2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #52265

Contexts and Contextual Thinking in the Engineering Classroom

Dr. Ryan Hearty, The Johns Hopkins University

Ryan Hearty teaches in the Center for Leadership Education's Professional Communication Program. He obtained his bachelor's and master's in electrical engineering and PhD in History of Science and Technology from Johns Hopkins University. As an engineer at the Johns Hopkins University Applied Physics Laboratory, Hearty built radio communications hardware for NASA's Parker Solar Probe. As a historian, he has studied collaborations across disciplines of engineering and applied science since the 1930s. His doctoral dissertation analyzed the rise and development of water quality management, a multidisciplinary field of applied science, from the New Deal to the Clean Water Act.

Prof. Jenna Tonn, Boston College

Dr. Jenna Tonn is a historian of science, technology, and engineering at Boston College. She received her BA and MA from Stanford University and her PhD from Harvard University.

Adelheid Voskuhl, University of Pennsylvania

Contexts and Contextual Thinking in the Engineering Classroom

Abstract

Scholarship on sociotechnical integration highlights pedagogical strategies for creating connections between technical subjects and their relevant social, cultural, and political contexts [1], [2], [3], [4], [5], [6]. This paper takes up a related question, that of context, and its meaning and function in engineering education. We focus on the process of developing contextual thinking skills among undergraduate students in the engineering classroom.

Drawing on our perspectives as historians of science and technology, and reflecting our teaching practices in schools of engineering and colleges of arts and sciences, we offer three strategies for introducing students to contexts and contextual thinking. The first strategy includes scaffolding student engagement with material culture of the past through: (a) close collaborations with college archives and special collections that provide students with a hands-on experience with asking questions of physical artifacts that reflect technical knowledge, such as sixteenth century texts on mechanics; and (b) assessments that guide students through the practice of "sleuthing" for context, or doing historical research to ask questions about the time, place, and experience of, for instance, topographic engineers during the U.S. Civil War.

A second strategy asks students to sharpen their understanding of engineering work as opposed to the *context* of engineering work through: (a) a course unit on the founding of Indian Institutes of Technology (IITs) in post-Independence India, as seen through primary sources that reveal the role of engineering in building a new post-colonial state in 1947, pondering how this is (in students' own language) a "political" or "governmental" context of engineering work; and (2) a course unit on the relationship between engineering work and the artistic *rendering* of engineering work, for example in pop culture and in films such as "War Games" (1983).

Our third strategy introduces students to the fields of history of technology, engineering studies, and engineering ethics within a single course. These literatures support the development of contextual reasoning by offering complementary perspectives: history of technology emphasizes temporal and institutional contexts; engineering studies identifies patterns in professional practice, such as boundary spanning; and engineering ethics highlights responsibility and judgment in specific situations. By developing these perspectives and applying them to their own emerging careers, students come to see themselves as situated actors whose decisions and opportunities depend on context.

Taken together, these course units help us engage, together with our students, the role that contexts and contextual thinking play in sociotechnical case studies and sociotechnical programs of study.

Introduction

One of the many benefits of teaching engineers in the liberal arts classroom is that we get to teach and learn about a wide range of both technical and non-technical (for lack of a better word) expertise and experiences. To develop our pedagogical strategies for this, we rely, as do many others, on LEES's vibrant tradition of far-reaching scholarship on sociotechnical integration. In this paper, we target specifically the concept and pedagogical practice of "context" and "contextualization." We find that, as we anchor our teaching in sociotechnical integration, we deliberately, inevitably, and continuously create connections between technical subjects and their relevant social, cultural, and political contexts [1], [2], [3], [4], [5], [6].

In 2021, Marie Stettler Kleine et al. [7] offered this crucial insight: "engineering educators, ourselves included, tend to view increased contextualization as an improvement to engineering pedagogy." We agree that, as engineering educators, we not only invoke the term "context" often, but we have a positive bias: we find, however intuitively, "context" and "contextualization" to be positive, productive, and responsible teaching practices and goals. Indeed, as Kleine et al. suggest in their title, contextualization may coincide with "virtue."

At the same time, there is as much agreement that it is unclear how "context" and "contextualization" actually function in our scholarship and the classroom. There have been sustained and successful efforts to systematize "context's" and "contextualization's" meaning and function, and yet there continues to be a sense of eclectic application of the terms and widespread relying on intuitive meanings of "contexts" (this holds for us, too). From our teaching experience, we find two issues particularly pressing. One is the changing nature of invoking context and contextualization within LEES-oriented scholarship in engineering education. The other is how, whether, if, or in what way this scholarship makes it into the classroom.

In this paper, we offer preliminary ideas to contribute to this current conversation in engineering education. We are concerned with our specific engineering classrooms, but also ask about the relevance of these concepts and analytic methods across the field of engineering education. Our notion of "context" for this paper will also remain a heuristic, like for other authors that we consider, not yet a fully developed concept.

We first look at a few more distinctions that have recently been drawn by prominent scholars in engineering education, and, second, revisit conversations in scholarly disciplines that neighbor engineering education, and which have already done for some decades work to conceptualize "context." We also present two more examples of terms that present similar pressures on us as the term "context" when teaching engineers in the liberal arts classroom, namely the term "technology" itself, as well as the term "technological determinism." We then present our three classroom strategies and draw preliminary conclusions.

Two Further Distinctions

We want to point out a few more distinctions that have been drawn by engineering education scholars, as examples of the work that has been done around the concept and pedagogical practice of "context" and "contextualization." We also suggest that these may offer guidance for members of our field as to the directions in which we want to draw our attention next. The distinctions demonstrate the sheer size and complexity of the problem of "context," but also how engineering education scholars, despite this, have managed to come up with sharp and tangible ways of explicating and ordering concomitant questions, concepts, and teaching strategies.

Kleine et al. draw in their article from 2021 [7], quoted above, an opening distinction between contextualization and normativity, that is, between teaching contexts, on one hand, and providing normative guidance for students, on the other. They break down a range of engineering educators' practices of contextualizing engineering, offer their readers a preliminary taxonomy of what different people mean by contextualization, and call for finding a balance in the classroom "of contextualization and normativity" [7, p. 3]. The question, which they explore further in a subsequent publication [8], is how to bridge the investment in context and contextualization, and normative guidance, with the practice of introducing it into the classroom.

Crucially, they also offer this observation: "despite decades of attempts by researchers and educators to situate engineering work and knowledge within a broader context, engineering students tend to perceive their profession as narrowly technical and disconnected from society and the environment" [7, p. 3]. This, in our view, points once again to a challenge at the core of engineering education, namely providing "context," and to the basic need for continued, sustained conversation, and attendant patience, among LEES scholars.

Matt Wisnioski, a well-known voice in the fields of engineering studies and engineering education, demonstrates the size of the "context complex" by drawing our attention to engineers' *own* contextualization. He distinguishes carefully between historians', teachers', or students' contextualizing engineering (such as in our classrooms and our scholarly writing) and engineers' contextualizing *themselves* and their work.

