Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
ASEE
Paper ID #47274

Pilot Implementation of a Game-Based Learning Module for Levee Inspection and Development of Engineering Judgement

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Pilot Implementations of a Game-Based Learning Module for Levee Inspection and Development of Engineering Judgment

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Abstract

Undergraduate engineering students often face challenges entering the workforce due to limited practical experience, particularly in applying engineering judgment—an essential skill for addressing complex, interdisciplinary problems. The increasing complexity of today's environmental, social, and technical issues underscores the importance of fostering engineering judgment, aligning with ABET student outcomes, which emphasize ethical responsibilities and informed decision-making in various contexts. However, traditional classroom settings rarely provide sufficient practice for this competency.

To bridge this gap, the GeoExplorer game, a mixed-reality learning platform offering virtual internship experiences, was developed. Its "*Levee Inspection*" module simulates levee inspection tasks, enabling students to assess integrity, identify failure mechanisms, and suggest remediation measures. This study evaluates the module's effectiveness in enhancing students' engineering judgment through pilot implementations at a four-year private research institution (91 students) and a four-year private primarily undergraduate college (21 students). Pre- and post-surveys quantitatively measured improvements in students' ability to report levee failure observations, recognize failure mechanisms, and propose appropriate remediation strategies.

Results indicated significant improvements across all areas following gameplay, demonstrating enhanced practical application of engineering judgment. Performance improvements were consistent among second- and fourth-year students, suggesting broad applicability across academic levels. These findings highlight the potential for integrating the "Levee Inspection" module into civil engineering curricula to effectively connect theoretical knowledge with practical skills. Future research should combine quantitative and qualitative analyses to further explore sustained impacts on engineering judgment development and professional readiness in today's evolving engineering landscape.

Introduction

The world is experiencing rapid transformation, and today's students need the knowledge and skills to respond to technological advancements, societal shifts, and changing expectations. Higher education institutions must also respond and adapt to these changes by supporting the development of the skills and competencies essential for student success and problem-solving in this dynamic environment. Among these skills, we focus on engineering judgment as a critical capability for mindfully addressing complex, real-world problems. Recognizing its importance, ABET has emphasized the development of engineering judgment in two of its Student Outcomes, highlighting the need for strategic educational approaches [1].

Engineering judgment involves making informed decisions in complex and uncertain situations, often leveraging a combination of technical expertise, hands-on experience, and ethical considerations. It is characterized by a reflexive and iterative consideration of comprehensive but often ambiguous or limited data from various sources and perspectives. This process allows engineers to analyze the fundamental causes of an engineering challenge and produce solutions that address the problem while considering its impact on all relevant parties [2]. As described by Bennett et al. [2], engineering judgment encompasses selecting the right problem to solve, establishing relevant criteria, applying key concepts appropriately, communicating decisions clearly, and striving to optimize societal well-being. Unlike traditional engineering skills, which may rely on procedural application or rote learning, engineering judgment requires critical thinking, adaptability, and situational awareness. Consequently, it must be practiced and cultivated through educational experiences that replicate the complexity and uncertainty of real-world engineering challenges.

The rapidly changing demographics and learning preferences of today's students necessitate the implementation of innovative tools to enhance engagement and motivation. In contrast to previous generations, modern students are digital natives who commonly perform well in interactive and experiential learning environments. Traditional teaching approaches, which primarily focus on passive knowledge transfer, fall short of addressing their needs. To bridge this gap, it is essential to have educational tools that promote active learning and skill development. These tools must not only capture students' attention but also develop competencies such as critical thinking, problem-solving, and engineering judgment—skills that are not explicitly developed by traditional instructional methods and are now critical for professional success [7].

Engineering judgment is essential in geotechnical engineering, where professionals often face complex, site-specific challenges that require unique solutions. Geotechnical projects often involve substantial uncertainties due to variable soil conditions, unexpected subsurface structures, and ever-changing environmental factors. Engineers must practice sound judgment to analyze data, evaluate risks, and suggest empathetic designs that prioritize safety and sustainability. The ability to apply engineering judgment effectively can significantly influence project outcomes, reducing risks and optimizing resources [6]. As such, fostering this skill in geotechnical engineering education is essential for preparing students to navigate these challenges successfully.

One promising approach to developing and assessing engineering judgment is the incorporation of game-based learning modules into engineering curricula. Game-based learning leverages interactive and immersive environments to engage students actively, motivate them to explore complex scenarios, and provide opportunities to apply theoretical knowledge in simulated practical contexts. Such tools can effectively facilitate the practice of engineering judgment while addressing the unique needs and learning preferences of today's students [3]. This game-based learning approach is distinctly different from traditional computer labs due to its adaptive and immersive nature, which can personalize the learning experience based on student progress. Unlike static computer lab exercises, the game adapts to the individual's learning pace and decision-making process by dynamically presenting challenges of varying complexity as the student progresses. This ensures that students remain engaged and motivated, while also promoting deeper comprehension of concepts by building on prior knowledge and skills incrementally. The GeoExplorer *Levee Inspection* module described herein integrates mixed reality elements and failure scenarios difficult to experience in the classroom, creating an experiential environment that replicates real-world scenarios more effectively than traditional computer labs. Such adaptability and immersion cater to diverse learning preferences and encourage active participation [3, 7].

