Introduction

Undergraduate-level engineering courses can sometimes be experienced by students as a semester-long march through content, with few opportunities for intellectual excitement or moments of deep cognitive engagement. This type of coverage-focused teaching persists despite the well-recognized need for instructors to "consider not only the content and topics that make up an engineering degree, but also how students engage with these materials" (Smith, et al., 2005, p. 97). The extent to which students are given opportunities to engage deeply with and make sense of engineering content may play a role in student retention (Danielak, et al., 2014) and in depth of student learning (Bransford, et al., 2000).

The theory of Imaginative Education (IE) (Egan, 2005) argues that traditional education systems often neglect the imaginative and creative aspects of learning, which are crucial for intellectual, emotional, and social development. Further, it offers a framework for leveraging the human ability to imagine and emote as a way to support learning. Imaginative Education involves creating engaging and meaningful learning experiences that tap into students' emotions, interests, and sense of wonder. Depending on the setting, it can involve using storytelling, drama, art, music, and other imaginative forms to help students understand and connect with the material they are learning. By accessing the imaginative and emotional parts of the brain, the theory suggests that students can better grasp and retain information and make connections between classroom knowledge and other, pre-existing or emerging understandings of the world.

Instructionally, IE offers a schema for designing lessons that are likely to engage students both cognitively and emotionally, by helping them to observe and connect to important features in the world around them (Judson, 2017) and allowing them to humanize complex topics that might otherwise be too abstract or disconnected from meaning (Hagen, 2013). As a teaching practice, it has shown promise in a variety of primary and secondary education settings, ranging from inquiry science (Hadzigeorgiou et al., 2012) and math education (James, 2006) to the informal study of literature (Stewart, 2014). Increasingly, IE is seen as a promising approach to supporting engineering students' engagement with content, both by connecting to students' emotions and by facilitating the conceptual transfer of key engineering design concepts (Ellis & Thornton, 2011).

IE is grounded in the development of five different and increasingly complex types of understanding that correspond to theorized stages of language acquisition. Associated with each type of understanding is a set of "cognitive tools" or mental devices that have been characteristic of human cognition throughout time (see Table 1).

Transmedia storytelling (Jenkins, 2006) is another approach to engaged learning. It is "a process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated entertainment experience" (Jenkins, 2007). The impact of transmedia is similar to IE; learners go beyond being merely consumers of information and instead become participants who create "new information through connections, explorations, and other forms of imaginative—and productive—play" (Rholetter, 2015). The benefits of using transmedia go beyond increased engagement. One is the variety of literacies transmedia environments support, "including textual, visual, and media literacies, as well as multiple intelligences…[it] allows for important social sharing among collaborators"

(Herr-Stephenson, Alper, Reilly, 2015). In the current study, transmedia techniques were used to complement the IE approach.

Table 1. Five kinds of understanding and the IE cognitive tools associated with each (Adapted from IERG, 2018)

Type of Understanding	Associated Cognitive Tools
Somatic (Pre-linguistic)	Bodily senses; emotional responses and attachments; rhythm and musicality; gesture and communication; referencing; intentionality
Mythic (Oral Language)	Story; metaphor; abstract binary opposites; rhyme, meter and pattern; joking and humor; forming images; sense of mystery; fantasy; games, drama and play
Romantic (Written Language)	Sense of reality; extremes and limits of reality; association with heroes, wonder; humanizing of meaning; collections and hobbies; revolt and idealism; context change
Philosophic (Theoretic use of Language)	Drive for generality; processes; lure of certainty; general schemes and anomalies; flexibility of theory; search for authority and truth
Ironic (Reflexive use of Language)	Limits of theory; reflexivity and identity; coalescence; particularity; radical epistemic doubt

This paper describes the process of developing, delivering, and assessing a university-level engineering course (EGR 340) using an IE approach coupled with transmedia storytelling , a narrative technique where the same story is told across multiple media platforms, each adding its own unique elements to the overall story. This creates a rich and immersive experience for the audience as they can engage with the story through different media and explore it from different angles. Although the tools are presented within the context of geotechnical engineering, the approach can be adapted and applied throughout engineering education.

The first section of this paper describes four types of understanding theorized by Egan, and how their associated cognitive tools and other transmedia techniques were used in EGR 340. Then, qualitative and quantitative assessment methods and findings are explained, which overall indicate that students may have experienced both cognitive and affective benefits from the approach. Finally, a discussion and conclusion offers additional details and reflections about the use of IE and transmedia in undergraduate engineering.

The Development & Delivery of EGR 340

Geotechnical Engineering (EGR 340) is a technical elective offered by the Picker Engineering Program at Smith College. Established in 2000, the Picker Program is the first engineering program at a women's college in the United States and one of only a small number of engineering programs set within a liberal arts college. The course meets twice a week for eighty minutes with labs integrated into the class time. The intended learning outcomes are:

- Develop a conceptual understanding of the properties of soil, water flow through soil, volume changes in soil and soil strength.
- Develop problem solving competence for soil phase diagrams; engineering classification of soils; 1-d water flow in soils; flow nets and 2-d seepage; effective stress in soil for hydrostatic, 1-d flow, 2-d flow and capillary rise; stress distributions caused by various loading shapes; amount and rate of consolidation; shear strength of soil; and soil compaction.
- Become familiar with laboratory soil tests and field sampling and improvement techniques.

