

REFLECTIONS ON TEACHING AN ENGINEERING COURSE THROUGH MURDER MYSTERIES

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Abstract

This paper presents a reflective analysis of a novel approach to Problem-Based Learning (PBL) to teach abstract concepts in a large-class setting, specifically tailored for a third-year required undergraduate course, “Introduction to Geotechnical Engineering.” The primary objective is to enhance student engagement and learning outcomes by employing forensic case studies-based learning, also known as murder mysteries. This unique adaptation of PBL offers a fresh perspective on teaching abstract concepts by introducing real-world engineering failures relevant to the topic. Students then identify potential reasons for failure, rank them, and cooperatively explore them. By progressing from the known to the unknown, students develop a comprehensive understanding of the fundamental principles they later encounter. by progressing from the known to the unknown This approach overcomes the limitations of traditional teaching methods that introduce abstract concepts before presenting real-world examples. The murder mysteries capture students’ attention and interest, allowing them to experience the process of doing real-world engineering. Consequently, the course rating improved significantly, achieving the highest score in the last twenty years - 4.9 out of 5.0, well above the average course rating of 3.8 during the same period. The paper delves into the background, methodology, challenges, and reflections on implementing and evaluating this engaging and effective PBL adaptation in a large-class setting for teaching abstract concepts in engineering.

Keywords – Problem-based learning, Murder mystery, Geotechnical engineering, STEM, Large-class-setting.

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1. Introduction

In the Fall of 2021, when I was assigned to teach the Geotechnical Engineering course, a third-year required undergraduate class in Civil Engineering, I was concerned. Students generally perceive this course as challenging, leading many to delay taking it until their final year. And for some, the course stands between them and their dream job. A straw poll of students taking the course in the Fall 2020 reflected the above sentiment; less than 12% of the students were interested in learning about Geotechnical Engineering. As students delay taking the course, very few would then continue in the field of geotechnical engineering, choosing other, more familiar streams of civil engineering. Unlike all the other

engineering courses, this is the first time the students will deal with particulate systems (soil) rather than continuum (the more familiar concrete, steel, and water). The course covers fundamental concepts of soil behavior, and the students learn how to design foundations and underground structures upon which all civil engineering structures are supported. The course is very demanding, with a lab and an assignment due almost every week. All this contributes to a low average student rating for the course of 3.8/5.0 in the last 20 years, compared to the organizational average of 4.1 for the same period. Although student ratings are not an objective metric, and studies have shown bias toward faculty's gender, age, and course grades (MacNell, Driscoll & Hunt, 2015; Fan, Shepherd, Slavich, Waters, Stone, Abel et al., 2019), they provide qualitative feedback, a relative metric on how much the students liked the course in comparison to other courses. My main concern was to make this course exciting and valuable. As a junior faculty, I was also concerned about the students' perceived lack of interest in the course translating to bad student evaluations influencing my tenure.

In my three years of teaching, all my courses have been on abstract subjects like numerical methods and computer programming. Students often struggle to learn abstract and complex concepts (Demise, Ochonogor & Engida, 2013), especially students from minority and underrepresented communities (Holland, 2019). Yet, solving critical science and engineering problems requires students to learn abstract reasoning. For example, teaching how to solve linear equations is abstract. Although the students may understand the process, they do not understand what the equations represent and what the variables in the equations mean. However, showing how a building deforms under the action of forces provides a concrete example of how the abstract concept of linear equations is used in a real-world structural design. Learning through concrete examples of forces-displacements instead of abstract variables enables the students to apply these concepts to other areas of study. I have realized the importance of grounding abstract concepts in real-world applications. Students appreciate the practical aspects and the links to real-world examples, as reflected by student comments such as *“Loved that you used real-life examples to teach the material, I learned really well because of the examples.”*

In thinking about how to approach the geotechnical engineering course, I hoped to apply some of the strategies of using real-world examples to facilitate deeper student learning. I also wanted to draw on the knowledge gained during a recent teaching fellowship focused on problem-based learning. I had initially planned on using real-world case studies as an introductory but isolated motivational example at the beginning of each lecture. Instead, I decided to restructure the entire geotechnical engineering course around learning new concepts by exploring real-world cases, which naturally led me to examine the idea of Problem-Based Learning (PBL).