Wisnioski's work on this appeared as an essay in an edited volume in 2015 [9]. The edited volume is fittingly subtitled *Engineering Education and Practice in Context* and is part of a prominent book series "Philosophy of Engineering and Technology" published by Springer Nature. Wisnioski writes in the first sentence: "Engineers make their own context" [9, p. 348]. Contrary to intuitions from history, sociology, or ethics, Wisnioski holds that engineers "have used visions of self, society, and technology to remake their world" [9, p. 349]. He draws our attention to engineers' agency, and less to reasoning in the classroom [9, p. 358].

This essay of Wisnioski's also underwent an important and telling journey that requires some contextualization. The 2015 version was a reprint from an original that he wrote in 2009. The original appeared in an edited volume equally suitably titled *Engineering in Context* [10]. This tells us about how important and versatile Wisnioski's ideas were and are, but also about the varied history in the last twenty or so years of the ways in which scholars, teachers, students, and engineers have used vocabulary around the word "context."

One other characteristic of this 2009 edited volume is remarkable for us, as it brings us to conceptual work on "context" that has already been done since the 1960s in the field of the history of science, leading, not least, to the inception of the so-called "new" history of science in the early 1980s. The editors of the 2009 volume *Engineering in Context* state in their introduction how they were inspired by another – now famous – volume edited by Barry Barnes and David Edge in 1982, titled *Science in Context: Readings in the Sociology of Science*. This volume has long since been a classic, a seminal work from the early days of science, technology and society (STS) and the so-called "new" history of science [11]. When the editors of the 2009 volume *Engineering in Context* explicate how they aim at "a better understanding of the contexts in which engineering activities are situated," they point to the "larger realm of human activities and the culture which surrounds them at the micro, meso and macro levels" [10, p. 5]. This is a palpable, if broad, definition of this thing that all of us "context scholars" are dealing with. Wisnioski's essay underwent a journey from the 2000s to the 2010s in the course of which it played distinct roles in two disparate anthologies that approach the matter of "engineering in context" very differently.

"Context" in Fields Neighboring Engineering Education

In fields that are adjacent to engineering education, for example the history of science (as noted just above), intellectual history, the philosophy of science, and science education, "context" has been used, scrutinized, dismissed, defined, and re-defined since at least the 1950s. One of the foremost periodicals in the history of science, for example, which is also a founding journal for the so-called "new" history of science of the 1980s, is named *Science in Context* (established in 1987, possibly also inspired by Barnes and Edge's 1982 volume). In 1983, a foundational collection of essays in intellectual history was edited by Dominick LaCapra, with the title *Rethinking Intellectual History: Texts, Contexts, Language* [12]. Perhaps the piece that connects best the history of science and intellectual history regarding the concern of "context" is the famous (and tongue-in-cheek) essay by Peter Burke entitled "Context in Context" [13], [14]. Other widely-read pieces on contexts in these fields include Steven Shapin's "Discipline and Bounding" from 1992 [15], Lorraine Daston's "Science Studies and the History of Science" from 2009 [16], and Sheila Jasanoff's "A Field of its Own" from 2010, republished in 2017 [17]. There seems to be no shortage of essays on "context" written in a whimsical manner. Apart from the one by Peter Burke, see, for example, one by STS scholar Nick Seaver entitled "The nice thing about context is that everyone has it" [18].

One other important example seems to us the extensive conceptual development around the terms "context of discovery" and "context of justification" in the philosophy of science, which started in the early twentieth century and to some degree has defined this very field. This work was, not least, eventually integrated successfully into the field of science education [19], [20]. Debates in the philosophy of science have yielded important insights into the rationality and truth value of science and engineering vis-à-vis other kinds of knowledge. This may seem rather separate from the questions that LEES is asking about the role of liberal arts in engineering education, or that engineering educators are asking about social justice and responsible design. However, our research and teaching experience has suggested that it may be helpful to try to harness the conceptual work done in fields adjacent to engineering education for LEES's efforts to integrate "technical" and "non-technical" (aka social) matters of engineering, and their distinctions.

What above-outlined debates do have in common with each other is the use of "context" as a tool to study the conditions and circumstances under which certain types of knowledge (scientific knowledge, engineering knowledge, or ideas in philosophy and social theory) emerge, are being explicated, and are being agreed upon. In this sense, "context" is also a foundational teaching method in the history of science and technology, a training that all three authors of this paper have undergone.

Terms Other Than "Context" For Which We Experience Similar Pressures and Ambiguities

There are a few other words for which we at times experience similar pressures and ambiguities when using them as teachers and as students, similar to our use of the word "contexts." This is the very word "technology," as well as the technical term "technological determinism." Both terms, and their difficult use in research and in teaching have been discussed widely among historians of technology. Leo Marx's foundational essay "Technology: The Emergence of a Hazardous Concept" asks, for example, how we are supposed to grasp the changes in society and culture in the industrial age that prompted the very emergence of the word "technology" ("the purported thing itself," he says). He suggests that those changes brought about awareness of novel experiences and phenomena "for which no adequate name had yet become available," he says, and that it was this void that the word "technology" eventually would fill [21, p. 563].

A second important example is the term and concept "technological determinism." Many historians of technology and engineering agree that "technological determinism" structures in powerful and not always visible ways discussions about the relationship between technology and various (social, political, etc.) contexts, inside and outside of classrooms. Ron Kline defines "technological determinism" as containing two claims: first, that technology develops in an "autonomous manner, determined by an internal logic independent of social influence"; and second, that "technological change determines social change in a prescribed manner" [22, p. 15495]. Kline and others use the word "society" where we in this current paper (and others such as [7] and [8]) try the use of the slightly broader term "contexts." The discussion around technological determinism was at its height in the 1970s and 80s, intimately bound up with Marxist history and historiography of technology [23, pp. 73–87], [24]. Interest perhaps culminated in a conference organized at MIT in 1989 resulting in the by now classical volume by Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History?* from 1994 [25]. The conference itself, and the publication of the concomitant volume, in fact straddled the end of the Cold War.

The viability of the term "technological determinism," and its connotations, have been contested continuously, and the debate around it continues to attract attention and polemical commentary [26, p. 681], [27, p. 65]. Historians of technology do use the term "technological determinism" for a wide range of purposes, including teaching engineers, and this use does evoke - whether intentional or not - fundamental ideas about relations between technology and "contexts." The often polemical and aggressive tone suggests that there is something important that the term calls attention to, independently of whether anyone believes in its specific tenets. We follow Sally Wyatt here who holds that technological determinism "persists" in analyses and linguistic habits, that it is "that model that makes most sense to many people's experience." She concludes from this that "we cannot ignore technological determinism in the hope that it will disappear" and that we must take it more seriously [28, p. 169].

Our hunch is that the claims, intuitions, and even the sense of urgency clustering around "technology" and "technological determinism" coincide with the issues that we and others are trying to understand regarding teaching contexts and contextualization in engineering classrooms. To outline our specific contribution to this issue, we will now each give an example of one strategy we have used to engage students in context(s) and contextual reasoning in the undergraduate classroom.