This article presents the pilot implementations of a game-based learning module specifically designed for levee inspection and levee failure mechanism identification. This module *Levee Inspection* is part of the larger GeoExplorer game, whose first module, *CPT*, simulates the Cone Penetration Test (CPT), a fundamental field testing technique in geotechnical engineering. The *CPT* module provides students with a practical and interactive experience, allowing them to grasp the complexities of soil analysis and the intricacies of subsurface profiling. It has been successfully developed and integrated into geotechnical engineering curricula at over ten higher educational institutes across the United States [5]. The *Levee Inspection* module aims to build on this virtual environment and continue to enhance student engagement and positive motivational attitudes while developing and assessing their engineering judgment. By simulating real-world scenarios, the module provides a practical framework for students to inspect levees, identify potential visual levee failure observations, identify correct failure mechanisms, report and communicate with project manager, and suggest appropriate mitigation measures for individual levee failure mechanisms [8]. The results of these pilot implementations offer valuable insights into the efficacy of the *Levee Inspection* module as a tool for fostering engineering judgment and highlights its potential for broader adoption in engineering education.

Description of Virtual Environment

"...this type of educational game was… intrinsically motivating. Like I played a game, I had a little fun. But I also learned something that I would need for my future" - student user of *GeoExplorer.*

The concept for the *Levee Inspection* module was inspired by the devastating impact of Hurricane Katrina in 2005. This event highlighted the need for effective flood risk management training, leading to the development of an innovative gaming prototype. Initially created as a modified version of a popular game, the prototype simulated a Dutch landscape where players learned about flood prevention by identifying potential levee failures. This simple yet impactful prototype demonstrated the potential of gaming technology in disaster management and led to the creation of a standalone game focused on levee inspections. The game blended simulation, action, adventure, and puzzle elements, receiving positive feedback from professional patrollers and emergency response teams. It was adopted for training in flood risk management in the Netherlands and helped raise awareness about the importance of inspecting and maintaining levee systems [4].

Building on its success, the game was adapted for broader audiences, including U.S. undergraduate students, with a focus on developing engineering judgment in geotechnical engineering. Supported by external funding, the game underwent significant enhancements, including updates to its simulation environment and virtual tools, to create a more immersive and realistic experience. The latest version of the *Levee Inspection* module has been integrated into educational curricula inspired by the successful integration of the first module of GeoExplorer, into introductory geotechnical engineering courses at over ten institutions. Simulating a real-world Cone Penetration Test (CPT), the *CPT* module guides students through a three-phase process: preparation, field site access, and test completion. Players begin by driving a CPT truck to the test site, minimizing damage en route. In the Preparation Phase, they ensure proper setup by leveling the truck, selecting the correct cone, and pre-digging the location. During the Field Site Access Phase, they verify calibration values to proceed with the CPT. In the final Test Completion Phase, players monitor live results inside the truck and determine when to stop the test. The module concludes with a detailed performance evaluation, providing feedback on driving, preparation, and CPT execution. As part of the GeoExplorer game, this module delivers a comprehensive understanding of the CPT process, equipping students with practical skills essential for geotechnical engineering.

On the other hand, in the *Levee Inspection* (the module on levee inspection), players take on the role of an intern tasked with inspecting a levee network for signs of failure. After logging in, they receive a mission briefing from the Project Manager outlining their responsibilities (Figure 1): observing failure progression, identifying failure mechanisms, and recommending mitigation measures.

Equipped with an in-game smartphone featuring a camera for documentation and communication, players set out for inspections using the vehicle provided in the virtual environment. A drone, accessible from the trunk, offers aerial views for closer observation. Players must capture photos of failure signs, report them promptly to the Project Manager (through the in-game phone), and provide detailed descriptions. Figure 1 illustrates key moments from the Project Manager's Briefing. The screenshots provide a visual representation of the briefing interface.

Throughout the mission, players are evaluated on six educational targets: observation quality, reporting thoroughness, severity assessment accuracy, communication clarity, understanding of failure mechanisms, and mitigation planning. The mission concludes with a performance review on a virtual scoreboard.

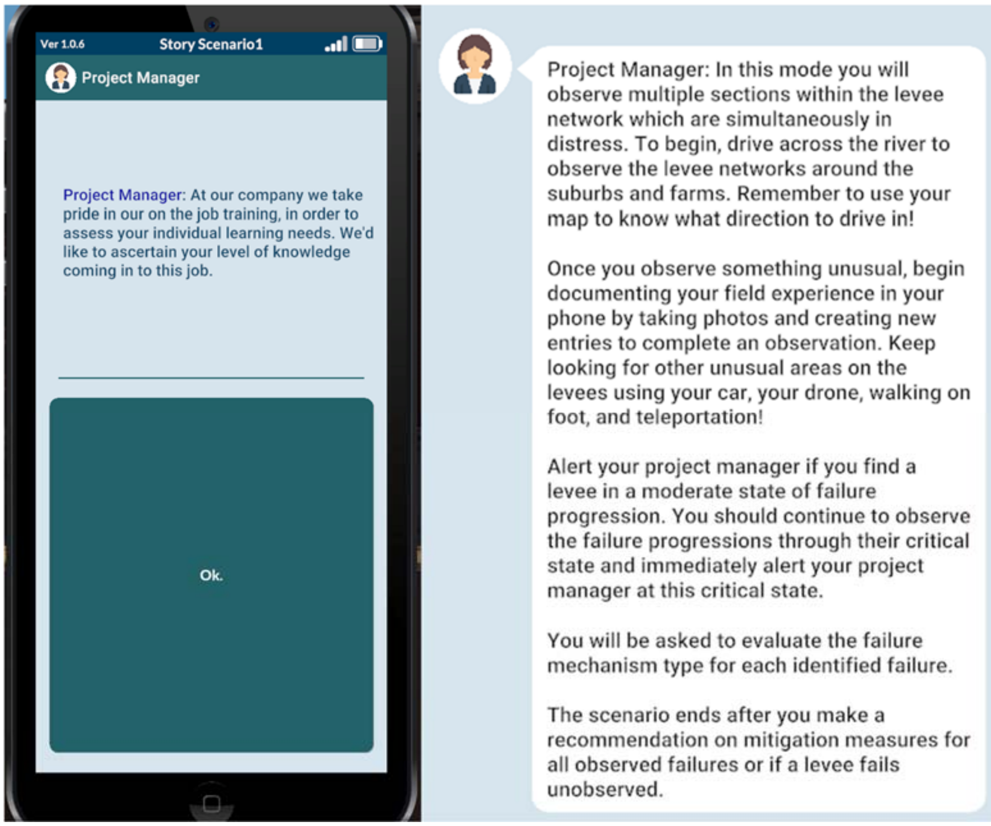

Figure 1: Screenshots of Project Manager's briefing.