PBL involves students divided into smaller groups examining real-world problems with no single or neat solution. While struggling with solving real-world challenges, students “acquire knowledge, content-related skills, self-management skills, attitudes, know-how: in a word, professional wisdom” (Biggs, 1999: page 207; Savery, 2015). The challenge for me was how to adapt PBL to a large class setting, where the effectiveness of PBL is not well known and remains largely untested (Pastirik, 2006, Klegeries, Bahniwal & Hurren, 2013, Manoharan, Ye & Speidel, 2022). The Introduction to Geotechnical Engineering course has about 70 students per section (~140 students per semester). Adapting the small group interactions to a conventional lecture-based engineering curriculum is impractical due to the lack of additional tutors to facilitate and monitor the cooperative learning phases in a large-class setting.

Previously, in the undergraduate course “Introduction to Computer Methods,” I successfully employed flipped classrooms. The course involved students viewing a 30-minute pre-recorded video lecture, and the synchronous in-person class session involved live coding and interactions via anonymized online quizzes. The flipped classroom is a practical approach to problem-based learning, where the pre-recorded videos help cover the knowledge required to solve real-world problems discussed during live sessions. But, Zoom fatigue (Peper, Wilson, Martin, Rosegard & Harvey, 2021) and extended screen times reduce student involvement in watching video lectures and diminish participation (Oberle, Gist, Cooray & Pinto, 2020). Also, the number of students watching the pre-recorded videos and the quality of learning, measured by

in-video quizzes, declines as the semester progresses. Although flipped classrooms and other active learning classes show improved performance in learning (through tests), the student's perception (feeling) of learning is diminished compared to traditional lectures (Deslauriers, McCarty, Miller, Callaghan & Kestin, 2019). Indeed, more than one-third of lecturers who try active learning techniques revert to passive lectures, citing student complaints. I explored different avenues for creating an active learning environment in a large in-person class setting.

My educational background spans India and the UK; I teach in the US. In all these regions and in every undergraduate textbook, the geotechnical engineering course is taught the traditional way through lectures by introducing abstract concepts, solving numerical examples, and illustrating some case studies for motivation. Even as a student, I did not find this approach particularly exciting. I thought I would be bored teaching the course in a traditional lecture-based setting as it involves many abstract concepts. We were coming out of the COVID pandemic, and after nearly two years of online classes, I wanted to make it worthwhile for the students to return to in-person lectures while also bringing new lessons from remote and hybrid learning. One of the techniques I continued to use in in-person lecturing is an online polling platform – Menti, that allows students to pose, rate, and answer questions anonymously. The anonymous nature of Menti reduces the students' fear of being judged and democratizes classroom participation neutralizing the few dominant individuals. Looking to make my course interactive, I was inspired by "The Guide to Soil Mechanics," a book by Prof. Malcolm Bolton, which discussed a case history of a failed dam in Swaziland to introduce the concept of grain size distributions and index tests (Bolton, 2013). The book gave me the idea of starting with a real-world failure case study and working backward to explain the theories while trying to solve the mystery of what caused the failure.

2. Methodology

2.1. Murder Mysteries and Teaching Philosophy

Instead of focusing on adapting PBL to a large class setting, I modified the course content and structure by distilling the core idea of PBL using murder mysteries (forensic case histories) to help learners build knowledge through practical problem-solving. First, we introduce an example of an engineering failure relevant to the topic; then, the students identify potential reasons for failure; we then cooperatively explore the different reasons where the students proceed from the known to the unknown and, in doing so, develop a comprehensive understanding of the fundamental principles (abstract concepts) they later encounter. This murder mysteries-based teaching solves the most glaring problem in the traditional method: introducing abstract concepts before presenting concrete examples in the real world. The conventional process inhibits student learning, as abstract concepts remain vague and unclear, causing students to lose interest in the subject. By offering an engaging, relevant forensic case study upfront, we capture students' attention and interest and allow them to experience the process of doing real-world engineering. Chi, De Leeuw, Chiu and LaVancher (1994) explain how students understand more when they go through "self-explanations." When students attempt to solve murder mysteries, they question why and offer explanations for the failure, reinforcing their learning of abstract concepts.