Strategy #1: Scaffolding Student Engagement with Context through the Material Culture of the Past

Since 2020, I have co-taught an interdisciplinary first-year course with engineering colleagues that integrates the history of technology and engineering with engineering and engineering design. This course has an expanded credit footprint. It has six credits, delivering three credits of history and three credits of natural science and engineering. Depending on administrative priorities, we have had enrollments of either 76 or 152 students. In terms of major background, approximately one-third of students are engineering majors and the rest are either majors from the College of Arts & Sciences, the School of Management, and the School of Education or students who are still deciding on their major pathway.

The learning outcomes for this course are interdisciplinary and include learning outcomes related to history, to natural science and engineering, and to cultural diversity. In terms of this paper, I am interested in exploring how learning outcomes and learning goals related to history support student engagement in understanding context and contextual thinking. The three most relevant learning outcomes on our syllabus related to this process are:

- **Historical knowledge:** Students will learn major events and figures in the history of engineering and technology since 1800.
- **Engineering and scientific knowledge:** Students will learn what engineering is as a profession and a practice.
- **Historical methods:** Students will gain facility in methods critical to the practice of history as a field of intellectual inquiry.

Here I think about "historical methods" in terms of introducing students to primary sources and creating assessments that ask students to analyze these sources and put them into historical context. While my history of technology lectures model how this process works, I have also created a series of hands-on activities and assessments to create opportunities for students to practice historical methods (i.e., participate in context-making).

Primary Sources as Context: Engaging with Archives and Special Collections

To complement student work in engineering labs on engineering design projects, I collaborate with Boston College's John J. Burns Library, which houses our institution's rare books, archives, and special collections, to create a unique "History Lab" session for our students. Historians, like engineers, need certain tools and facilities to do their work and these tools and facilities can be found in the Burns Library. I work with the Head of the Burns Library, the Instruction and Public Services Librarian, and the BC Libraries History Liaison to curate materials and design instruction for our students.

Each year, during the second week of classes, the Burns Librarians host our students in their reading room. They introduce students to rare books, archives, and special collections; curate a wonderful set of material from the collections related to engineering and technology;

and guide students through the process of interacting with these primary sources. For many students, this is the first time they have worked with seventeenth century or eighteenth century materials, so it is important to learn how to properly handle the materials and conduct preliminary research to identify and analyze them.

The Burns Librarians scaffolded this engagement in several ways. Students were asked to sit at tables with preselected materials that all related to a particular theme (i.e. transportation, comics, innovation) and to work as a group to get to know the breadth of primary sources at their tables. Students were then invited to act as curators and to select one primary source to focus their attention on. The “History Lab Assignment” (Figure 1) guided students through how to begin to gather information to understand the specific context of the source at hand and then how to engage and analyze it.

History Lab Assignment

Part I - Getting to know your primary source

- *Basic Identification:* Who wrote, prepared, or published this? What is their role within the engineering field? When/where was this written? What is it about?
- *Context*: What audience was this made for? Why was it made? What is the tone? What is striking about the writing or visual style? What is the argument being made? Can you tell what it is arguing against (if anything)?
- *Evidence*: What qualifications/authority does the author have? What data or evidence is used to make this argument? What social, cultural, and/or institutional impacts are considered?
- *Class themes:* What is interesting, striking or unexpected about it? How does this item relate to course themes?

Part II: Critically engaging with your primary source

- *Basic identification:* What is your source? Use your research from Part I to answer this question.
- *Image:* Take a representative image that best illustrates its contents. Write a 50-word label for this image.
- *Citation:* Fully cite the source (try your best).
- *Reflection on the source:* (write 3-5 sentences for each question).
    - What was the creator’s purpose in making this primary source? How do they get their message across?
    - What was the creator's particular point of view and audience? What language or symbolism in the document supports your response?
    - What is your overall assessment of this document? What conclusions can you draw from it?
    - How does this source relate to course themes or course materials so far?
    - What do you gain by making use of primary sources and engaging with them in person?
    - Where would you go after doing a lab like this in terms of further research?

Figure 1: This is an example of the History Lab Assignment given to first-year students to guide them through the process of engaging with primary sources in the John J. Burns Library archives and special collections.

The Burns Librarians pulled a fabulous range of materials for students to engage with including seventeenth-century Latin texts about hydraulics and mechanics [29]; an eighteenth-century construction manual [30]; and nineteenth-century sources related to electrification [31]. They also provided examples of more ephemeral media such as early dime novels [32] and subsequent superhero comics [33]. Perhaps most interesting were examples of how our own institution’s archives reflect the professionalization of engineering, so correspondence and contracts for writing a classroom building in 1901[1] and a copy of an early computing guide.[2] In a reflection of our university's institutional context, students also engaged with government pamphlets from Northern Ireland documenting the rapid expansion of coal-powered electricity in the 1960s which reflects the Burns Library's well-known collection strengths in Irish history.

Student reflections on their use of primary sources in "History Lab" highlighted a sense of historical authenticity. Students commented on how they were able to physically touch an object, pay attention to its unique qualities, and then use this attention to specificity as an anchor in their research and writing. Here is a selection of their responses:

- *Student Group 1*: "Primary sources give an authenticity and unique sense of relation towards the time period in which they were created. Being able to personally study objects/writings from a desired time period reveals history and even a way of life. Primary sources aren't altered by future perspectives or opinions and require the researcher to interpret their own conclusion, rather than following the views or another. They are the most pure sense of information which gives factual info, and gives your work undeniable attention."
- *Student Group 2*: "By making use of primary sources we're able to gather a really deep and specific understanding of what was done and the process that was completed. There is no room for inferring or unreliable information. Engaging with them in person allows us to better understand that time period. With our document, we're able to tell that a typewriter was used and we're able to point out where the editor fixed spelling errors or entered new information."
- *Student Group 3*: "Experiencing the physical sources help with better connecting with the past, and in some ways make its history feel—literally—more significant. From a technical standpoint, having a physical source allows access to small details or patterns that could have been otherwise overlooked. Seeing some aspects of a physical copy could tell about the history of the item's use as well, not just the content. This makes the experience more intellectual and personal, as you encounter not only the content, but the history of the object itself."

It is impossible not to remark on the awareness of technology and technological change in these responses, for instance invoking the use of a typewriter and the notion that physical artifacts have their own histories.

Sleuthing as Contextual Thinking

After the History Lab experience, students take what they have learned about the specificity of primary sources and build on it by applying these skills to a new primary source with relevance to the history of engineering as a profession. The "History Project: Nineteenth-Century Primary Source Analysis" (Figure 2) asks students to take on the role of the historian and to act a historically-minded sleuth to better understand the life and work of the topographic engineer, Gilbert Thompson (b. 1839, d. 1909) based on his handwritten diary from the time he served in

---

[1] Recitation Building electric wiring and gas piping, 1911 - 1912, Box: 1, Folder: 39. Thomas Ignatius Gasson, SJ, President's Office records, BC-1986-020E. John J. Burns Library, Boston College.
[2] *Time-Sharing*, approximately 1984, Box: 54, Folder: 13. Boston College publications, BC-2001-047. John J. Burns Library, Boston College.

the Union Army during the U.S. Civil War. What is important about this assignment is that the historical materials under consideration are not located in a library or archive but are available more widely online to the public thanks to dedicated work in the field of digital humanities.