Failure Mechanisms

The current version of the *Levee Inspection* module has been under development for many years. Extensive collaboration between the research team and developers has attempted to produce a virtual environment that closely replicates real-life scenarios. This was made possible by utilizing detailed examples of levee failure progression, videos of actual failure events, and photographs of real-world conditions.

The module now includes three distinct types of levee failure mechanisms: slope instability due to shear failure, internal erosion by underpiping, and internal erosion by through piping. In the virtual environment, each failure mechanism progresses through a series of five distinct visual observations, with each representing an increasing level of severity.

Slope Instability due to Shear Failure

Figure 2 illustrates the progression of slope instability caused by shear failure within the *Levee Inspection* virtual environment, described as follows:

1. Subtle Cracking (Low Severity)

Initially, small cracks appear parallel to the road or crest on the protected side slope, and subsequently appear near the toe of the levee. These cracks may seem insignificant at first, but over time they grow larger and increase in number, forming several parallel lines. Eventually, these cracks join together to create a single large crack.

2. Perpendicular Cracking and Settlement (Moderate Severity)

As the shear failure progresses with time, cracks begin to form perpendicular to the road or crest, first appearing near the crest. These cracks gradually increase in size and depth. The worsening condition of these cracks indicates a shift to a moderate level of severity. Over time, the parallel cracks near the toe and crest, along with the perpendicular cracks near the crest, start to connect, leading to settlement. Settlement becomes noticeable at the crest, particularly in the areas impacted by these interconnected cracks. Simultaneously, bulging develops in the protected area near the base of the levee.

3. Severe Bulging, Crest Settlement, and Breach (Critical Severity)

The bulging in the protected area (near the toe of the protected slope) becomes more severe, while the crest experiences significant settlement. As failure progresses, the bulging in the protected area becomes increasingly severe and widespread, while the crest undergoes significant settlement. Eventually, a failure plane develops, linking the cracks at the crest to the bulging area at the toe. This results in a breach with rotational sliding, where water initially flows clear but soon turns turbid as sediment is transported through the failed section.

Figure 2: Slope instability by shear failure progression in the virtual environment.

Internal Erosion by Underpiping

Figure 3 shows the progression of internal erosion caused by underpiping failure within the virtual environment, described as follows:

1. Bubbling (Low Severity)

The process begins with the appearance of localized clear bubbles in the drainage canal. At this point, there are no significant structural changes, but it may indicate water movement through the levee cross-section

2. Sand Boil Formation and Sediment Transport (Moderate Severity)

As the bubbling continues, it starts to turn to discolored water and sand boils start to form in the drainage canal. These sand boils gradually grow larger in diameter and height. The water in the canal begins to turn brown as sediments are carried away by the flow. At the same time, localized cracks start to appear, forming both parallel and perpendicular patterns in the area.

3. Crack Linkage and Crest Progression (Critical Severity)

The cracks in the drainage canal connect and form a continuous failure pathway. This pathway expands and progresses back toward the crest of the levee. At this stage, the system is critically unstable and on the verge of collapse. As the underpiping process continues, internal erosion and sediment transport result in the complete loss of structural integrity. The levee breaches, allowing water to flow uncontrollably, carrying away sediments and leading to structural collapse.

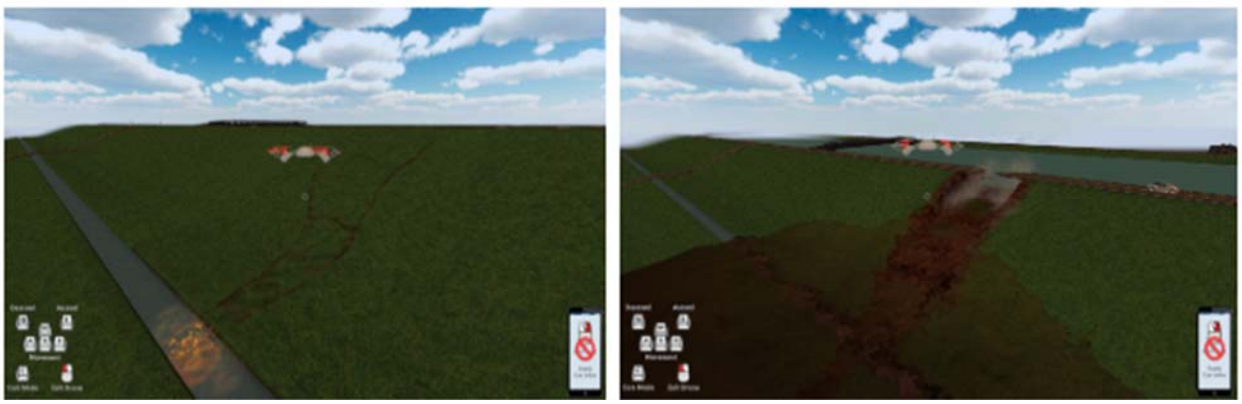

Figure 3: Internal erosion by under piping failure progression in the virtual environment.