Introducing geotechnical engineering concepts through murder mysteries (forensic analysis of failed case histories) is not different from the philosophy of PBL, where students encounter problems instead of facts and theories. The forensic learning model emphasizes shifting from "what is being *taught*" to "what is being *learned*." Let us now consider how the topic of the weight-volume relationship is introduced in the murder mysteries approach and what the students learn.

2.2. Introducing Geotechnical Engineering – Weight Volume Relationship

This is the first lecture on Geotechnical Engineering. Traditional teaching, including the prescribed textbook "Principles of Geotechnical Engineering" by Braja M. Das, introduces the weight-volume relationship as (Das, 2021):

“A given volume of soil in natural occurrence consists of solid particles and the void spaces between the particles. The void space may be filled with air and/or water; hence, soil is a three-phase system. If there is no water in the void space, it is dry soil. If the entire void space is filled with water, it is referred to as saturated soil. However, if the void is partially filled with water, it is moist soil. Hence it is important in all geotechnical engineering works to establish relationships between weight and volume in a given soil mass.”

Although this text explains that soil is a three-phase system with soil solids, water, and air, it does not explain why a weight-volume relationship is needed or its significance. More importantly, it completely ignores the fundamental concept that the amount of water in the soil controls its settlement. Without knowing where and why these abstract fundamental concepts are used, the students have a hard time constructing new knowledge without a reference to known information and quickly lose interest in the subject. Let’s now explore how I introduce this concept through a murder mystery.

2.3. The Case of the Collapsed Boiler House

“In 2018, a healthy food firm had new owners, who spent over \$400,000 for a new boiler house, which supplied steam under pressure to a food processing plant. The factory is situated near Houston, TX. Only weeks after going into full production, the boiler house was giving trouble. First, windows began to shatter, then cracks appeared in the concrete floor (Figure 1). The local builder was unable to fix the problem.”

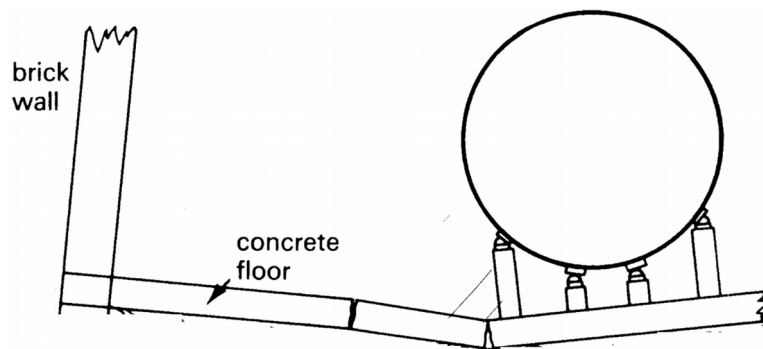


Figure 1. The mystery of the collapsed boiler house

After introducing the case study, the students are asked to explore potential reasons for failure using their current engineering knowledge. The students are tasked with finding this reason for failure within a prescribed number of questions (typically 10). The students initially post as many questions as possible online, then collectively rank them. I then answer the top-ranked questions. The students have an opportunity to rerank other questions based on my answers. I go down the list from highest ranked to lowest. The students’ questions and my answers to the top-ranked questions for solving the boiler house murder mystery in Spring 2022 are summarized in Table 1. In just six questions, the students discovered a fundamental relationship in soil – the loss of water from the soil voids (measured as weight loss in terms of water) causes soil settlement (change in the void space). Adding water to soil (measured as water content) causes swelling (measured as changes to the void ratio), whereas removing water causes settlement - this is the weight-volume relationship between water content and void ratio. Figure 2 reveals the failure mechanism for the students.

Even though the students solved the mystery in just six questions, we did not stop answering the other questions on the online portal. The students posted a total of 30 questions. After solving the mystery in the six questions, I answered nine more questions about the case study. A traditional lecture does not offer the opportunity to explore beyond the bounds of the topic, as it focuses on the linear delivery of content. Advanced topics such as the settlement of foundations, evaluating flooding impacts on foundations, and structural design are only introduced later in the semester or in a different course, limiting the students’ ability to link concepts with applications and wrongly promoting knowledge silos.