In addition to traditional homework and tests throughout the semester, students were assigned several larger narrative-based assignments. In one, they are given two soil samples related to a potential lawsuit on campus. They are then asked to conduct Atterberg Limits and grain size distribution tests to analyze the suitability of the soil for underlying pavement and for lining a pond. In the second assignment, students calculate the volume of the excavated soil needed for the pond clay liner accounting for phase changes, transportation and evaporation losses. In the third assignment, students are tasked with analyzing the safety of a proposed dam design to replace a Victorian-era gravity dam in a nearby community. This requires applying much of the course content to calculate seepage, stress and the potential for liquefaction.

As a discipline, geotechnical engineering is dynamic and deeply connected to the drama of human fortunes and misfortunes. In didactic settings, however, mastering its concepts and techniques can be experienced as complex, tedious, and disconnected from meaning. To support students in achieving the intended learning outcomes, the instructors of this course have, over time, come to incorporate both transmedia and IE elements, using an iterative process of design, testing, and adaptation to refine and optimize the curriculum and its components. Four types of understanding — mythic, romantic, theoretic, and ironic — and their associated cognitive tools were used in EGR 340:

Mythic Understanding

In general, mythic understanding refers to the comprehension and interpretation of stories that explain cultural beliefs, values, and natural phenomena. A mythic understanding goes beyond a literal interpretation of narrative and instead focuses on the symbolic, allegorical, and metaphorical meanings behind the story. Mythic understanding can provide insight into the cultural and personal unconscious and can serve as a tool for deeper insight into self and society.

One of the cognitive tools that accompany this understanding is the use of story—including fantasy stories that support students in imagining scenarios that are removed from the rules that govern everyday life, mystery, a sense of drama and humor. Referring to the challenges geotechnical engineers face in dealing with such a complex, ever-changing, three-phase material (and with only limited knowledge of the material due to sampling difficulties and expense), geotechnical engineering is sometimes referred to as the "dark arts of engineering." With this in mind, EGR 340 used the dark arts as a mythic fantasy cognitive tool to engage students and support the development of ironic understanding. It began on the first day of class when students were welcomed to the “dark arts” class as if they were witches and wizards learning their craft at Hogwarts (the fictional boarding school for wizardry in the popular Harry Potter books that was part of many student’s youth) and included a short video clip of class at Hogwarts from one of the Harry Potter movies to set the mood. At this point students began working in teams to brainstorm what might be meant by “dark arts”. The resulting discourse on why soil is such a complicated engineering material led to the students coming up on their own with much of the course content to be learned.

Because geotechnical engineering is a relatively young discipline, many faculty teaching it can trace their lineage back to the founders of the field including Karl Terzaghi and Arthur Casagrande. At Smith, the professor’s lineage went back to Tschebotarioff–an important scholar with an interesting history and a rival to Terzaghi. This led to the idea that students in the class were not part of the mainstream, but were instead part of a different lineage that was similar to the Slytherin house at Hogwarts. That made their instructor analogous to Professor Snape and Tschebetarioff analogous to Voldemort. Combining Smith with Slytherin resulted in students referring to themselves as Smytherins.

This dark arts reference was revisited throughout the semester in a variety of contexts to frame classroom activities in fun and engaging ways. This included:

- Visits from Voldemort who would suddenly appear in PowerPoint slides or videos. While this was always welcomed by students (humor is a mythic cognitive tool), his appearances also played an important role in learning. In Fig. 1a he highlights key points; in Figs. 1b and 1c he asks important questions; and in Fig. 1d he makes a mistake that highlights a misconception held by many students.
- Visits from Professor Snape who played the part of a biased and harsh instructor. In Fig. 2a he leads the class in a series of questions in the style of the book character to provide practice and formative assessment. True to his character, in Figs. 2d, 2e and 2f he is showing his bias against Gryffindor by unfairly grading their work. To counter this practice, students in EGR340 are tasked with providing arguments opposing Snape.
- Visits from fictional Smytherin students. In Figs. 2b and 2c, the EGR340 students are challenged to find the simplifying assumptions hidden in the 2d flow derivation before the fictional Smytherins do. Knowing these assumptions is critical in properly applying the flownet solutions and this helps focus student attention.

While a variety of mythic tools were used throughout the course–including humor, mystery, binary opposites, fantasy and drama–the most important tool was story and it was used extensively throughout the unit. Often the story involved embedded videos in the PowerPoint slides that allowed the videos to be modified and fully integrated into the storytelling. An example is shown in Fig. 3. This figure shows screenshots from videos clips that were taken from a popular home improvement show and were repackaged in PowerPoint to have interactive opportunities for students to advise the show’s protagonists on buying a house to be flipped; analyzing the foundation problems; and proposing an engineering solution.