History Project: Nineteenth-Century Primary Source Analysis

The aim of this assignment is to read the topographic engineer Gilbert Thompson's (b. 1839, d. 1909) diary from his time serving in Union Army during the U.S. Civil War and to analyze it within its historical context. Each component of this assignment guides you through the process of "doing history," or developing skills in contextual thinking. Components of this assignment include:

- **Create a timeline**. Use the library subscription to Ancestry Library Edition, a database that centralizes official records of individuals in the U.S., to establish a comprehensive timeline of Thompson's life.
    a. Find answers to: Where was he born? What were the names of his immediate family members? When did he enlist? When/where did he enlist? Where did he live after the war and with whom? Did he marry? Did he have children? Where/when did he die?
- **Transcribe his writing**. Locate Thompson's diary via the Library of Congress, which has digitized his handwritten diary and made it available to the public (https://www.loc.gov/resource/mss95752.01/?st=gallery). Faithfully transcribe at least five days of the diary, replicating his potentially surprising spelling, punctuation, and phrasing.
- **Connect to the news.** Select one of Thompson's transcribed diary entries, which has a clear date and location. Use the Library of Congress's online resource Chronicling America, Historic American Newspapers (https://www.loc.gov/collections/chronicling-america/about-this-collection/) to find a local newspaper published as close as possible to Thompson's diary entry in terms of date and geography. Analyze the relationship between the diary entry and this newspaper in terms of content, audience, etc.
- **Engineering as a profession**. Use the database HathiTrust (https://www.hathitrust.org/) to find three sources that address what topographic engineering is and how it has changed since the 1860s.
- **Context and contextual thinking.** Put all of these sources together to analyze Thompson's diary as an example of topographic engineering in the nineteenth century and comment on what has changed inter of his life, work and the role of the engineer over time.

Figure 2: The History Project assignment invites students to read, transcribe, and analyze a nineteenth-century diary written by a topographic engineer.

Students reflected on the process of doing this kind of historical work. They brought up a number of themes related to the felt experience of digging into Thompson's diary – enjoyment, frustration, confusion, and excitement. One of the most striking patterns in their reflections about this assignment is that a student felt like a "detective" on the hunt for clues to decode Thompson's life and work.

- *Engineering Student Reflection 1:* "I found this experience to be quite challenging at times, especially when it came to trying to find journal entries related to engineering, since Thompson's handwriting was not exactly easy to read and his journal spans several years. Through this process, I learned that history is complex and not always straightforward; it requires thoughtful analysis to connect topics that might seem distant upon first glance, but are really related in some shape or form, like drawing and engineering. Throughout the project, I was fascinated by Thompson's writing. Even though words weren't always clear, he seemed to get his point across or express the way he was feeling very well, which, like I said previously, makes sense being that his job required him to be very descriptive, but I was still surprised. During this process, I gained insights into the evolution of the role of the topographical engineer, Thompson's role in the Union Army during the Civil War, and how to read and analyze a primary source in the larger context of history and engineering, which I hope to continue to improve on throughout this course and the rest of my time in college."

- *Engineering Student Reflection 2:* "I quite enjoyed the physical transcribing aspect of this project. I felt more connected to the work I was doing as I saw the primary source first hand. Thompson's admiration and attitude towards his life was enlightening. Deciphering his handwriting and researching more about the specific things he mentioned, such as "John Brown's Song", was also enjoyable. I went off on tangents in pursuit of such facts, but through this I delved deeper into the time period Gilbert Thompson lived in. This also educated me on how to utilize the primary sources in data bases available to the public."
- *Engineering Student Reflection 3:* "I had a love/hate relationship with conducting this research. On one hand, I enjoyed learning directly from primary sources because I had actual proof from a historical document. However, primary sources were much harder to understand than secondary sources, because I was the one drawing conclusions. I thought Thompson's entries were very interesting– it was cool just to know what someone living in 1862 was thinking. It was also interesting how intertwined Thompson was with the war as an engineer. This project definitely gave me a newfound appreciation for historians and the way they decipher historical documents."
- *Engineering Student Reflection 4:* "This process of researching was very interesting and also somewhat tedious. I enjoyed looking through the old records, trying to find information in old government records about Thompson's life. It felt like I was a detective piecing together the story. What I did not enjoy was having to transcribe that journal. I didn't really know how to read cursive handwriting before this project. Thompson's handwriting in the field didn't help either. But after a long time squinting at [the] computer screen, I think (more so hope) I managed to decipher enough of it to get a good grade."

Taken together, these assignments encourage students to think about what materials we use from the past that help us understand the experience of people living in times and places unlike our own and the process that we as historians use to put those materials into legible contexts. Contextual thinking, as Engineering Student 4 notes above, ideally takes "a long time." Thus, in many ways, contextual thinking is experienced as a process that takes time and dedication.

Strategy #2: Distinction-Drawing as Contextual Thinking in Classes on "Engineering Cultures"

For the last twelve years, I have taught at various schools and in various versions a class called "Engineering Cultures," which was first developed about two decades ago at Virginia Tech by Gary Downey [34], [35, pp. 47–56], [36, pp. 136; 203]. It has since then been widely known and widely taught among historians of technology and scholars of engineering studies. The course is now part of the curriculum in a range of undergraduate majors at schools such as the Colorado School of Mines, the University of Pennsylvania, the University of Virginia, Penn State University, Drexel University, and Purdue University. I teach a version of it in the College of

Arts and Sciences at a large, private research university in the Northeast in both seminar form (up to 35 students) and lecture course form (up to 140 students). I usually have no control over the format or size in which I teach this class in any given year.

In the class, students and I try to understand the kinds of attributions that we and others make about what counts as engineering, and what counts as context of engineering. We discuss in particular how we experience our attributions' appeal, function, validity, and effectiveness in varying situations. We do not sort distinctions into correct and false ones. Rather, we try to come up with a preliminary typology that helps us grasp whether and how we distinguish engineering from "everything else." The typology is not set in stone as regards student responses and learning outcomes: it actually changes from year to year in which I teach this course.

One important experience in this class comes from the fact that it typically attracts many pre-medical students. An obvious distinction, therefore, that becomes an ongoing theme in the classroom is that between engineering and the work of experts in medical fields. Students often approach the specific question of engineering expertise versus medical expertise with a strong need to distinguish the two. Engineering expertise is technical, sometimes profit-driven, they point out, and there is a complementary need on the students' part to express at least a wish, or a societal and policy goal, to have medical expertise be more closely connected to non-technical, that is, social, matters, and separate the realm of medical work and care from the supposed pressures of profit-making.

