alpha = 0.05$ for all statistical comparisons. Qualitative responses underwent thematic analysis to identify patterns in student experiences and perceptions, focusing particularly on changes in student-instructor interactions and student confidence in using AI for technical problem-solving.

Results

Pre-course survey results revealed similar baseline characteristics between the two groups. Approximately 60% of students in both groups reported either “Limited Use” or “Basic Awareness” of AI technologies during initial assessment. Initial comfort levels with using AI (Figure 1) were comparable, with median comfort ratings of 3 and similar distributions across categories. Over 60% of students (85% control, 64% intervention) rated their comfort level as 3 or lower, indicating limited AI experience and moderate apprehension, setting the stage for examining how structured implementation influences confidence and instructor interactions.

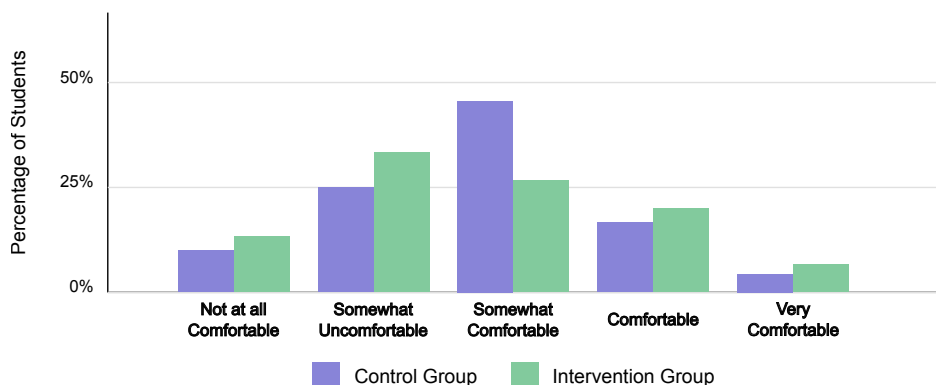


Figure 1: Pre-course Comfort Levels

Both groups also expressed concern about potential honor code violations, with approximately 20% of students in each group mentioning this concern explicitly in their open-ended responses. Students in both groups indicated mixed expectations about AI’s impact on their learning. The majority of students (approximately 60% in both groups) expressed a belief that AI tools would help them achieve course learning outcomes (Figure 2).

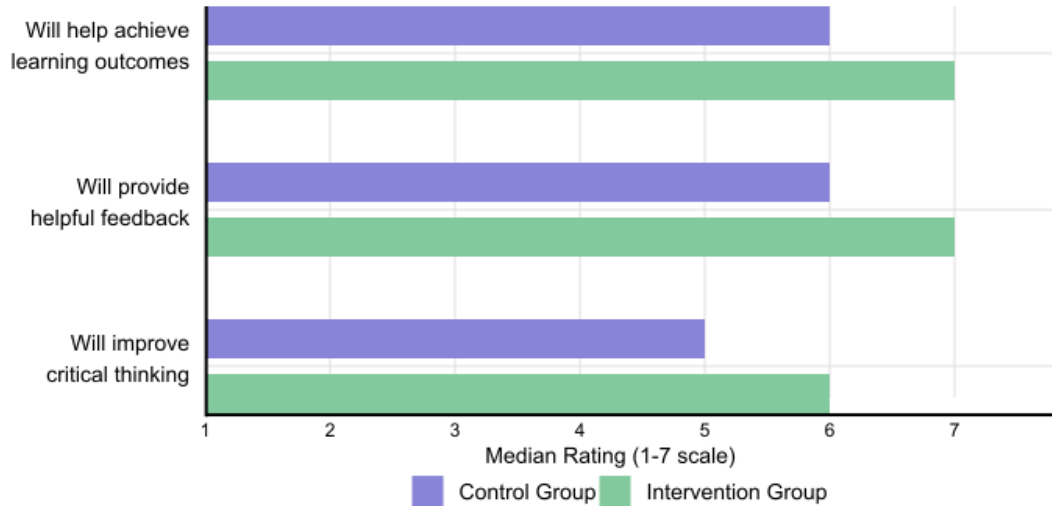


Figure 2: Pre-course Expected Impact on Learning Outcomes

Analysis of student-instructor interactions revealed distinct patterns, addressing Research Question 1 on how explicit AI instruction affects dynamics. The intervention group reported structured AI use, with 80% describing a pattern of resolving basic questions via AI before seeking instructors assistance, reflected in higher agreement (median=5 vs. 4, $p=0.0451$) to “The integration of AI changed the way I interact with my instructor.” Control students showed reluctance to replace instructor engagement with AI, with 25% avoiding it entirely, favoring traditional interaction.