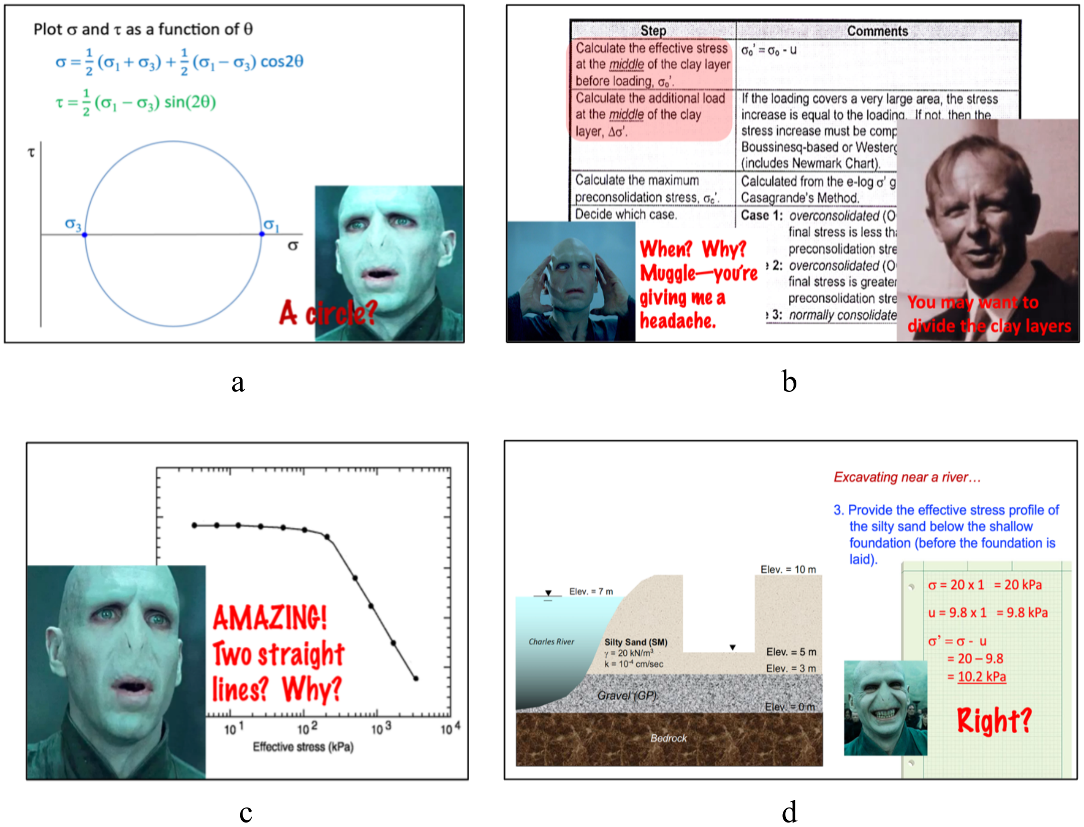


Figure 1 PowerPoint slides showing Voldemort's appearances to direct students' attention to key points presented in lecture, including: (a) Voldemort is amazed that the derived stress equations can be plotted as a circle; (b) Voldemort asks an important question that should be on learners' minds; (c) Voldemort brings attention to the mystery of why a soil void ratio versus effective stress results in two straight lines on a semi-log graph; and (d) Voldemort brings attention to a common student misconception by incorrectly solving a problem using static fluid and not dynamic fluid equations–a mistake that students must find and correct.

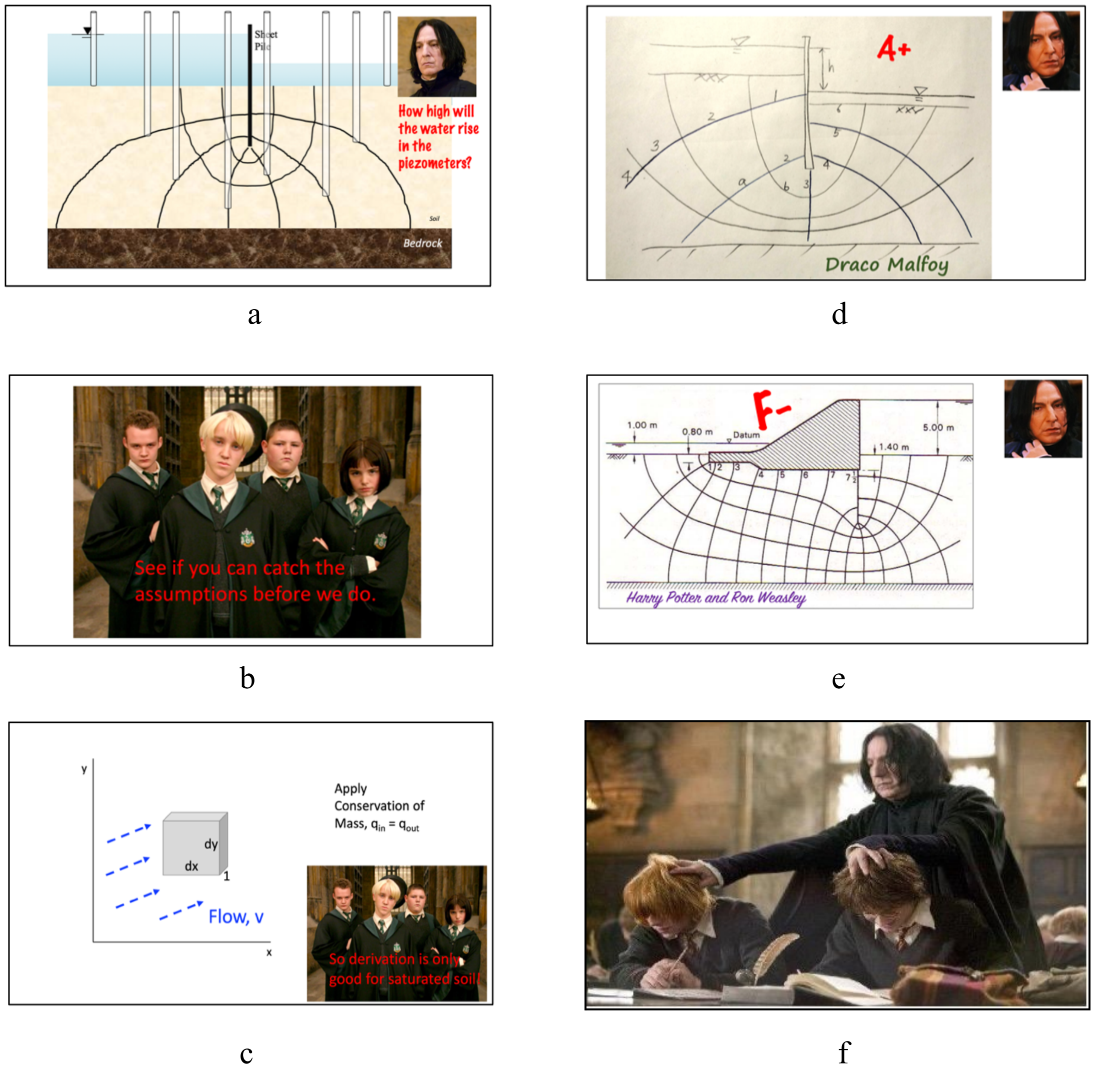
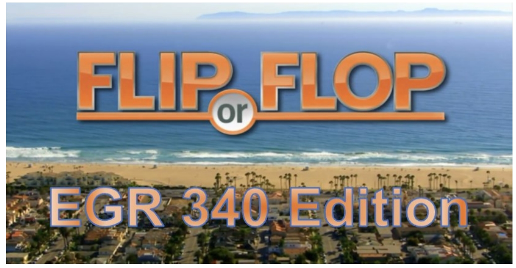