A major benefit in my teaching from bringing in these matters is that, when specifically engineering and medical professions are involved, students are more inclined than with other topics to *speak*. They speak about their personal and familial experience, their pre-med studies and pressures, their professional goals, their parents' or grandparents' experiences who have worked in technical or medical fields (surprisingly often connected with experiences of migration and displacement), and they sometimes are able to make explicit that their own or their parents' wishes for them and their profession is connected to what we refer to as "context," i.e., social status, meaningful pursuit of life, comfortable salary, or family traditions. I often take advantage of this topic and my experience that it is more relatable to students' experiences than many others, to stimulate conversation among us.

My own understanding of contextual reasoning, furthermore, involves specifically an ability to scrutinize distinctions – both ad hoc and methodically – between engineering itself and contexts of engineering. My strategy in the classroom therefore is to ask students (and myself) what does, and does not, count as engineering for us, and what does, and does not, count as context of engineering for us, and whether we can we come up with observations about when, how, and why we draw these distinctions.

In the classroom, I also often rely on the fact that the very process of distinguishing one thing from another is an eminently distressing issue in the field of philosophy, and has been since the field's inception. One prominent debate, with relevance to engineering education, emerged just after the horrors of World War I in Europe: efforts to distinguish science from pseudoscience. In some ways, this was also the beginning of the very discipline of philosophy of science. Karl Popper aimed to distinguish first in 1919, and then in more detail in the grim times of the early 1930s, between empirical-scientific statements and those of metaphysics. He also lived in exile from 1937 for his whole life. Since then, this distinction has gained steady prominence as the so-called "demarcation problem" [37], [38].

I select three examples of class units in my course "Engineering Cultures," in which we practice drawing distinctions between engineering and contexts of engineering, and talk about the what, where, when, and why of our distinction-drawing. My first example is one about the founding of Institutes of Technology in post-Independence India (so-called "IITs"), for which we explore texts about the role of engineering in the building of a new (post- and de-colonial) state in 1947. The texts include primary sources from nineteenth-century British India concerning parliamentary initiatives to found an engineering school, primary sources from the mid-twentieth century about the Indian Independence movement under the aegis of Mahatma Gandhi, secondary sources from scholarship in business and finance, and scholarship in the history of technology [39, pp. 13–15, 265–271, 311–315], [40, pp. 1–25], [41], [42], [43], [44], [45].

Students often refer to this type of context of engineering and engineering education as "political" or "governmental." In class discussion, our distinctions between "engineering itself" and "political context of engineering" usually become more and more difficult to draw: the more closely we look at a specific distinction, the less we find it to be self-evident or easily agreed-upon. As a result, we refine further and further the characteristics that we ascribe to the work of engineers and to that of political and social leaders, in an effort to keep them distinct from each other. This exercise in itself - practicing the drawing of distinctions - yields learning results in this class in the form of students' witnessing and tracking the process of this analytical practice together with the resulting agreements and disagreements.

Both the matters of social justice (as famously taught through Mahatma Gandhi) and those of political and professional autonomy (for engineers and beyond) are topics that generate especially lively activities of boundary-drawing in the class and subsequent challenges of this boundary. Like any other question, boundary-drawing is always already contested, which, in the words of a historian of math education, merely means that we are reasonable people: Chris Phillips famously said in *The New York Times* that "[r]easonable people can and will disagree about it" [46]. I assign his op-ed early in the class, usually to great enthusiasm.

My second example is artistic work, a very different type of context. We ask specifically about the relationship between engineering and artistic representation of engineering, for example in pop culture and in film. I use the film *WarGames* from 1983 (Figure 3 through 5). In it, protagonists such as teenagers, engineers, elected officials, and military officers, encounter each other and negotiate boundaries between different kinds of expertise and authority. This happens under the threat of a nuclear first strike. The material includes the film itself, and ample time in the classroom for viewing passages one by one, scholarly literature from media studies on "teenaged technologies," scholarly literature from cultural studies on the figure of the hacker, reading on the film's director John Badham, and from general media studies about narratives in popular culture [47], [48], [49], [50], [51].

Figure 3: The 1983 movie "WarGames" *depicts "teen-aged" technologies in the early 1980s: how is the emergence of the personal computer visualized in film?*

Figure 4: The 1983 movie "WarGames" *also illustrates the Cold War on a "massive screen," visualized on a national and global scale.*

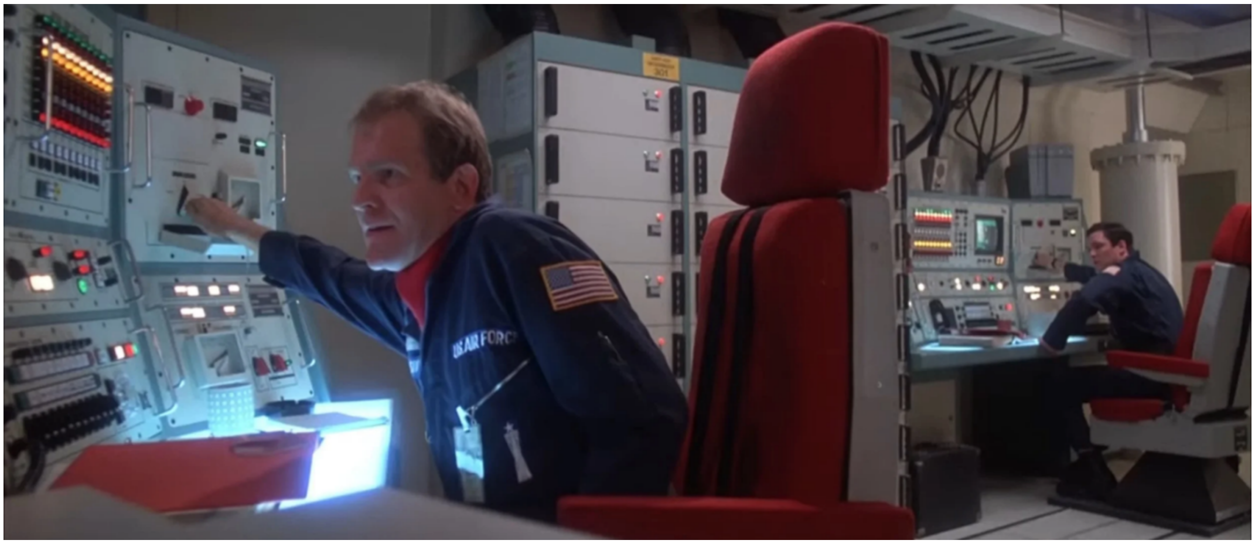

Figure 5: The 1983 movie "WarGames" *depicts decision-making about launching nuclear missiles, featuring men of a very different age group and status compared to other parts in the film where the main actors are male teenagers and hackers.*

What brings these two class units together is a third unit that introduces students to the debut novel by Chetan Bhagat from 2004, *Five Point Someone: What not to do at IIT*. It is set on the campus of an IIT, named among the most prestigious engineering schools in India, and follows three protagonists, all of them are men and students on that campus. The novel brings out in numerous episodes the contradictions, pressures, and disappointments of everyday life of engineering students. It was made into two films, one in Tamil/Kollywood, one in Hindi/Bollywood. We watch the Bollywood loose adaptation called *3 Idiots* (Figure 6) and discuss on the basis of the two art forms - novel and film - engineering education and its contexts [52], [53].