Student confidence in AI tools, per Research Question 2, diverged over the semester. The intervention group maintained confidence in evaluating AI solutions, with 67% retaining positive responses (rating 5) and median scores for “Engaging with AI will challenge me to think in new ways” rising from 5 to 6. The control group’s confidence declined, with only 34% maintaining positive responses and median scores dropping from 5 to 4 ($p=0.0127$) for “Instructor’s AI prompt demonstrations improved my problem-solving ability,” suggesting structured guidance sustains belief in AI’s utility.

The intervention appeared to have a particularly notable impact on students’ perception of how AI challenged their thinking. When asked about agreement with the statement “Engaging with AI technology will challenge me to think in new and different ways,” the intervention group showed meaningful growth from pre- to post-course responses, with median Likert scores increasing from 5 to 6. In contrast, the control group’s median response remained static at 4 throughout the semester (Figure 3), suggesting less development in their approach to AI utilization.

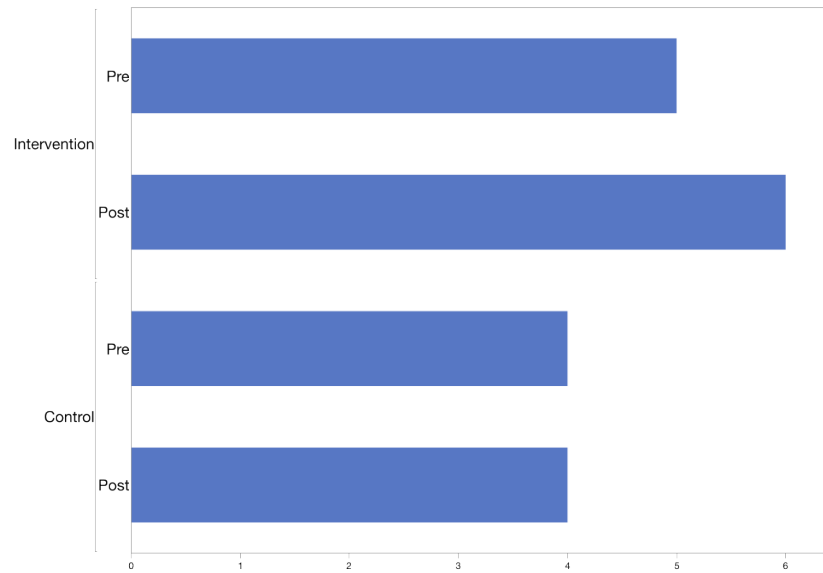


Figure 3: Engaging with AI technology will challenge/challenged me to think in new and different ways

This study revealed that structured AI implementation fostered sophisticated engagement beyond basic use, aligning with consistent usage patterns (80% intervention vs. 25% control), and influenced students' confidence in AI for cognitively demanding applications, including assessment-related activities. For the statement "AI-assisted reflection activities following graded events will/did improve understanding of course concepts" (Figure 4), the control group's median Likert response dropped from 5 to 4 ($p=0.0571$), reflecting a moderate decline in confidence, while the intervention group maintained a steady median of 4 throughout the semester. This pattern suggests structured guidance helped sustain realistic expectations about AI's utility for reflection activities without excessively boosting confidence, whereas students without formal guidance experienced diminished belief in its effectiveness. This finding aligns with broader trends of maintained confidence in the intervention group versus declining confidence in the control group across multiple AI use dimensions.