In addition to student-driven discussions, I also take the opportunity to discuss how the engineer in charge solved the mystery while emphasizing that it is one of the many possible paths to the solution. While the students focused on finding the answer by asking the least number of questions, an engineer would use her judgment and knowledge to adopt a methodological approach to solving the mystery. It allows me to discuss with the students how to approach a problem systematically. Although the first question from the student was to figure out the soil type underneath the foundation, which would require expensive soil sampling and testing, this was the last step taken by the engineer. I discuss how the first step is to do a reconnaissance to determine if the problem is local or site-wide, eliminating potential failure causes such as weather and natural hazards.

#	Question posed by the students	Answer	# upvotes (out of 58)
1	What kind of soil material was the boiler room built on?	Clayey soil	33
2	What is the type of foundation?	A raft foundation resting on clayey soil	30
3	<i>Was the boiler load larger than the safe load?</i> (students applying structural engineering knowledge of load-bearing)	No, the foundation was over-designed and can safely sustain the load	23
4	Were there any adverse weather conditions?	No, but this is an insightful question as students are considering if it is a local site effect or a more global problem	11
5	Where is the water table?	the water table is 2 m below the foundation, the soil voids (pore space) are saturated with water	11
6	Did the heat from the boiler cause shrinkage in the soil?*	Yes! Mystery solved!	10
7	Was the subgrade properly compacted?	Clayey soil cannot be compacted easily and does not respond to mechanical compaction.	4
8	Has the clay been treated before with lime?	No	4
9	How thick was the foundation?	The answer was unknown to the author and discussed live during class	3
10	Could water leak into the soil from the boiler?	No, the boiler did not leak until failure	2

Table 1. Questions posed by the students to solve the murder mystery of the boiler house and the corresponding answers and the student ranking for each question. Question marked with a * denotes the solution to the mystery

The engineer carefully observed the site (shown in Figure 1) – the caving of the room inwards means the soil underneath is shrinking rather than swelling (which causes the walls to bulge out). When the engineer asked to cut through the foundation slab near the door, by the light of the flashlamp, she could see the culprit directly under the concrete slab: **nothing!** (see Figure 2). Where there should have been compacted rubble, there was a gap so deep that it was only possible to confirm that the rubble did indeed exist somewhere below. As the engineer ruefully withdrew her hand, she took back another clue in the form of a blistered finger. The ground was scorching; a thermometer registered 212 F (100 °C) in the rubble, while the concrete raft was only warm to the touch. Finally, she asked to sink a few small boreholes through the foundation and in the general vicinity, away from the influence of the heat. The first question from the students (what was the soil) was the engineer's last question to prove her hypothesis. The murder mystery approach not only offers a means to construct new knowledge but also helps develop a technique to apply their knowledge in solving real-world mysteries.

The forensic approach also allows the students to explore more complex questions, which are otherwise never discussed in a traditional setting:

- How should the new boilerhouse be founded?
- Would using compact sand under the raft have had the same effect as the compact clay, and if not, why not?
- And practical questions such as: *How much compensation should the original builder pay?*

The students could discuss these questions on an online discussion board. A traditional engineering lecture does not offer the chance to discuss philosophical and political issues. The engineering profession is not just about handling technical issues but also solving associated societal and political challenges. For example, constructing a dam is not just about creating a sustainable source of water and energy but rather considering the potential dislocation of communities and the environmental impact of wildlife. The lack of consideration of the political and societal needs will result in badly designed infrastructure that can harm the environment and the public.

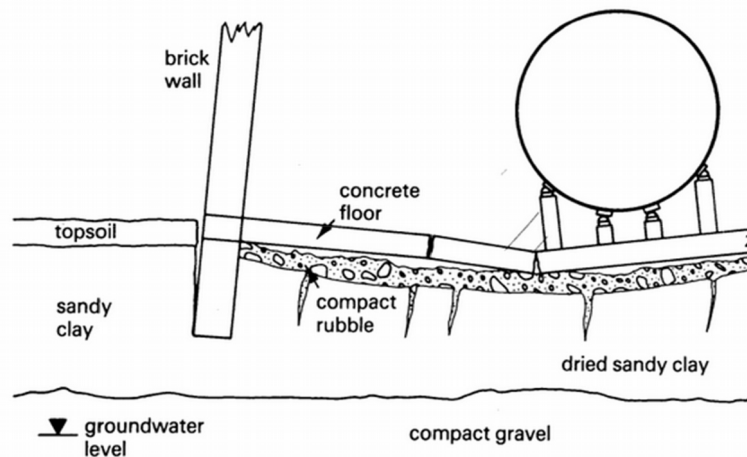


Figure 2. The case of the collapsed boiler house - mystery revealed (Bolton, 2013)