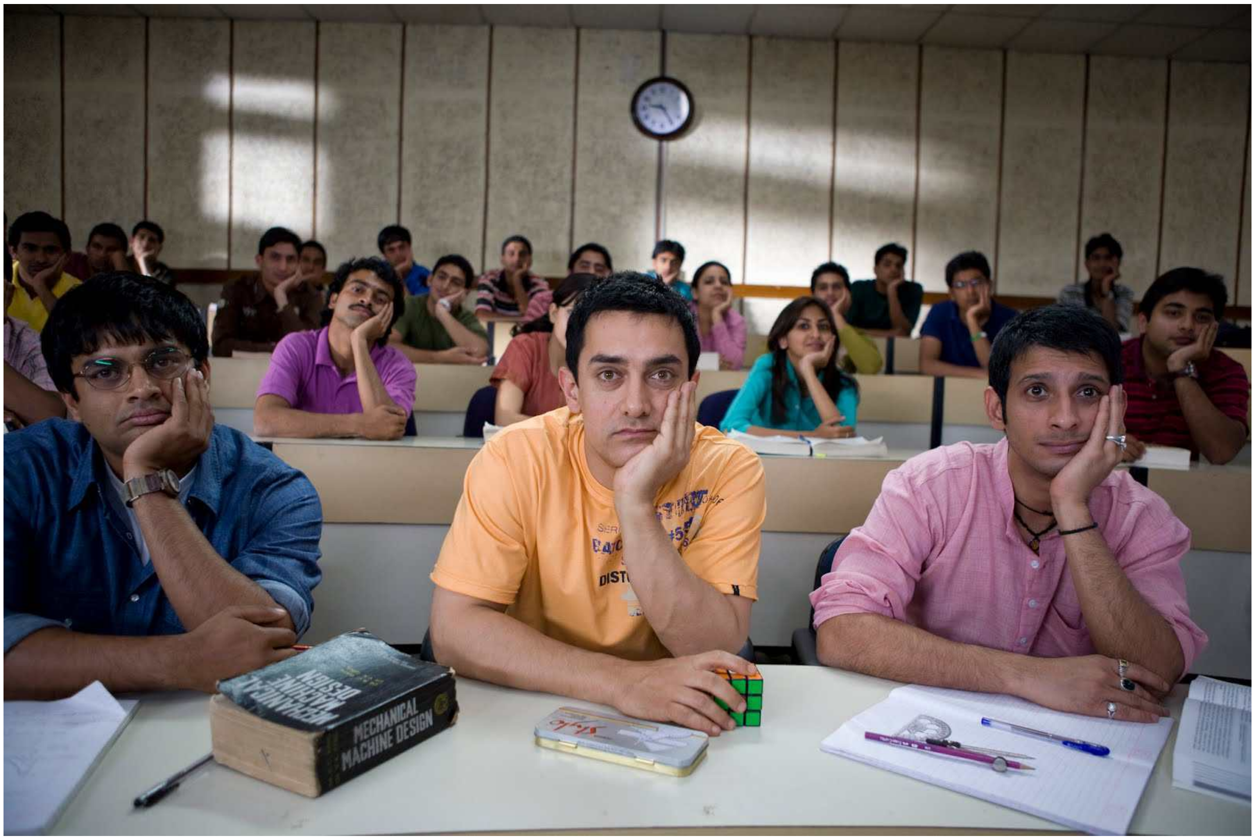

Figure 6: Bollywood film “3 Idiots” *(2009), set on the campus of an elite Indian Institute of Technology (IIT).*

Outcomes of this class, for both seminar form and lecture course form, include detailed records that we keep in the class about our efforts of distinction-drawing, the disappearance and reappearance of boundaries between engineering and context of engineering, a set of carefully curated examples of types of contexts (such as political, social, artistic, ethical, demographic, cultural, linguistic, etc.), and outlines of the kind of “contextual thinking and reasoning” we have engaged in during the class, and what materials and ideas have provoked us to do so.

One other typical outcome of these three class units is an emerging appreciation on the part of students for material from film studies and literary studies. If they have been in a position to take classes at our university’s communication school, or literary studies, media studies, or area studies departments, they appreciate recognizing this material and accompanying questions in the class. If this is their only class in which they have exposure to pop culture and art and its interpretation, they usually embrace it in due course and find opportunity to interpret it using questions about context and contextual reasoning.

Like questions of context, social justice, or politics, the practice of, and reflection on, distinction-drawing trains critical thinking in the broadest sense, of both teachers and students. It makes us aware of the always limited reliability of our reasoning capacities, and it has the capacity to destabilize very effectively received assumptions about the world and about us as subjects. This lines up with academic disciplines that have emerged in the past 100 years, and to which scholarship in engineering education has connected since its inception. As such, the rather old-school philosophical problem of demarcation reemerges in the engineering undergraduate classroom, and helps teach the general potential of destabilizing any set of received notions or narratives.

Strategy #3: Seeing Context in Secondary Sources Across the Fields History of Technology, Engineering Studies, and Engineering Ethics

A third strategy starts from the premise that we can help our engineering students perceive themselves in context: as beings in history who work through institutions that have evolved over time; as soon-to-be early-career professionals who will build their own networks and span various boundaries; and as moral agents whose professional decisions will have different consequences for different groups of people. Here I present the strategy I used in redesigning a course, "Culture of the Engineering Profession," at my university. That strategy is to introduce undergraduate students to three fields of inquiry—history of technology, engineering studies, and engineering ethics—within a single course. The writings of humanists and social scientists together teach us, instructors and students, to see our own evolving roles in the history of the global engineering profession.

In 2024, I had the opportunity to substantially revise the course, which has an enrollment cap of nineteen students. With such a small group, it is possible to create a seminar-like experience in which students read broadly, discuss what they are observing, and pursue their own interests under the guidance of both the instructor and their peers. I used this opportunity to introduce students to three fields—history of technology, engineering studies, and engineering ethics–rather than just one. They each tell us something different about engineering culture. I understood that few, if any, undergraduate courses in the United States try to introduce students to all three of these fields in one semester. But I also knew that many of my students' curricula were so tightly structured that they would either encounter these fields here, in my course, or potentially not at all during their undergraduate education. My guiding question became: what might upper-level undergraduate engineering students learn if they were introduced to all three fields in a single semester?