Internal Erosion by Through Piping

Figure 4 represents the progression of internal erosion caused by through piping failure in the virtual environment, described as follows:

1. Unusual Wet Area (Low Severity)

Initially, an unusual wetness appears on the protected side slope, with slight signs of water movement, such as an indentation in the grass.

2. Seepage and Sediment Transport (Moderate Severity)

The unusual wetness on the slope gradually develops into seepage as water starts to trickle down. This movement of water begins to carry sediments with it, turning the clear water brown and murky. Simultaneously, cracks form in the wetted area, appearing both parallel and perpendicular to the crest of the levee.

3. Crack Linkage, Circular Failure Zone, and Breach (Critical Severity)

As seepage progresses, the cracks in the wetted area connect, forming a circular failure zone. This zone gradually expands and moves back toward the slope, reaching the crest or road. The connected cracks, combined with ongoing sediment loss, significantly weaken the structure. Water flow accelerates, carrying large amounts of sediment and causing structural collapse, marking the final catastrophic stage of through piping failure.

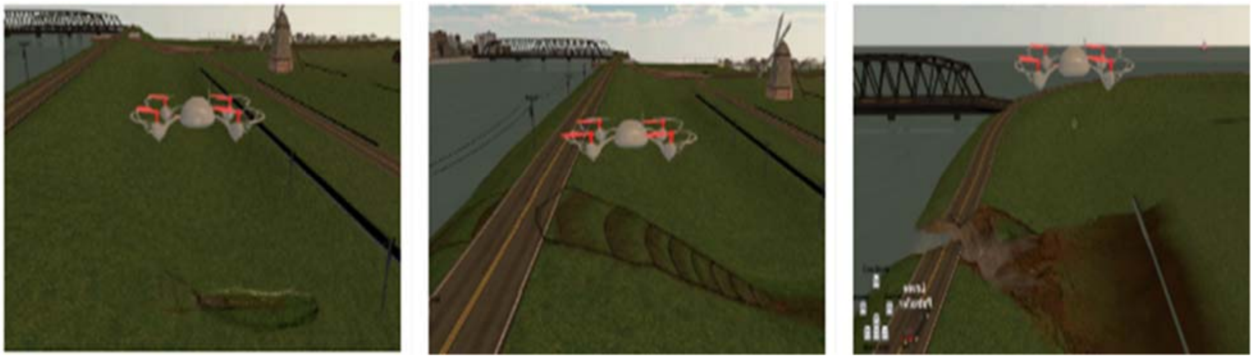
Figure 4: Internal erosion by through piping failure progression in the virtual environment.

Tutorial

The module includes an interactive tutorial that is designed to provide players with a comprehensive guide to the key tools and functionalities needed to navigate and perform required tasks in the virtual environment. It walks users through the essential features step-by-step, ensuring they are prepared for gameplay. Figure 5 highlights the Project Manager's instructions, and user interface, including key navigation controls and the locations of essential tools required for performing inspections in the virtual environment. Completion of the tutorial is required before players can progress to playing in the virtual environment.

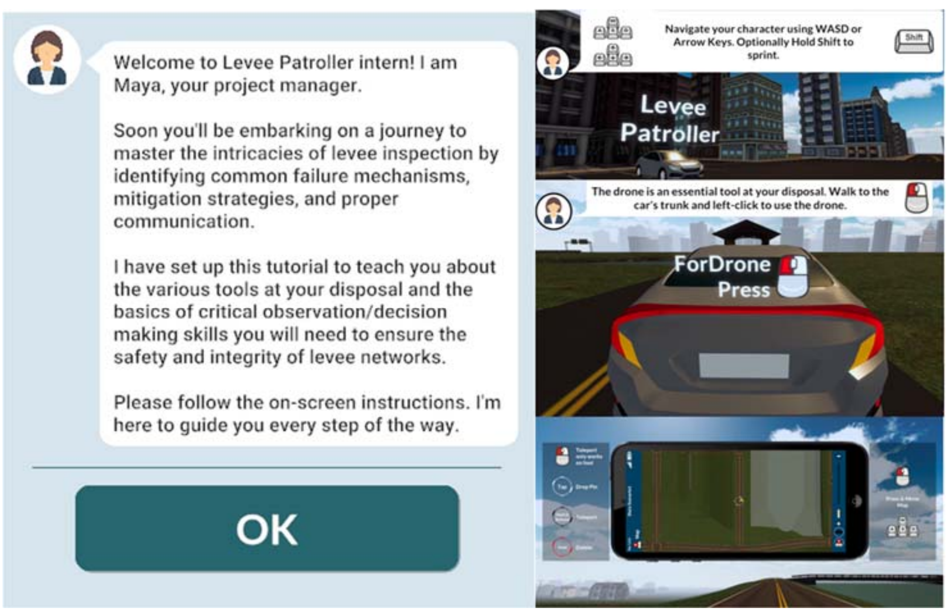

Figure 5: Tutorial practice for navigating and using tools in the virtual environment.

1. Driving: Players are first introduced to driving, which is one mode to explore the virtual environment. The car can be controlled using the W, A, S, D keys or the arrow keys. To enter the car, players must approach its left-hand side and left-click.
2. Drone Operation: Next, the tutorial explains how to operate the drone, a useful tool for aerial inspections. Players can access the drone by left-clicking near the car's trunk and

using the W, A, S, D, Q, E keys or arrow keys for navigation. The drone also features a Cam Mode, which can be activated by pressing C, allowing players to capture detailed views from above. Players can exit the drone by simply clicking the left mouse button.