2.4. Summary of Murder Mystery Course Structure

Figure 3 presents an overview of a typical murder mystery class. Unlike a traditional motivational example, a real-world forensic case history is interwoven throughout the class. Each class begins with a story or a context for the mystery, which includes the site's location, geology, type of structure, and often the socio-economic context. The socio-economic context provides the much-needed and often lacking societal view of how engineering decisions impact our society. Once the students learn the context, they are encouraged to think of possible reasons for the failure. Their current knowledge and common sense are often sufficient to narrow down potential causes. Online polling tools such as Menti facilitate broader participation among students. The students then collectively brainstorm the possible reasons and prioritize them based on their understanding. The instructor then introduces new concepts or clarifies misconceptions by answering the top-ranked question. When a new concept is introduced, the students build on their current framework of understanding (constructivism) and use their new knowledge to identify another piece of the puzzle. The class is iterative, as each new question from the students is an opportunity to explore new areas and facilitate deeper discussions and understandings. Finally, after several iterations of exploring new concepts, the students acquire all the knowledge to solve the murder mystery. Like typical murder mysteries, this approach also leads to deadends, where students try to explore new ideas and discover that the approach does not work. Engineering decision-making involves a scientific trial-and-error approach where students constantly test their hypotheses. The murder mystery-style teaching encourages having a testable hypothesis and prepares the engineering students for the real world. We can also simulate real-world hard choices by restricting the number of questions or limiting their ability to choose between two difficult choices with partial information, as is often the case in engineering.

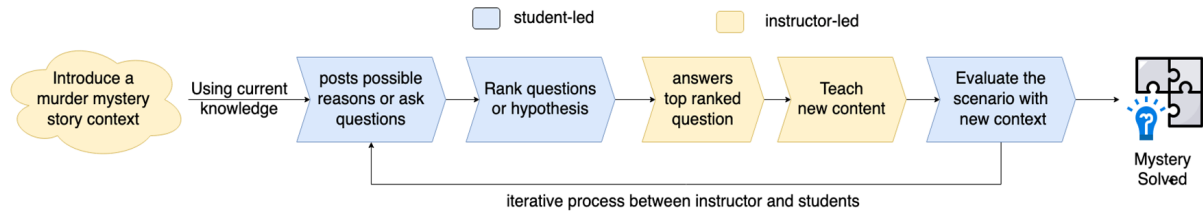


Figure 3. Murder mystery class structure overview

2.5. Students' Feedback on Learning

I taught the course through murder mysteries in the Fall of 2021 and Spring of 2022 and had an overwhelmingly positive response from the students. Forensic-based learning is a compelling student-centered learning model for teaching engineering material behavior and will benefit students across engineering and sciences. The students were not only able to intuitively arrive at the weight-volume relationship but also apply it to other real-world problems. An example discussion board post by one of the students shows their level of understanding of the subject after just one lecture: “*The tennis courts near my house [Austin, TX] tend to crack when the water table rises beneath the asphalt and allowing water to seep into the court, and with repeated seepage or extreme temperatures it can cause fractures and cracks. I think building on an elevated platform and good drainage can reduce cracking.*” This discussion shows not just the student’s ability to identify the problem’s source but also the ability to apply their newly acquired knowledge in proposing possible solutions.