The answer, I now see, is that students would enhance their contextual reasoning. By studying engineering in context, whether through the disciplinary lenses of history of technology, engineering studies, or engineering ethics, students could turn these three lenses back upon their own life to ask:

- How am I situated in history?
- How much of the findings of sociologists and other engineering studies scholars might apply to my own budding career?
- How am I, through my training and aspirations in engineering, a special kind of moral agent with my own set of duties, virtues, and choices that have consequences?

So much of what we read, so many discussions held, so many questions asked, all pointed to the initial answer, "it depends [on context]."

While students can learn something different from each field, learning outcomes are mutually supportive, each strengthening a different kind of awareness. History of technology can train students' temporal and institutional awareness: each part of the engineering profession emerged in a specific context and has evolved as an institution. Engineering studies, meanwhile, trains organizational and interactional awareness by framing engineers as boundary spanners whose communication and coordination activities influence their careers and projects. And engineering ethics trains normative awareness, alerting students that they will need to navigate through specific contexts while growing or sustaining their professional responsibilities and virtues. These are just some of the capabilities and opportunities opened by these fields that we educators can draw from. In what follows, I will narrate each part of the course as students are introduced to these fields in sequence.

History of Technology Can Depict Engineers-in-Context and Reveal Patterns from the Past

I begin the course by mapping the origins of the global engineering profession using Erik van der Vleuten, Ruth Oldenziel, and Mila David's *Engineering the Future, Understanding the Past: A Social History of Technology* (developed for engineering students at Eindhoven University of Technology in 2018) [54]. The book provides a broad context for engineering practice in terms of both time and global scale, and it is written explicitly for an engineering audience. Its core premise is that engineers never work in a vacuum; they work in contexts, and historians of technology analyze those contexts to explain behaviors and outcomes.

This course must fulfill ABET's ethics requirements for my engineering students, and so even this module encourages students to consider past engineers' choices, many of them moral. There have been increasing efforts to formalize historians' tracing of our actors' moral contexts. For example, Jan Goldstein has proposed that historians analyze the "moral field" of our historical actors, just as Michael Faraday, James Clerk Maxwell, William Thomson, and other physicists developed the "field" concept in the mid-nineteenth century to explore electromagnetic force [55]. Motivated by such ideas, I assign the text first in order to immediately foreground how and why context matters to all engineers, past and present.

The book helps students develop contextual thinking in two ways. First, as our definition of contextual thinking in the introduction implies, studying historical actors encourages students to attend to timing, place, and lived experience as factors that shape perspective. Second, the text repeatedly invites students to move between the general and the specific by asking: is this case part of a broader pattern?

The authors begin by explaining the conditions under which the engineering profession emerged, situating its rise in the nineteenth-century "Age of Promise," when many across Europe believed technology could solve a wide range of social and economic problems. The profession emerged amid significant optimism, and early engineering societies often envisioned themselves as leaders of a technological revolution. At the same time, the chapter shows that engineering has always been entangled with social aspirations and political projects, and that optimism could easily slide into naïveté.

The course then follows the book's narrative by asking how technological promises led to crises, including the world wars of the twentieth century. Here, the authors introduce four recurring mechanisms through which technological dreams may turn into nightmares: repurposing (peaceful technologies are adapted for war), dependence (systems fail once societies rely on them), gradual drift (slow, unintended, often invisible harms accumulate), and crisis response (short-term solutions create new long-term problems). These are not predictions, but historically grounded patterns distilled from multiple case studies. Because such mechanisms recur, learning to identify them is a first step toward recognizing when similar dynamics may shape engineers' own contexts and, therefore toward attempting to prevent their recurrence.

Finally, the book turns to how engineers and societies responded to twentieth-century crises. After the Second World War, many societies embraced technocracy, including the linear model of innovation and systems thinking, as approaches that promised expert control over complex sociotechnical systems. Yet these approaches often marginalized users and affected communities. Often, they concentrated benefits to certain groups over others. From the late 1960s and 1970s onward, participatory approaches gained prominence in many settings as institutions and publics demanded a greater role in shaping technological development. Van der Vleuten and his coauthors conclude by reflecting on the early twenty-first century "grand challenges" articulated by engineering academies and societies across Europe, the United States, and China. The authors argue that engineers will need to blend and balance technocratic and participatory approaches. The overarching lesson for students is that contextual reasoning—recognizing which approach fits which situation, and with what tradeoffs—is now more central than ever to the engineering profession. But the book also encourages students to put themselves in the shoes, so to speak, of past actors, from the optimistic engineers, such as Michel Chevalier, who believed that railroads would foster global peace, to the members of engineering societies, such as the Verein Deutscher Ingenieure in Nazi Germany, who were intimidated into cooperating with authoritarian regimes.

Engineering Studies Can Apply Social Scientific Insights to Engineering Practice

If history of technology trains students to notice patterns across time, the field of engineering studies can help them recognize patterns in today's workplaces. Engineering studies is a multidisciplinary field of inquiry and a subdiscipline of science and technology studies (STS) that is more focused on the institutions and professional practices of engineers as a social group [56]. If history of technology asks students to think through dozens of examples, engineering studies scholarship offers us mental models for discerning general professional behaviors. After framing the course with a survey of the history of technology, I introduce students to the idea of boundary spanning, a sociological framework for understanding the roles played by engineers. Then we read more specific advice for how to carry out this boundary spanning in practice. Students can weigh the advice to recognize what is most relevant to their own situations. Students can also save relevant sources they can later revisit, as their contexts shift in their early career. They might come to view an article or book that seemed irrelevant when they were a student as suddenly relevant in their early career.

The idea of engineers as boundary spanners encourages students to be mindful of context, since engineering work routinely involves spanning boundaries of expertise, organization, and culture that change over time and vary with place. To develop this idea, students read Brent K. Jesiek et al., "Performing at the Boundaries: Narratives of Early Career Engineering Practice" [57]. This article carefully defines boundary spanning and then examines the boundary-spanning practices of early-career engineers using interview data collected around 2015 from twenty-seven engineers working in manufacturing. Three of these engineers are presented as illustrative cases.

Jesiek and his coauthors ask what kinds of boundary spanning early-career engineers experience in their daily work. They identify five particularly important activities: building and maintaining networks, communication, coordination, information and knowledge management, and representing and influencing. These activities recur across several types of boundaries, including job roles and expertise, knowledge domains, organizational structures, individual characteristics such as gender and race, and time and space.

The course complements this sociological perspective with practical advice drawn from James Trevelyan's *Learning Engineering Practice*, first published in 2021 and revised in 2025 [58], [59]. Trevelyan has distilled, from his long career as an engineer, from interviews conducted over decades, and from his familiarity with the field of engineering studies, valuable lessons for engineering educators and students. I will highlight two of them here.

First, Trevelyan argues that engineers must continually hone and practice their habits of critical perception. His emphasis on the role of perception builds upon Bernard Carlson's claim, shared at an ASEE conference in 2003, that representation is a central aspect of engineering work: "engineers gain insight into the material world by representing it using pictures, numbers, words, and computer simulations" [60]. An engineer's perception is enhanced through listening, reading documents, reading people, and "seeing" creatively within organizational contexts.