3. Teleportation: The tutorial then demonstrates how to mark locations of interest using pins. Players can drop pins by entering Cam Mode with the drone and left-clicking on the desired spot. These pins serve as markers on the map and enable teleportation between pinned locations, streamlining navigation and reducing travel time within the virtual environment.
4. Camera Tools: Capturing photos is another key aspect covered in the tutorial. Players can open the Camera app and left-click to take pictures. Any photos captured within geo-located areas are automatically aggregated.
5. Creating Entries: The tutorial guides players on creating entries. This involves opening the Gallery app, selecting a captured photo, and clicking on Create a New Entry. This feature allows players to document and save important observations of the levee failure progression.

Story Mode

In the two pilot implementations described herein, students played two scenarios from the story mode: Scenario 1 and Scenario 2. In the virtual environment for Scenario 1, two failure mechanisms develop over time to different levels of criticality: shear failure in Suburbia Row to moderate severity and underpiping in Alice Farms to critical severity (site names used within the virtual environment are used to internally identify zones for individual failure mechanisms). These mechanisms evolve independently, culminating in their respective severity levels. Scenario 2 presents a more complex situation where three failure mechanisms—shear failure in Suburbia Row to critical severity, through piping in River Road to moderate severity, and underpiping in Alice Farms to low severity—develop simultaneously. The scenario concludes when the levee section at Suburbia Row breaches due to a shear failure. Players must strategically manage all three mechanisms, prioritizing their actions based on the level of criticality in each area to stabilize the virtual environment.

Methods

Pilot implementations of this module were conducted at two institutions. The implementation at University A, a four-year private research university, involved 91 students total. The implementation at University B, a four-year private primarily undergraduate college, included 21 students. Despite differences in institutional settings, the implementation structure followed a consistent format designed to ultimately evaluate the module's effectiveness in enhancing student engagement, shifting to positive motivational attitudes, and opportunities to develop engineering judgment.

The implementation process varied based on the module’s development stage at the time of the pilot. At University A, two initial pilot implementations were conducted during Fall 2023 and Spring 2024 while the module was still under development. As the module was not yet functional for gameplay, students participated in video-watching sessions featuring the failure animations from the virtual environment.

In contrast, the pilot implementation at University B in Spring 2024 and a subsequent implementation at University A in Fall 2024 provided students with the opportunity to directly interact with the fully functional module (Figure 6). These gameplay sessions allowed students to engage actively with the virtual environment, offering a more immersive and hands-on learning experience compared to the earlier video sessions. A summary of the pilot implementations is provided in Table 1.

Figure 6: Students participation during the pilot implementations.

A uniform procedure was followed across all pilot implementations to ensure consistency. Prior to the class intervention, students completed an online pre-survey via Qualtrics to assess their baseline knowledge and expectations. The class intervention included a lecture that provided foundational knowledge on levee failure mechanisms and mitigation measures. Depending on the development stage of the module, students either participated in a video-watching session or a gameplay session during a scheduled class period. Following the intervention, students completed an online post-survey via Qualtrics to evaluate their achievement of learning outcomes, perceptions of the module, and level of engagement. Figure 7 displays the knowledge questions included on the pre- and post-surveys along with their answer choices, with the correct answers highlighted in bold.

Q1. Which mitigation measure helps reduce the risk of levee overtopping?			
Raising the height of the levee crest	Installing pipes	Grass planting	Sandbagging the base
Q2. Which failure mechanism involves the movement of particles (sediment transport) due to water flow?			
Overtopping	**Under piping**	Slumping	Bulging
Q3. When attempting to mitigate internal erosion, generally the seepage flow can be reduced by all the following techniques except:			
Reducing the infiltration of floodwater in or under the levee	Increasing the seepage path	**Raising the height of the crest of the levee**	Reducing the hydraulic head
Q4. What is the likely first indication of a shear failure?			
Parallel crack	Perpendicular crack	Sand boil	Wetness
Q5. A sand boil is most likely a result of which failure mechanism?			
Shear failure	**Under piping**	Through piping	Overtopping

Q6. During a levee inspection, what would indicate an increased risk of external erosion?			
A heavy presence of wildlife near the levee	**Evidence of soil displacement or scouring on the waterside**	Dense shrubbery growing on top of the levee	The presence of cracks on the landward side of the levee
Q7. Which of the following is a sign of potential internal erosion in a levee?			
Birds chirping	Clear water at the base	**Turbid water or sand boils**	Dry patches on the surface
Q8. Which of the following is a sign of shear failure in levees?			
Sand boil	**Bulging or horizontal movement**	Clear water at the base	Freshly mowed grass
Q9. Identify the zone in the levee cross-section where impermeable sheeting (geosynthetic) should be placed to reduce infiltration in a through-piping failure.			
Flood area	**Flood slope**	Crest	Protected slope
Q10. If used, what is the likely function of a geotextile in levee systems?			
Hydraulic barrier	**Reinforcement and filtration**	Lighting	Soundproofing

Figure 7: Knowledge questions with answer choices (correct answers are in bold).

Acknowledging that multiple choice questions are not effective at assessing higher-order thinking, the most recent implementation added an open-ended question aimed at assessing students' development of engineering judgment: "Sketch two different emerging failure mechanisms on separate levee profiles at three different levels of severity during the failure progression and annotate the failure mechanisms. Sketch a mitigation strategy for each type of failure mechanism." This prompt was provided to students at three points in the implementation (before the lecture, before playing in the virtual environment, and after playing in the virtual environment). Qualitative evaluation of student responses to this prompt is ongoing.