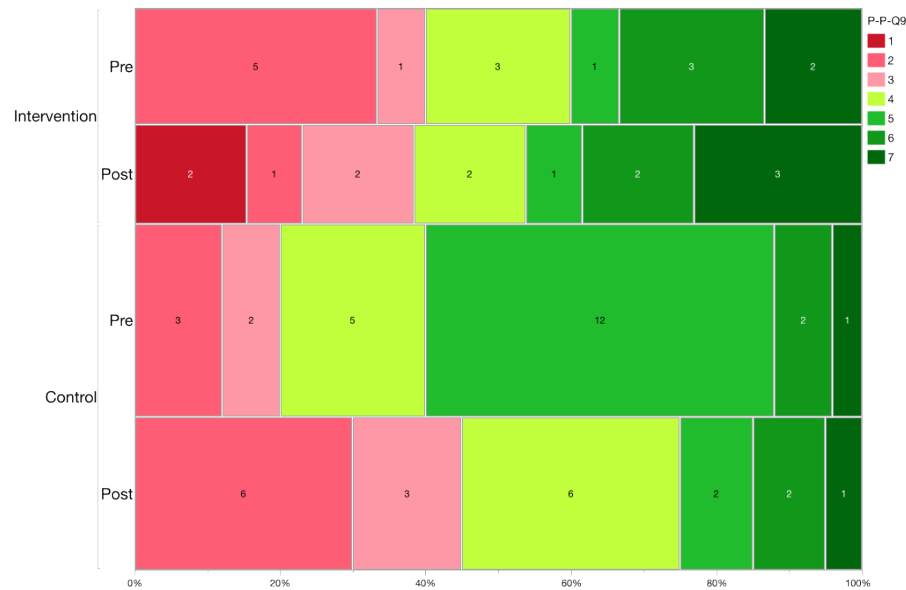


Figure 4: I believe I will use/used AI-assisted reflection activities following graded events (exams and quizzes) to improve my understanding of course concepts

Final grades (Figure 5) showed no significant difference (control: 88.4%, SD=7.2; intervention: 85.7%, SD=8.4; Mann-Whitney U, $p=0.2365$; t-test, $p=0.3438$ post-outlier adjustment), indicating altered interactions and confidence did not affect academic outcomes. Open-ended responses highlighted nuanced confidence dynamics: control students cited AI's unreliability for calculations and risk of dependence, with 25% avoiding it, while intervention students (80% noting documentation policy) maintained confidence (e.g., median=6 for challenging thinking) despite frustrations with documentation and AI errors. Both groups worried about AI as a crutch.

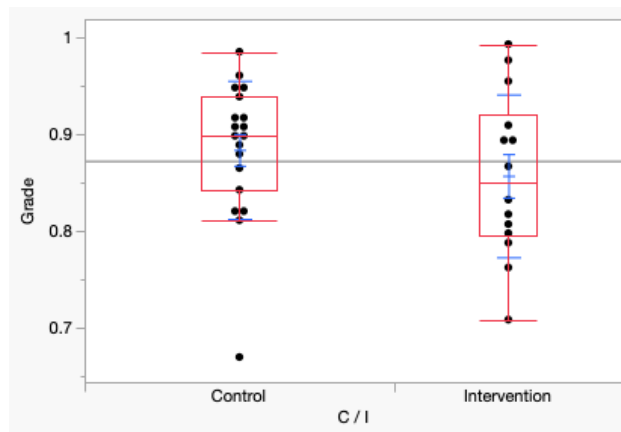


Figure 5: Final Grades Comparison

Post-course survey analysis revealed fewer differences between groups than the pre-course survey. The most notable difference appeared in responses to the statement “The integration of AI has changed the way I interact with my instructor” ($p=0.0451$), directly addressing Research Question 1 on student-instructor dynamics. The intervention group reported a higher median response (median=5) compared to the control group (median=4), with this shift measured via the 7-point Likert scale and corroborated by qualitative responses indicating intervention students used AI as a preliminary resource before engaging instructors, while control students favored direct instructor interaction. A comparison of pre- and post-course responses within each group revealed one significant change, occurring only in the control group. For the statement “I believe the instructor’s demonstrations of effective and ineffective AI prompts improved my ability to use AI for problem-solving in geotechnical engineering,” the control group’s median response decreased from 5 to 4 ($p=0.0127$), suggesting that structured AI implementation meaningfully influenced student-instructor interactions.

A comparison of pre-course and post-course responses within each group revealed one significant change, occurring only in the control group. For the statement “I believe the instructor’s demonstrations of effective and ineffective AI prompts improved my ability to use AI for problem-solving in geotechnical engineering,” the control group’s median response decreased from 5 to 4 ($p = 0.0127$). This may indicate that students that do not receive formal instruction in AI use in a university setting feel they are falling behind their peers that do.