Figure 2 PowerPoint slides showing Professor Snape and other Smytherins in the Dark Arts class prompting student engagement about 2d flow in soil, including: (a) Snape leads a formative assessment activity; (b) fellow Smytherins challenge students to identify the assumptions made in deriving the LaPlace equation to describe 2d soil flow; (c) students try to find the derivation assumptions before their fellow Smytherins do; (d) students form arguments to challenge Snape's favoritism in grading Draco Malfoy's poor flownet; (e) students form arguments to attack Snape's harsh grading of Harry Potter's and Ron Weasley's excellent flownet; and (f) screenshot from imbedded video that accompanied Snape's unfair grading.



a

b

c

Figure 3 PowerPoint screenshots from video adventure introducing foundation consolidation, including: (a) show introduction, (b) show protagonists receive foundation repair estimate and (c) foundation is repaired.

Romantic Understanding

Romantic understanding connects human qualities and emotions — courage, compassion, tenacity, hope, fear, delight, etc. — to the learning process by inviting students to infuse academic concepts with human meaning. As with all of Egan's understandings, it asks students to *feel things* about a topic as well as *think things* about it. While largely absent from many STEM pedagogies, use of romantic understanding is ubiquitous in mass media and pop culture.

One approach to harnessing romantic understanding is through the example of extraordinary people. In geotech — and in EGR 340 — Karl Terghazi (1883-1963) and Arthur Casagrande (1902-1981) serve as central extraordinary figures. Their contributions to the field including the formulation of the effective stress principle and its influence on soil settlement, strength and permeability qualify them as "heros" of geotech, an idea that is woven through in the course in the form of stories of their struggles to advance and disseminate their work through a uniquely dangerous and turbulent period in European history. Course sessions often kicked off with one of these artifacts and both individuals made regular visits throughout the course to provide insight into the theories they developed. Figures 4a-4c show screenshots of Terzaghi being introduced to students through a time travel adventure in which students experienced the rise of geotechnical engineering and Terzaghi's early leadership. Figure 4d shows an example of Terzaghi appearing during classroom problem solving to offer insights to students. Figure 4e and 4f show Casagrande introducing students to the triaxial testing he invented and leading them on solving the mystery of how testing soils can reveal their prior stress history.