Table 1: Summary of pilot implementations.

Implementation	# of students	Use of Virtual Environment	Typ. curriculum placement
Uni. A (Foundation Engineering) Fall 2023	19	No	Upper-level elective
Uni. A (Intro to Geo) Spring 2024	55	No	Second-year spring required
Uni. B (Intro to Geotech. Applications) Spring 2024	21	Yes	Upper-level elective
Uni. A (Foundation Engineering) Fall 2024	17	Yes	Upper-level elective

Findings from Pilot Implementations

The findings herein focus on the quantitative analysis of students' performance on knowledge questions during the pilot implementations. At the time of this writing, the review of the findings of these pilot implementations only assess the effectiveness of the *Levee Inspection* module in supporting student achievement of the following learning objectives: recognizing levee failure mechanisms, identifying failure mechanism progression, and selecting appropriate remediation measures. To quantitatively evaluate these learning outcomes, a pre- and post-survey approach was used, focusing on the ten knowledge questions in Figure 7.

Assessment of the first learning outcome, "recognizing common failure mechanisms," includes three knowledge questions: question 2 (Q2), question 4 (Q4), and question 5 (Q5).The pre- and post-survey results for Learning Outcome 1 for the four pilot implementations reveal improvements across all questions shown in Figure 8. For Q2, which assesses understanding of failure mechanisms that involve the movement of particles (sediment transport) due to water flow, post-survey scores showed the highest gain observed in University A (Foundation Engineering) Fall 2023. The most dramatic improvements were observed in Q5, which addresses the sand boil failure mechanism. For example, University A (Foundation Engineering) Fall 2023 percentage of correct responses jumped from 24% to 95%, while University B Spring 2024 showed improvement from 5% to 59%.

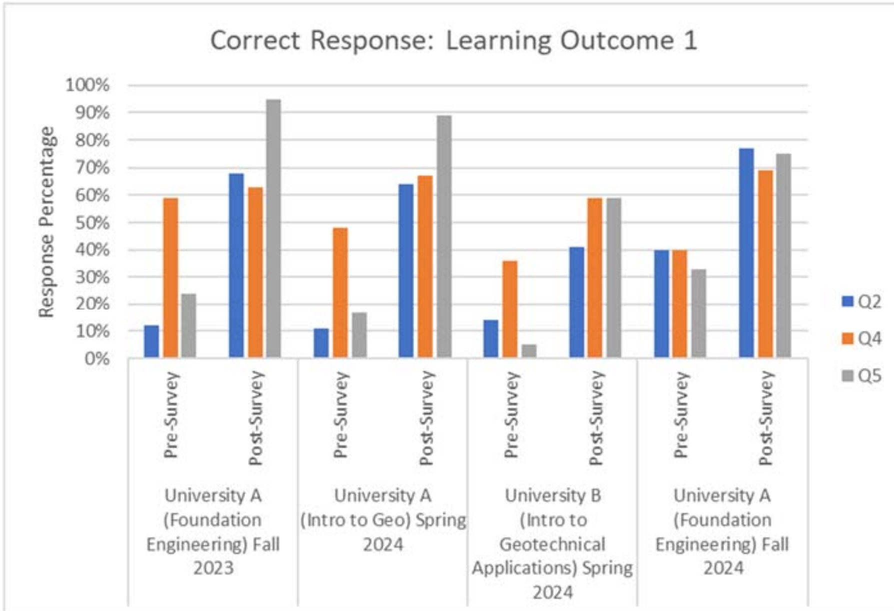

Figure 8: Correct response to questions for learning outcome 1.

The second learning outcome, "Identifying failure mechanism progression," includes three knowledge questions: "During a levee inspection, what would indicate an increased risk of external erosion?" (Q6), "Which of the following is a sign of potential internal erosion in a levee?" (Q7), and "Which of the following is a sign of shear failure in levees?" (Q8). Figure 9 shows the percentage of correct responses in learning outcome 2.

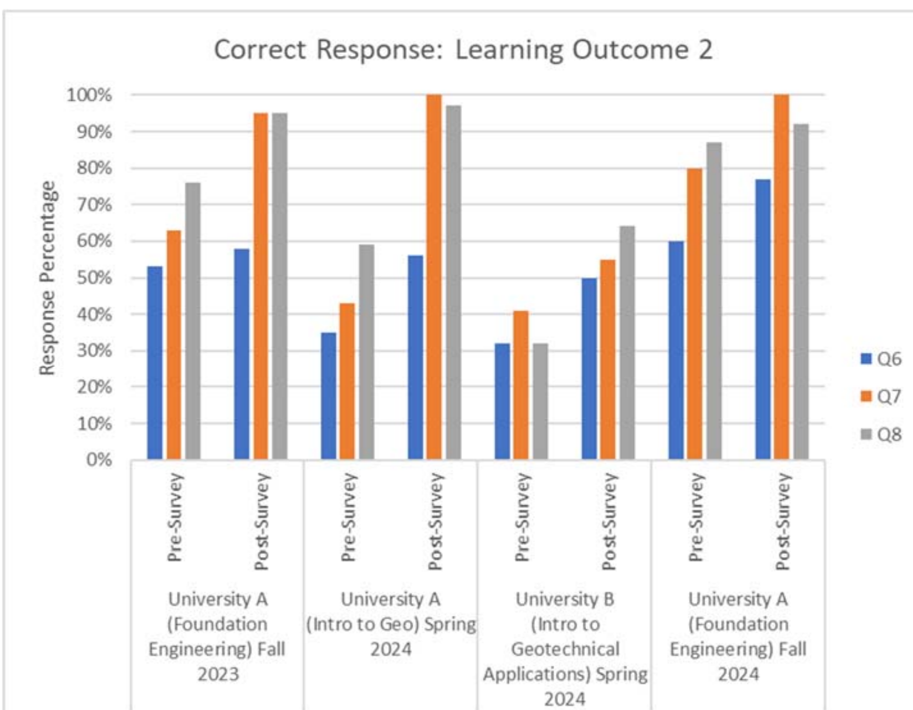

Figure 9: Correct response to questions for learning outcome 2.