Overall, the course rating improved considerably, achieving the highest in the last twenty years - a rating of 4.9 out of 5.0. Highlights from student feedback: “*the case studies presented in the lectures were a fantastic way to tie in the concepts to their uses in the practical field.*” and “*I think of all my classes, I learned the most in this one. I love telling my friends and family about the interesting case studies we’ve talked about, and that’s all because your teaching style has been really beneficial for me.*” Students enjoy solving puzzles as they feel connected to their future experiences as engineers: “*I please ask you to have some sessions with fellow faculty and teach them your teaching style. It is just amazing and works very well. I always felt interactive during class and understood so much stuff that I don’t think would make sense if I just studied on my own.*”

2.6. Challenges in Developing the Course As Murder Mysteries

When I first taught the course in Fall of 2021, I was co-teaching the course with another professor. We both taught our sections and were free to adapt our teaching philosophies and approaches. But, we must cover the same content each week so the students can complete the assigned labs. I adopted a hybrid approach with students attending both in-person (reduced density classrooms) and online. In contrast, the other professor adopted asynchronous videos with online discussion sessions.

Since the syllabus is fixed between both sections, we had to cover the same topics. The main challenge is covering all the topics while also discussing the case studies in the same duration. Lecturers employing active learning are often concerned about content coverage. Although I was worried about content coverage, I decided to try the murder mysteries approach for at least the first few lectures and reevaluate. To my surprise, after the first couple of case studies, I covered the same content as the other section using asynchronous lectures. This puzzled me; I thought maybe I was glossing over intricate details. After a few weeks, it dawned on me that the murder mysteries (the forensic case studies) were the *content*. The forensic case studies explained the engineering concepts in intricate detail while offering the motivation for each lesson. In many cases, it allowed me to discuss practical applications and advanced topics (such as why the minimum void ratio of clays cannot go below 0.35), which would be impossible to do in a regular lecture or will stand out as a disconnected fact that the students quickly forget.

When I taught both sections of the course in the Spring of 2022, I was surprised by the difference in the questions from the students trying to solve the same murder mysteries. Unlike a traditional lecture, where I would have repeated myself, I often discovered different angles to the same problem. This truly defined

the student-led learning approach to murder mysteries. The student-centric approach means I do not end up rushing through the content when I teach it for the second time on the same day. I never felt I was repeating myself in the second section, which soothed my anxiety about being bored due to repetition. Yielding control of the content to the student offers a lively classroom environment.

The other side to yielding control is that I am vulnerable and fallible when facing an unexpected but insightful question. Since the problem is open-ended, not only do I need a thorough knowledge of the forensic case study but also the surrounding regions. In one of the sections, I had a question on whether an earthquake triggered the boilerhouse failure. Since the failure happened due to the heating of soil underneath the foundation and not a natural disaster - stating that natural disasters did not affect the region would have been sufficient. However, since the boiler house is situated in Texas, I had the opportunity to discuss the increased seismic activity in Texas. Texas is not located in an active tectonic region, yet, recent anthropogenic activities related to shale/oil extraction cause minor tremors in Texas. There has been a rise in seismic activity in Texas in the last decade. Although the description of the increase in seismic activity has no direct relevance to the problem at hand, it allows the students to construct knowledge that may be useful in a different situation.

After solving the mystery of the boiler house, a student asked *What was the thickness of the foundation?* Unfortunately, I had not found any details about the thickness of the foundation when researching the case study. Without that fact, answering the foundation thickness is tricky. I explained that I did not know the exact thickness of the foundation. However, the foundation was not too thick; otherwise, the heat would not transfer through to the soil, nor was it too thin (weak) that it failed to support the structure. The engineer who designed it did not consider the thermal conductivity of the concrete. I used my lack of knowledge of the foundation thickness as an opportunity to show my students how I would go about designing the foundation. I was able to determine a sufficient thickness based on the thermal conductivity of concrete (which we all found by searching online during the class). The active learning environment offers students many planned and sometimes unplanned learning opportunities. We discussed nearly twice as many questions after solving the mystery, which made me curious. The students were interested in knowing more about the problem and understanding the issues and concepts thoroughly rather than just solving the mystery.

Most textbooks do not teach Geotechnical Engineering through case histories. Although this course has been taught for almost a century to undergraduates, I had the daunting task of identifying relevant case studies that sufficiently and accurately describe the concept. Often failures in the real world are due to complex sets of reasons. It is not always the case that a single issue causes a catastrophic failure. I can spend hours or even days finding the most appropriate case study to teach a particular geotechnical concept. In addition to the lecture slides on murder mysteries showing failures and concepts, I also wrote detailed descriptions of case studies for each lecture (10 pages/case study). How long do I spend to find the case study? I arbitrarily decided that I would not spend more than six hours per concept. Sometimes I was lucky enough to find a case history that exactly fits the concept I was planning to teach. At other times, I resorted to simplifying the case study or using the same case study over multiple concepts when the failure was complex. For example, I used the failure of the Leaning Tower of Pisa to discuss both consolidation and bearing capacity concepts.