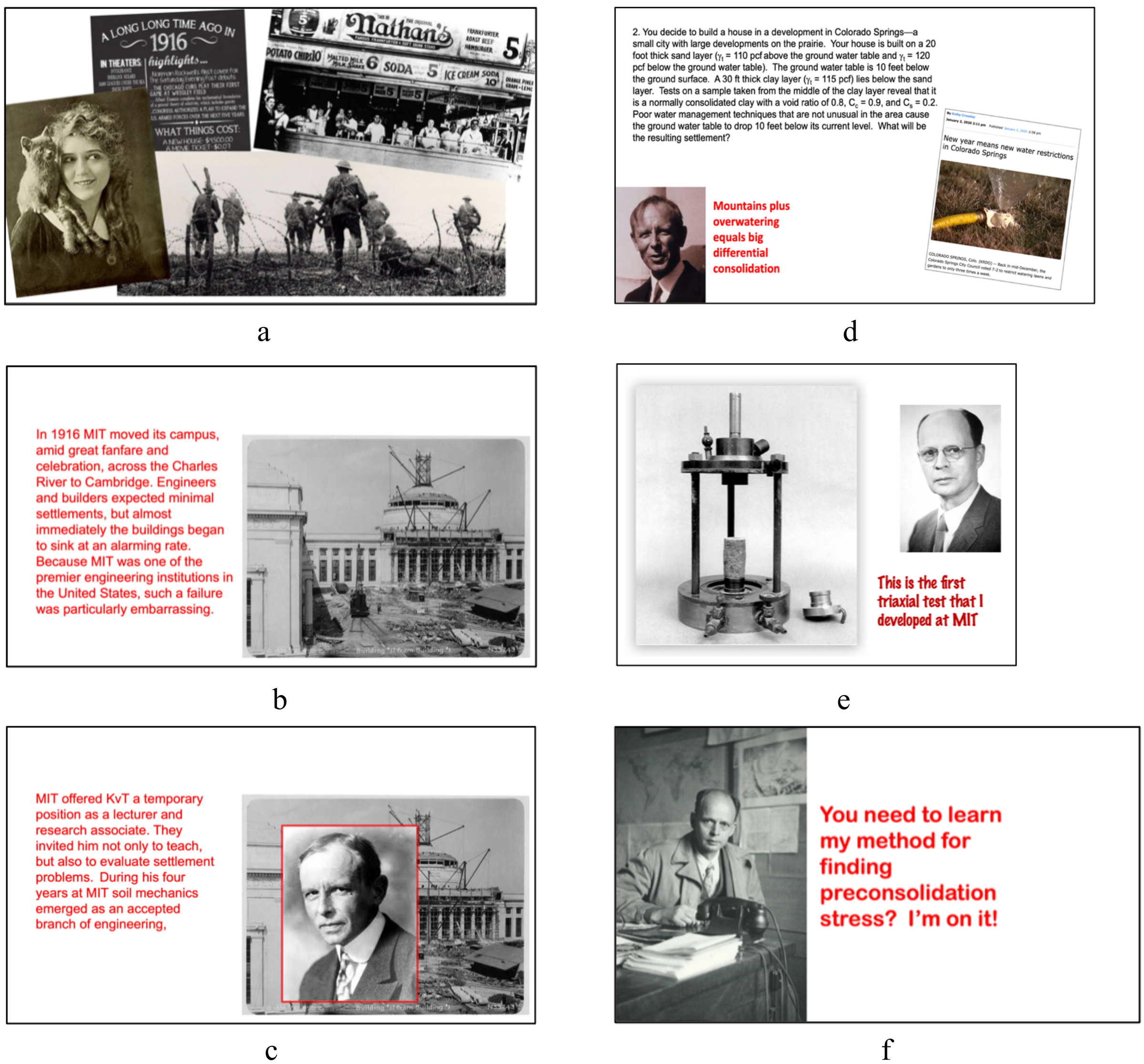


Figure 4 Karl Terzaghi and Arthur Casagrande led the development of soil mechanics. They appear throughout the course offering guidance to students. Example PowerPoint slides include: (a) first slide of a time travel adventure in which students discover the beginning of geotechnical engineering and the emergence of Karl Terzaghi as its leader; (b) students learn about the consolidation problems in building MIT's campus; (c) students experience the emergence of Karl Terzaghi; (d) Karl Terzaghi adds his insight to a problem; (e) Arthur Casagrande shows students the triaxial testing device he developed and then leads them through a series of questions; and (f) Arthur Casagande leads students in solving the mystery of how testing soils can reveal their prior stress history.

The course also accesses romantic understanding through the cognitive tool that Egan calls the *limits and extremes of reality*. For example, a narrative is structured around the mysterious-seeming (and often misrepresented) phenomenon of quicksand. A common approach to describing quicksand in geotechnical engineering is to lead with a presentation of the effective stress principle; then introduce the stresses and pressures caused by flow; and then finally to use these ideas to show how rapidly soil conditions can arise. EGR 340 uses a different technique, with a liquefaction demonstration presented earlier as part of the mythic dark arts story that is followed by students working in teams to develop initial theories to explain the abrupt change in soil from a solid to a liquid. Only then, with students steeped in an unsolved mystery and some of their preconceptions about stresses and pressures surfaced, does the unit go on to explore effective stress and how it is affected by seepage.

Another use of extremes of reality is the introduction of magic tricks into the class. These always produced a high level of student engagement and piqued students' interest in applying soil mechanics to solve the mystery of how they worked. Figures 5a and 5b show the production of quicksand through the use of a spell that is part of the dark arts narrative and engages students in solving the mystery of why tapping the beaker causes solid ground to liquefy. Figure 5c shows a screenshot from an animation in which Voldermort fantasizes about casting a spell that uses a Newmark Chart as a web to destroy Harry Potter. Finally, Figure 5d shows a screenshot from a video clip in which students must explain a magic trick as part of their review of fluid mechanics needed for the course.

Philosophic Understanding

As humans grow to become aware of the vastness and complexity of the world, we search for underlying patterns and sources of truth or order to help us make sense of it. Philosophic understanding infers general principles of schemes from individual instances. EGR 340 leverages this understanding primarily through the use of concept maps that help students see the big picture of a concept from the beginning of their exploration, and regularly reflect on their journey toward deeper and clearer understanding.

Students initially become familiar with concept maps through the example of a course concept map (see Fig. 6). Then as the course progresses, they use a variety of instructor-created and self-generated concept maps for a variety of concepts such as particle size distribution and effective stress.