The third learning outcome, “selecting appropriate mitigation measures”, includes four knowledge questions: “Which mitigation measure helps reduce the risk of levee overtopping?” (Q1), “When attempting to mitigate internal erosion, generally the seepage flow can be reduced by all the following techniques except:” (Q3), “Identify the zone in levee cross-section where impermeable sheeting (geosynthetic) should be placed to reduce infiltration in a through piping failure?” (Q9) and “If used, what is the likely function of a geotextile in levee systems?” (Q10). Percentage of correct responses of learning outcome 3 is shown in Figure 10.

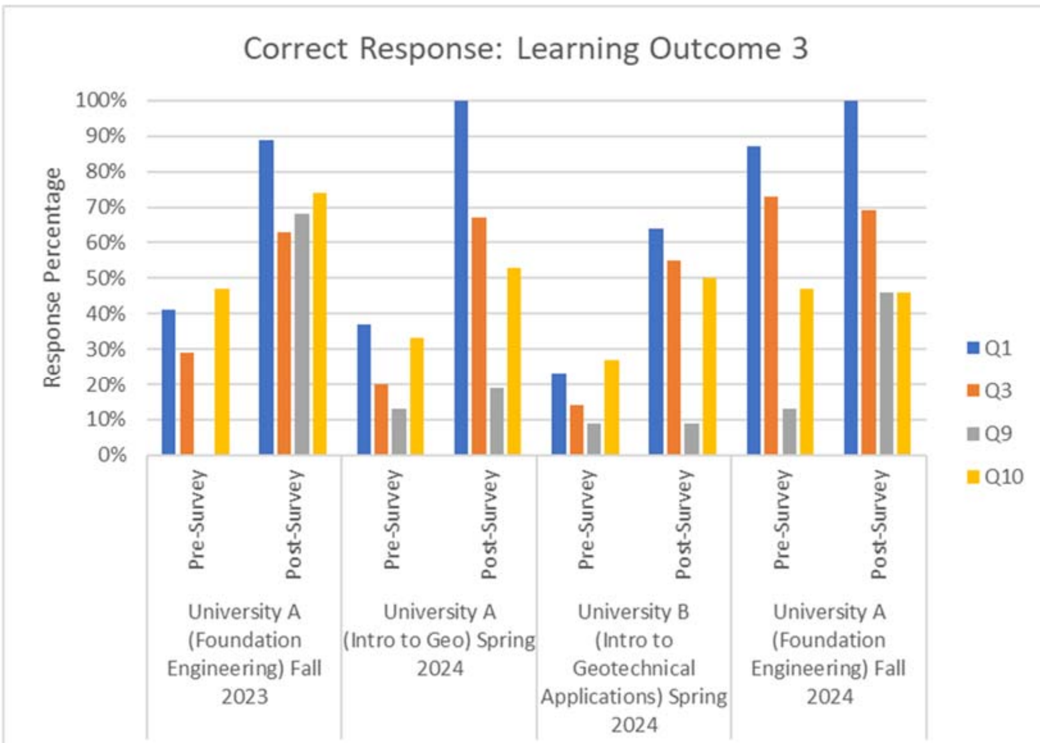

Figure 10: Correct response to questions for learning outcome 3.

Figure 11 illustrates the overall correct response percentage from the Spring 2024 implementation, in which students played in the virtual environment, conducted at University B for a limited number of students (N = 21). Overall, for the ten knowledge questions, the pre-survey median was 25% and the post-survey median increased to 55%. Figure 12 shows the correct response percentage from the Fall 2024 implementation, in which students played in the virtual environment, conducted at University A for a limited number of students (N = 17). Overall, for the ten knowledge questions, the pre-survey median was 43.5% and the post-survey median increased to 76%.

The results from pre-survey and post-survey assessments (10 knowledge questions) across the four implementations (Table 1) reveal improvements in student knowledge, highlighting the appropriateness of the knowledge questions, instructional methods and implementation design. Across all courses, average post-survey correctness increased compared to pre-survey responses. For instance, University A’s Foundation Engineering Fall 2023 class improved from an average pre-survey score of 40% to 77% in the post-survey; University A’s Intro to Geotechnical Engineering class increased from 32% to 71%; University

B's Intro to Geotechnical Applications class increased from 23% to 51%; and University A's Foundation Engineering Fall 2024 class increased from 56% to 75%. Within the limitation of these small sample sizes, we note the improvement in performance of students at different stages in their curriculum. University A's Intro to Geotechnical Engineering second-year students were able to achieve a post-survey correctness of 71%, compared to 77% and 75% achieved by upper-level students at the same institution.