An overwhelming majority of the students found the course and the teaching mode helpful. Many students cited that was the only reason they turned up to the classroom, rather than just reading a textbook. I also received a comment where the student found it difficult to distinguish between the case study and the covered concept and preferred that I cover the abstract concepts first and then the case study. The comment highlights that most students are still trained the traditional way and using active learning and other teaching philosophies, however compelling, are still perceived as not-effective.

I have focused my efforts on improving and restructuring the course content, and I have not worked on improving the homework assignments and lab work that are integral parts of the course. As such, students keep bringing it up as an issue: *"The only struggle was the labs."* We had labs and homework due almost every

week of the semester (10 homework and labs). Since I had not altered the labs and homework, they are disconnected from the case histories the students solve. Although labs teach the students how a particular property is measured in the lab or field, which helps them solve the puzzle in class, there is no direct connection. In the future, I would work on integrating the lab as a piece of the puzzle to solve murder mysteries or a mystery in itself.

2.7. Reflections on Teaching through Murder Mysteries

Murder mysteries and forensic case histories-based learning provide a coherent, unifying framework to help students structure their knowledge. The students cooperatively explore the potential reasons for a failure by solving the forensic mystery - this is the idea of constructivism in teaching (Biggs & Tang, 2011, Merve., 2019). Students acquire and build knowledge and develop an in-depth understanding of fundamental concepts through solving forensic mysteries. They also create an engineering approach to problem-solving, often contributing unique and creative solutions to the problems.

The murder mysteries approach explored in the Introduction to Geotechnical Engineering course is not specific to Civil Engineering. It is, in fact, applicable to almost all materials courses in engineering and sciences, which have been traditionally taught in a lecture setting. Murder mysteries are adaptable to other teaching modes: lecture-based, hybrid/remote, asynchronous, and flipped classrooms. Murder mysteries are not just starting from a case study and moving to abstract concepts, it creates an active learning environment for students to explore. Student participation is critical for the success of this approach to teaching engineering.

Schwartz and Bransford (1998) observed that analyzing contrasting cases/concepts help students to differentiate between the features/topics in each case, leading to a better understanding of the explanations of the respective topics afterward. After the students learned that bunnies digging burrows caused a failure of an earthen dam, most students overwhelmingly listed bunnies as the potential failure mechanism of a concrete dam. This shows how the students compare previous problems to the current situation to understand better the newer concepts.

After teaching the geotechnical course through murder mysteries for two semesters, I examined why I thought leading it the traditional way was boring for me and why my students liked the real-world problem-solving aspect of the course. As an engineer, my job is problem-solving. It took me a while to understand that the students I teach are future engineers like me. In other words, my students and I are the same! We are all excited about applying science to solve the world's significant challenges. How do I teach and make a course enjoyable? The solution was staring at my face - I teach how I would like to be taught. The courses should teach me practical problem-solving skills. A student's feedback says it all: *"I may forget the intricate technical details, but I will never forget how to solve problems."*

My students and I enjoy the learning experience because we are both engineers at heart - we love solving problems and acquiring new knowledge. I finally solved why murder mysteries were compelling: As an engineer, I teach future engineers by solving the world's mysteries.

3. Conclusions

The murder mysteries approach to Problem-Based Learning in a large-class setting has proven effective in enhancing student engagement and learning outcomes. By introducing real-world engineering failures and encouraging cooperative exploration of potential reasons for failure, this unique adaptation enables students to develop a comprehensive understanding of fundamental principles and apply them to problem-solving situations. Furthermore, this approach can be adapted to various teaching modes and disciplines beyond Civil Engineering. The success of this method stems from the shared passion for problem-solving among both instructors and students, as well as the emphasis on practical skills and active learning environments. By teaching students in a manner that resonates with their future roles as engineers, this approach fosters a lasting understanding of essential concepts and the ability to tackle real-world challenges.

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