Ironic Understanding

Ironic understanding is the most complex of Egan's five understandings. Simply put, this type of understanding acknowledges the role of skepticism and doubt of the world as it appears, therefore allowing for greater cognitive flexibility and the ability and disposition to suspend belief in an absolute truth. In EGR340, students develop ironic understanding as they begin to recognize the inability of theories to fully explain the complexity that underlies many of the course's key topics and they develop an appreciation of the personal and communal processes that can help add value and meaning to the work of geotechnical engineering. Developing an increasingly deep and sophisticated understanding of why the term "dark arts" is used to describe geotechnical engineering is the underlying theme throughout the semester.

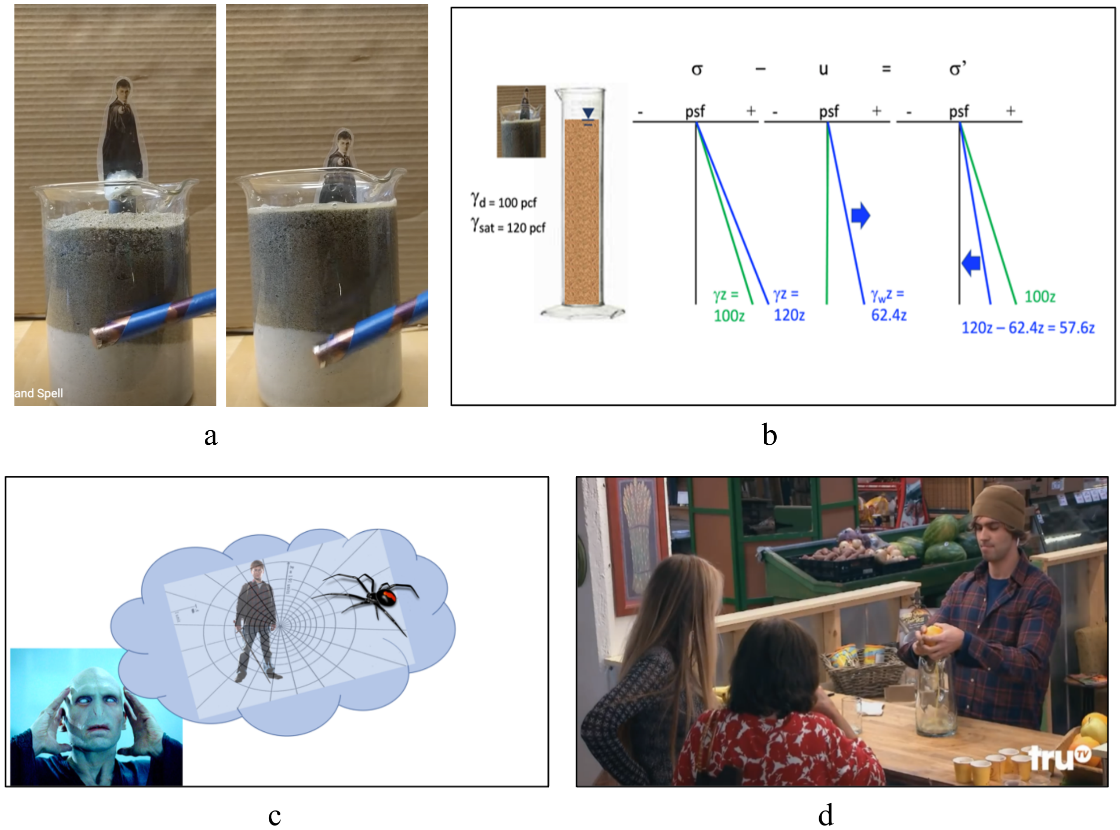


Figure 5 Examples of magic used throughout the course, including: (a) pictures taken in class showing a quicksand spell being used to destroy Harry Potter by tapping the beaker with a magic wand; (b) students create graphs of the stresses created by tapping the beaker; (c) Voldemort fantasizing about using a Newmark Chart (a tool used in geotechnical engineering to calculate stress attenuation) as a web to destroy Harry Potter as a spider walks across the screen; and (d) students review fluid mechanics by using their understanding to explain the magic performed by Michael Carbonaro.

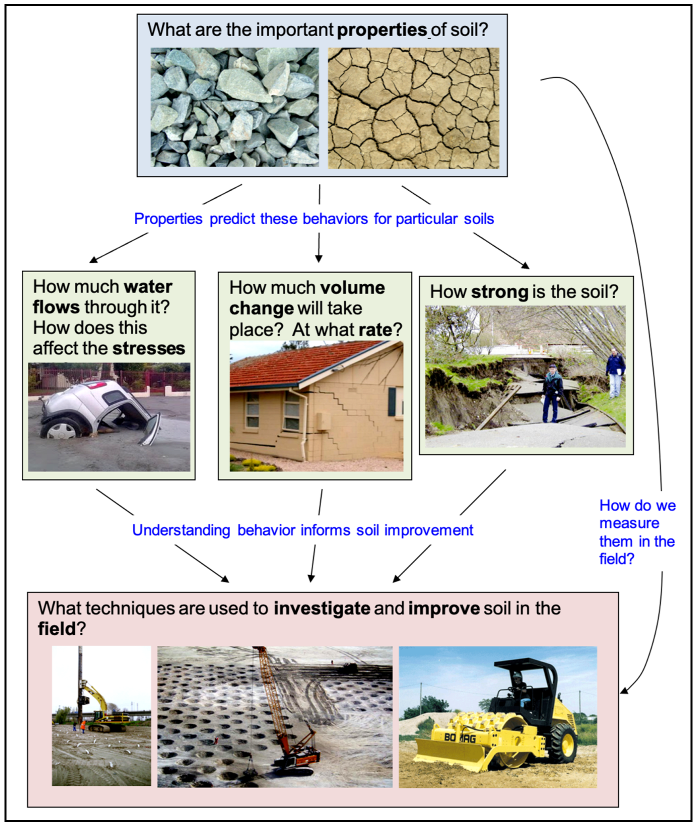


Figure 6 Instructor-generated, course-level concept map for EGR 340.