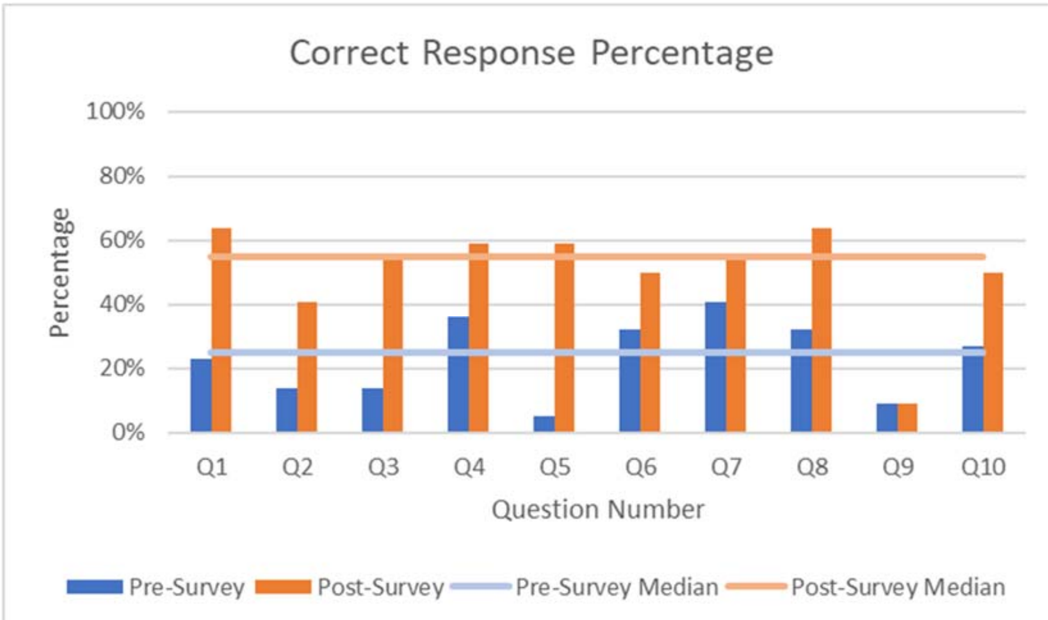

Figure 11: Overall correct response percentage from Spring 2024 implementation in University B.

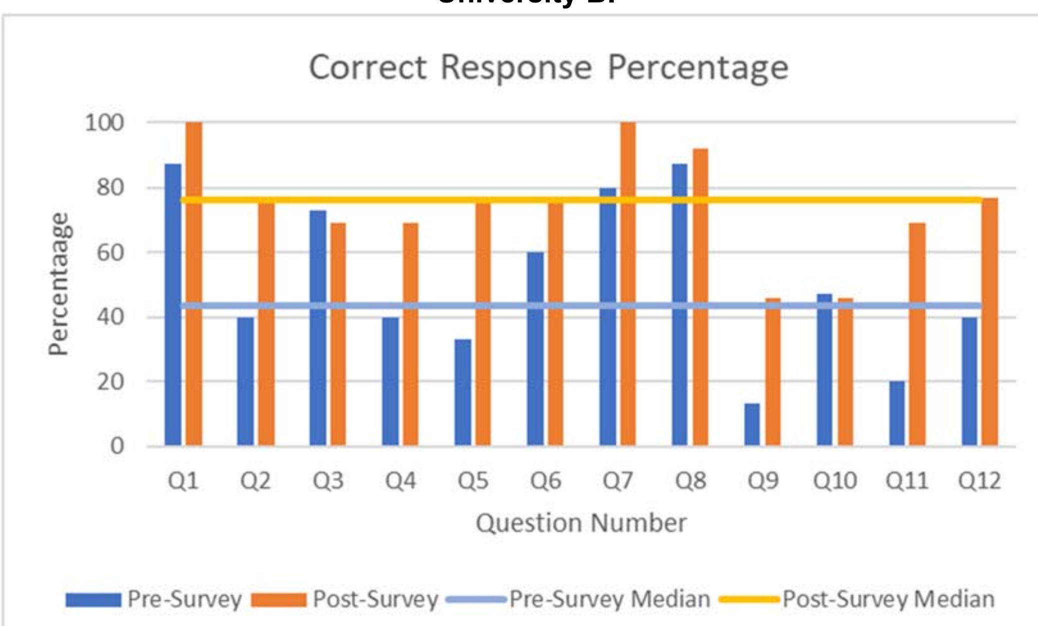

Figure 12: Overall correct response percentage from Fall 2024 implementation in University A.

Performance gains were observed in individual question performance, while the average pre-survey correct response was 35%, indicating that the knowledge questions were not easily answered prior to content delivery. However, certain questions, such as Q9 in both University A's Intro to Geotechnical Engineering class and University B's Intro to Geotechnical Applications class, showed limited improvements, indicating potential areas for targeted instructional enhancement or the need to review the phrasing of this question. Students in University A's courses consistently outperformed students in University B's course in both pre-survey and post-survey results, which may reflect differences in instructional methods, course resources, or student preparedness, and reminds us of the importance of reviewing contextual factors along with these findings.

Summary

The pilot implementations of the game-based learning module on levee inspection and failure mechanism identification have demonstrated potential in enhancing the development of engineering judgment among undergraduate geotechnical engineering students. Through interactive and immersive learning experiences, students were able to engage more deeply with complex concepts and apply theoretical knowledge to real-world scenarios. The preliminary findings indicate that students who participated in the game-based learning module showed improved understanding and retention of key concepts related to levee inspection and failure mechanisms. Evaluation is ongoing with respect to the effectiveness of the module for fostering critical thinking and problem-solving skills, which are essential for effective engineering judgment. Future work will focus on refining the module based on feedback from the pilot implementations and expanding its use to more institutions within the GeoExplorer network. Continued assessment and iteration will ensure that the module remains an effective tool for developing the skills and competencies needed by the next generation of engineers. Overall, the integration of game-based learning into engineering education holds promise for enhancing student engagement and learning outcomes, ultimately contributing to the preparation of well-rounded and competent engineering professionals.

Acknowledgement
This material is based upon work supported by the National Science Foundation (Award #s 1915121 and 1431838).

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