Analysis of open-ended responses revealed distinct patterns between groups, shedding light on Research Question 2 regarding confidence in AI for technical problem-solving. In the control group, approximately 25 percent of students reported never using AI during the course or using it minimally, with some explicitly stating they performed better by avoiding AI, reflecting a decline in confidence (e.g., median dropped from 5 to 4, $p=0.0127$, for AI prompt effectiveness). Common concerns included AI’s unreliability for technical calculations and the risk of dependence over understanding. The intervention group demonstrated more consistent AI usage, with over 80 percent mentioning the documentation policy, and maintained confidence in AI’s utility (e.g., median=6 post-course for challenging thinking, up from 5), though some found documentation cumbersome and noted AI’s mathematical errors. A notable critique was that AI integration sometimes reduced class time for geotechnical content, with one student commenting, “We spent too much class time talking about AI instead of geotechnical engineering.” Both groups expressed concerns about AI as a crutch, despite initial optimism, highlighting a nuanced confidence dynamic influenced by implementation approach. The qualitative responses suggest that students remained mindful of maintaining a balance between AI assistance and direct instructor engagement throughout the course.

Discussion

This study reveals complex dynamics of structured AI implementation in a technical engineering course, with three themes: implementation’s impact on confidence, evolving student-instructor interactions, and balancing AI with technical content. Pre-course optimism was high (intervention medians=6, control 4-5 across learning outcomes, feedback, critical thinking), but post-course reality was nuanced. Structured guidance sustained intervention group engagement (80% regular use vs. 25% control), yet academic performance remained unaffected ($p=0.2365$).

Confidence differed markedly: 67% of intervention students retained positive AI evaluation views (median=5) vs. 34% control (median drop 5 to 4, $p=0.0127$), with qualitative data showing critical discernment, e.g., “AI excels at explaining processes but not equations.” Structured guidance thus preserved belief in AI’s utility, addressing Research Question 2, while unstructured use eroded it. Student-instructor interactions, per Research Question 1, evolved distinctly: intervention students used AI for basic queries (“a low-stakes environment”) before instructors, unlike control students’ preference for traditional engagement (“If the teacher relies on AI, that’s unacceptable”), supported by Likert data (median=5 vs. 4, $p=0.0451$).

The evolution of student-instructor interactions revealed nuanced patterns in how students integrated AI assistance with traditional instructor support. Intervention group students reported using AI as an initial resource for basic conceptual questions before seeking instructor guidance. One student noted, “I feel better talking with AI than with my teacher about simple questions that I should already know the answer to,” suggesting AI served as a low-stakes environment for foundational concept review. However, students demonstrated clear discrimination in when to rely on AI versus instructor expertise, particularly for complex technical problems.

The control group exhibited markedly different interaction patterns, with several students expressing reluctance to substitute AI for direct instructor engagement. One representative response stated, “If the teacher has to rely on AI to answer questions that students have then that is unacceptable,” indicating a strong preference for maintaining traditional instructor-student dynamics. This perspective was echoed by another student who commented, “I don’t think AI affects the way I interact with the instructor,” suggesting minimal impact on established communication patterns.

The intervention group’s experience revealed a critical challenge specific to technical engineering courses: the deceptive appearance of correctness in AI-generated solutions to complex geotechnical problems. Students discovered that when using AI for calculations (e.g., effective stress, saturated soil consolidation), the AI would sometimes generate solutions that appeared correct but contained fundamental errors that only someone with technical expertise could identify. This observation reinforces the continued importance of developing strong foundational technical skills while suggesting that AI integration in engineering education must emphasize developing students’ ability to critically evaluate AI-generated solutions.

The study also highlighted important considerations about classroom time allocation and documentation requirements. The critique from intervention group students about excessive time spent discussing AI rather than technical content raises an important pedagogical challenge: how to effectively integrate AI instruction without compromising core subject matter coverage. While intervention group students reported greater comfort using AI due to reduced concerns about potential honor code violations, the documentation process itself presented challenges. Students were required to submit complete chat sessions alongside their work, with detailed statements explaining their AI utilization. This approach created a paradox: while explicit documentation requirements provided clarity and protection against honor violations, they also introduced a significant administrative burden that some students found excessive.

These findings have important implications for engineering education. While structured AI implementation appears to help maintain student confidence and create new modes of

student-instructor interaction, careful attention must be paid to balancing AI integration with technical content delivery. Future work should focus on developing efficient methods to achieve these balances while maintaining the benefits of structured implementation, particularly streamlining documentation processes to maintain academic integrity without creating undue workflow disruptions.