Assessment of the Course

To provide evidence that would better articulate the differences in learning outcomes that can occur as a result of implementing a course making use of transmedia IE, we implemented an analysis of coursework and of student reflections for the years 2018 and 2022 for the EGR340 course. These years were selected because the former course, 2018, featured a “proto IE” version of the course and the latter, 2022, featured a full “transmedia IE” version of the course that featured dynamic visual and audio components.

Our analysis was formulated as a parallel mixed-method approach that made use of coursework grade and open-response data provided by third-year engineering undergraduate students at the researchers’ home university. This approach was, to some extent, driven by practical considerations of the program. Quantitative methods were more useful in describing the differences in scores assigned to students as the IE versions of the coursework were being implemented, and qualitative methods were more effective for drawing insights from the students’ reflected understanding of their experience as they responded to IE elements in the course.

A preliminary Shapiro-Wilk’s test of normality determined that the coursework data was not normally distributed ($p < .05$). As such, quantitative analysis was carried out using non-parametric comparative analysis (Wilcoxon Rank Sum Tests) of grade data for students in both the 2018 (n = 10) and 2022 (n = 13) versions of the course. Six assignments comprised the total coursework for the EGR 340 course: (1) Homework assignments, (2) the Borrow/Fill simulation project, (3) The Atterberg project, (4) Gravity Dam project, (5) a midterm, and (6) a course final assessment. The projects–Borrow/Fill, Atterberg, and Gravity Dam–are detailed above *(see the section titled Development & Delivery of EGR340*). All six assignments were equally weighted in both 2018 and 2022. All quantitative analyses were carried out using R software (R Core Team 2020).

Qualitative analysis followed a process of grounded analysis of themes that were represented in student responses to three open-response items made available at the end of the course. These items prompted students to reflect on the topics of (1) what they felt they had gained most from the course, (2) what they thought about the teaching methods utilized in the course, and (3) their thoughts about the structure and format of the coursework. Eight students provided complete responses to the open-ended course reflection questions in 2018; nine students provided complete responses to these questions in 2022. Qualitative data were first analyzed using a method of structural coding of aggregated responses gathered in Google Sheets followed by a pattern coding process from which our initial themes emerged (Saldaña, 2013).

Quantitative Findings

Analysis of coursework comparing the 2018 "Proto IE" and 2022 "Transmedia IE" versions of the course found statistically significant differences for two of the project coursework grades: Differences were found between the 10 scores for the Atterberg project in 2018 (M = 93.63, SD = 2.04) and the 13 scores for the Atterberg project in 2022 (M = 97.29, SD = 3.09), $p < .001$. Likewise, differences were found between the 10 scores for the Gravity Dam project in 2018 (M =89.64, SD = 6.75) and the 13 scores for the Atterberg project in 2022 (M =95.12, SD = 6.36), $p = .019$. No other statistically significant findings were determined (*see Table 2 below for more*).

Table 2. Analysis of EGR340 coursework for the years of 2018 and 2022

Assignment	**2018 "Proto IE" (n = 10)**	**2022 "Transmedia IE" (n = 13)**	**p-value[2]**
HW	95.37 (4.21)[1]	97.63 (4.78)	0.20
Borrow/Fill	97.50 (5.40)	96.23 (3.68)	0.073
Atterberg	93.63 (2.04)	97.29 (3.09)	**< 0.001**
Gravity Dam	89.64 (6.75)	95.12 (6.36)	**0.019**
Midterm	86.20 (8.16)	88.62 (6.03)	0.6
Final	80.65 (11.75)	80.01 (10.43)	0.9

[1]Mean (Std. Dev.)
[2] Wilcoxon rank sum test

In short, these findings provide some evidence to indicate that students performed better on these projects in the 2022 year, during which their experience with the course was enhanced by the full Transmedia IE version of the course. As Transmedia IE provides a more comprehensive method of engagement with coursework, it is noteworthy that the projects–which were themselves based on imagined scenarios–benefited from a deeper expression of Transmedia IE. However, a limitation of these findings is the relative small sample size of each group, which limits the generalizability of the results.

Qualitative Insights

Overall, student responses reflected positive and enthusiastic sentiments across all three open-response prompts for students in both the 2018 “Proto IE” and the 2022 “Transmedia IE” version of the course. Primarily, student responses indicated a high degree of engagement with the coursework and appreciation of their experience in the course across both years. Common statements to this effect included direct language, such as “The teaching methods in this class are excellent, solidified, and refined to really get students to not just learn, but understand these topics,” as well as more indirect statements like “the amount of effort that you put into making this class a positive, fun experience helped to make this a very positive learning experience for me.”