Conclusions

This study shows structured AI implementation in a geotechnical engineering course shapes student-instructor interactions and confidence, though not academic performance ($p=0.2365$), addressing both research questions. Interactions, measured via “The integration of AI has changed the way I interact with my instructor” (median=5 intervention vs. 4 control, $p=0.0451$) and qualitative data, shifted as intervention students (80%) used AI for initial queries before instructors, unlike control students’ (25% avoidance) traditional preference. Confidence, per structured guidance, held steady in the intervention group (e.g., median=6 for challenging thinking, up from 5; 67% positive) while declining in the control group (e.g., median=4 from 5, $p=0.0127$; 34% positive), yet grades remained similar. Educators must balance AI with technical content, streamline documentation, and enhance evaluation skills to leverage these benefits effectively.

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Appendix

Type	Question
Likert	I believe my grades will improve/improved as a result of using AI to better understand the course content
Likert	AI tools will help/helped me achieve the learning outcomes of this course
Likert	I believe/believed that AI technology will provide/provided me with timely and helpful feedback on my work
Likert	AI tools will provide/provided me with resources that are directly relevant to my learning needs
Likert	The use of AI tools in the classroom will improve/improved my ability to analyze and evaluate information effectively
Likert	I believe/believed AI tools will stimulate/stimulated my creativity in approaching academic tasks
Likert	Engaging with AI technology will challenge/challenged me to think in new and different ways
Likert	I believe I will use/used AI to generate practice Graded Reviews (GRs) or additional homework problems to reinforce course concepts
Likert	I believe I will use/used AI-assisted reflection activities following graded events (GRs and quizzes) to improve my understanding of course concepts
Likert	I believe use of AI will affect/affected my engagement with the course material
Likert	I believe in-class exercises where I explain concepts to Large Language Models (LLMs) and receive feedback will be/were useful to me
Likert	I believe using AI as a learning tool in this course will influence/influenced my critical thinking and problem-solving skills in geotechnical engineering
Likert	AI tools will enhance/enhanced my interest in this subject matter
Likert	The use of AI in this course will support/supported my learning, helping to bridge any knowledge gaps that may exist and understand new concepts
Likert	The customizability of AI tools will allow/allowed me to learn at my own pace
Likert	AI tools will help/helped me to make this course relevant to my interests
Likert	I believe AI technology can be/was designed to cater to a wide range of learning preferences and needs
Likert	I believe that the flexibility of AI tools as they are being/were incorporated and allowed in this course could help/helped me to approach learning in a way that best suits my style
Likert	The use of AI will help/helped to address my specific educational challenges and learning barriers
Likert	The integration of AI will change/changed the way I interact with my instructor
Likert	I believe AI use in the classroom will make/made my interactions with my instructor more efficient and productive
Likert	I believe my reliance on my instructor's support will decrease/decreased due to the effective use of permitted AI tools
Likert	I will be/was more willing to work with my peers when we use AI technologies in this course
Likert	My collaboration with peers in this course will be/was more productive when we integrate AI into our work
Likert	AI tools will introduce/introduced new ways for me to engage and interact with my classmates in this course
Likert	The use of AI by my instructor for administrative tasks like grading and feedback is/was beneficial for my learning experience
Likert	AI's role in handling routine tasks will give/gave my instructor more time to focus on teaching
Likert	I believe that my instructor's use of AI will enhance/enhanced the quality of the educational content in this course
Likert	I believe the instructor's demonstrations of effective and ineffective AI prompts will improve/improved my ability to use AI for problem-solving in geotechnical engineering
Text	Based on your experience this semester, what do you consider to be the primary benefits and challenges of using AI in the classroom?
Text	How has the use of generative AI throughout this course impacted your understanding of the course material? Did it help or hurt you in understanding the content?
Text	How have your comfort level, trust, and overall attitudes towards AI evolved throughout this course?
Text	As the semester draws to a close, what are your thoughts on using AI in future courses? Please share any concerns or hopes regarding its continued use.
Text	What recommendations would you offer to instructors who are considering or currently using AI as part of their course?
Text	What components of a course AI policy are important for you to feel comfortable and protected against honor violations when using AI?
Text	How do you think the integration of AI will change/changed the way you interact with your instructor? Are there questions you might be/were more comfortable asking AI tools?
Text	What type and amount of AI use is acceptable for your instructor in this course?

Table 2: Survey Questions