In addition, many students specifically noted that the IE and/or transmedia elements of the course had been uniquely important to their learning. Comments included the sentiment that course slide decks were enjoyable and were “works of art.” Students noted that they appreciated learning about historical figures, and how geotech is the “is the Dark Arts of Engineering.” One student’s comment captured a sentiment seen across many remarks:

> *The introduction of things like comparing the founders of geotech to different Harry Potter characters and all the demonstrations that were done in the class helped to keep me really engaged with the material.*

A number of responses also suggested a deeper appreciation of geotechnical engineering as a discipline itself — a key macro-objective of the course. Indications of this appear in such comments as:

> *I really enjoyed it! Definitely an engineering discipline for me to think about possibly exploring!*
>
> *I didn't think I would be good at geotech but I'm glad I took the class because I love it and can see myself doing geotech as part of my career.*
>
> *I know so much about soil now! I go around thinking about all the soils I step on, what type they are, how saturated they are, how strong they are, and how they would drain or consolidate. Especially at the barn because it’s so muddy, I’m trying to think of ways to drain it better. Maybe installing wick drains would help?*

I learned about seepage and honestly have been having a great time explaining to friends how water moves below us. I also feel like I learned about what is happening in the soil which is nice.

Notably absent from student responses was any indication of frustration, annoyance, or confusion related to IE and/or transmedia — not a given outcome when introducing unorthodox teaching methods. It was clear from student responses overall that both the IE approach, and its complementary transmedia techniques when offered, positively shaped their learning experience, and in many cases helped facilitate deep understanding of and appreciation for the field of geotechnical engineering.

Limitations

In developing this paper, one purpose we identified was to demonstrate the applicability of IE principles in facilitating student engagement and scaffolding learning in an undergraduate geotechnical engineering course. One limitation that this approach has is that much of what we have described is particular to that course content and the context in which it was presented. For new engineering educators who would like to make use of this approach, we recognize that the coursework would need to be similarly contextualized to the contingencies inherent in different courses. Although we cannot provide an exhaustive list of the procedures and considerations that one would need to undertake, our intention is that by providing a rich example in our discussion of this course, that we can surface major themes and provide some thinking around the transmedia elements that would be incorporated into the course presentation.

Another limitation in our approach is that our analyses have provided some evidence to indicate that the transmedia IE method is (1) engaging and that it (2) helps to scaffold student learning around projects embedded in the coursework. However, a noteworthy gap in the findings is indication that this method can impact students' understanding of the content as it is situated in midterm and final examinations. We believe that more work would be necessary to further explore this gap and to develop strategies to mitigate this lack of responsiveness to the assessment methods.

Discussion & Conclusion

The engineering education literature has long recognized the need to rethink how students engage with content (Smith, 2005). Many have raised concerns that reductionist engineering courses that omit intellectual and sociopolitical histories help discourage people of color and women from scientific fields (Adelman, 1998; Bleier, 1991; and Goodman et al., 2002). Adams, Fleming and Smith (2007), Smith (1998), EiE (2010) and Ellis et al. (2010, 2011, 2015) all provide examples of how storytelling and the intentional drawing of meaningful cross-disciplinary connections can successfully address these concerns in engineering education at a variety of grade levels. This paper offers an example of a specific approach and techniques that may be adapted for use in other undergraduate engineering contexts.

The use of IE cognitive tools has been shown to support student engagement and deep, intentional learning in K-12 education throughout the world. However, IE remains a novel approach in undergraduate engineering education. In this paper we combine IE with the complementary pedagogy of transmedia narrative. We found that with or without the transmedia component, student response to the pedagogy is encouraging. The 2018 student course feedback showed that seven students *strongly agreed* that "the instructor created an effective learning environment" and two *agreed* that "the course contributed significantly to my education." In 2022 all nine students *strongly agreed* with both of these statements. Because class sizes at Smith College are small, it is difficult to show quantitatively the added benefit of combining transmedia narrative with IE. However, the initial results and the palpable student enthusiasm in the 2022 classroom are encouraging signs and support further study on a larger scale.

One important point to make about using cognitive tools and transmedia narrative in instructional design is that it has little impact on the amount of content that can be covered in a class. The focus of this approach is not adding additional content. Instead, it is to better organize the current content to be taught and to shape events in the classroom to bring out the emotional force. For example, the story of the trip to Venice, Italy that frames the consolidation analysis due to a lowered water table takes less than a minute of class time. But by doing so it allows students to practice concepts within a realistic and engaging mystery.

This study has several key limitations, including small sample size and lack of a counterfactual condition. Nonetheless, these findings suggest that IE, and IE complemented with transmedia components, may be a promising approach to engaging undergraduate geotechnical engineering students, and warrants additional exploration. In EGR340, IE appeared to support students not only in more deeply engaging in and enjoying the course, but also in drawing connections between the course content and the world around them, and in appreciating key disciplinary features of geotechnical engineering.

Fruitful areas of additional research include (a) developing and investigating other means of incorporating IE into a range of undergraduate engineering courses, and (b) more deeply understanding the extent to which, and ways in which, transmedia elements may support the effectiveness of an IE-based engineering curriculum. In addition, there is also room within an IE approach to engage in curricular co-design with students; in EGR340, for example, some of the nods to movies, shows, and other pieces of popular culture will lose relevance over time, and students can be a part of drawing new connections between the course's overarching narrative and meaningful cultural touchpoints. Overall, IE is an area that shows promise for supporting engineering student engagement and learning outcomes, and which merits additional attention at the undergraduate level.

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