Second, Trevelyan emphasizes the significance of coordination, the set of practices that enable engineers to manage large technological projects. Coordination is at once technical and social and is one of the primary means through which engineers generate value for users, enterprise, and society [61]. Indeed, neither perception nor coordination fit neatly within engineering educators' common distinction between technical skills on the one hand, and the social, "soft," communication, professional, or management skills on the other. Skills of perception and coordination, in Trevelyan's account, are regarded as the most important competencies for engineers, forming the foundation for collaboration and influence, as well as enabling engineers' ideas to be transformed into reality.

Engineering Ethics Can Foreground Responsibilities, Virtues, and Consequences in Context

If engineering studies scholarship reveals the work practices of coordination, perception, and boundary-spanning, engineering ethics asks students to explore the limits and potential of their own moral agency. The course introduces students to the enduring and ongoing debates in engineering ethics, curated through Deborah G. Johnson's *Engineering Ethics: Contemporary and Enduring Debates* [62]. Students may never encounter the specific dilemmas discussed in the engineering ethics literature, such as whistleblowing, but they need to be aware that such situations are possible within engineering cultures. The existence of whistleblowers, moreover, reveals much about engineering culture in particular national and organizational contexts. Older cases, such as the Challenger disaster, illustrate how engineering culture has evolved, while more recent cases, including Dieselgate and Theranos, shed light on contemporary strategies that corporations use to circumvent regulations and the pressures and incentives faced by engineers working for such corporations.

Within this final part of the course, students learn to think about codes of ethics not simply as rules to be followed, but as statements that uphold the profession's reputation. Codes are also resources that engineers can cite if they ever need to resist unethical demands from employers. More generally, students are encouraged to see ethical frameworks such as deontology, consequentialism, and virtue ethics as aids to thinking rather than prerequisites for ethical judgment. I emphasize that ethical reasoning does not require mastery of philosophical frameworks. What matters more is how frameworks might aid intuition in specific contexts. An example that illustrates the role of frameworks in enhancing intuition and contextual thinking is the "ethical cycle" articulated by Ibo van de Poel and Lamber Royakkers in 2007 [63].

Other debates also help students practice contextual reasoning. Discussions of whistleblowing prompt students to ask why whistleblowers exist, whether whistleblowing is always reasonable, and whether it can sometimes be seen as traitorous. Johnson also asks whether "rotten apples" or "rotten barrels" are responsible for technological mishaps. This debate encourages students to question their assumptions: some students might overwhelmingly expect that disasters are caused by individuals, while others may believe that organizational culture is almost always to blame. But in each debate, whether over codes of ethics, whistleblowing, or technological disasters, students are repeatedly brought back to the same conclusion: the answer depends on context.

The Benefits of Reading Across Three Fields

Students who begin thinking about the history of technology, engineering studies, and engineering ethics can learn some of the prime examples, major synthetic claims, and enduring questions of three mature and active fields of inquiry devoted to analyzing engineering from the perspective of the humanities and social sciences. My goal is to provide students with lots of examples from the past, as well as an introduction to the disciplines and methods that scholars have used to structure our understanding of engineering history, culture, and ethics. Some examples will resonate with certain students, other examples with others. But the takeaway is that there are several ways, not just one, to study engineering as a human activity. Similarly, each student may gravitate toward one field and its methods over others. My own current approach needs revision, particularly to introduce students to the work of anthropologists.

The strategy outlined here, of reading secondary sources that introduce undergraduate students to the fields of history of technology, engineering studies, and engineering ethics, may vary in how it can be implemented into teaching, given educators' own institutional contexts, other obligations, and other teaching strategies. Yet the strategy illustrates how the three fields can work together to emphasize contextual reasoning in engineering education. I believe there is as much opportunity for educators as there is for students in the growing awareness that these literatures exist and can be brought into the classroom.

Conclusion

We would like to return to our framing ideas about the emergence of terms like "context" and "contextual thinking" (as well as "technology" and "technological determinism") in fields adjacent to engineering studies and to take a step back and think more broadly about what it means for the three of us to be thinking and writing together about strategies of bringing contexts and contextual thinking into our classrooms.

In this paper, we have been grappling with a compelling problem of scale in terms of context and contextual thinking. We were all trained in the history of science and technology, in fields in which scholarship focused on context and contextual thinking contributed to realigning a field of study away from internalist analyses and toward the interplay between technical knowledge and society. When we think about our interest in context from this vantage point, it is a way of acknowledging our own socialization in a changing academic field of study [15], [22]. Recovering context in service of understanding the social dimension of science, technology, and engineering has resulted in excellent and thought-provoking work in our field.

From our perspective as teachers in the engineering classroom, the question, as invoked above by Kleine et al. [7], [8], is how to translate our interest in context/contextual thinking as a scholarly infrastructure into the undergraduate classroom in which many other priorities, experiences, goals, outcomes, and assessments come into play. While this is a simple observation, it is unsurprising that our three pedagogical strategies all emphasize the importance of "text" – reading a text, examining film as a text, sorting through text(s) that have relevance to our students' lives. We hope that choosing the right "text" for the right engineering classroom will motivate students to think about engineering in context and engineers within their own times and places. Focusing on context and contextual thinking—through in part identifying the "texts" we can interrogate with our students in the classroom—creates the space to deliberately examine exemplary texts, films, sources, etc. We share the commitment that focusing on a text, sitting with it through reading or watching, is important for learning, analysis, and conversation.

Despite similar training and expertise, it is interesting to note the differences in our strategies in the classroom. Strategy #1 might be considered taking a radical primary source approach to contexts and contextual thinking. It invites students to physically open old books, sift through archival file folders, and flip through colorful ephemera in a library and then to do that work at a more sophisticated level using a range of digital humanities tools. In this approach, contextual awareness happens through the process of interacting with defined primary source material. Strategy #2 offers a different slice into the historical record by asking students to consider not just individual sources but how engineers as a social group have been rendered within particular social, cultural, and historical contexts and the ways in which that group can be categorized, analyzed, and destabilized given what we know about the past and the present. In this case, following engineers across political boundaries and/or onto the silver screen illuminates both the presence of the engineer as a social category and the unexpected ways in which this category continues to need shoring up. Strategy #3 might be considered a radical secondary source approach to contexts and contextual thinking in its focus on reading across the fields of history of technology, engineering studies, and engineering ethics. These fields map how scholars have interpreted the engineering profession, and this approach invites educators and students to explore that map together. In this approach, contextual awareness develops as students learn cases and examples, identify patterns, develop new perspectives, and apply those perspectives to discern their own contexts. Across these strategies, our interest in contextual thinking remains consistent while our choice of texts varies.

To acknowledge our current context(s), we recognize that both scholarship in our fields and the experience of teaching in the undergraduate engineering classroom are being informed by often rapid transformations in technology and society. We are writing this during a spring in which generative AI tools and their influence on society are of great interest, from their influence on higher education to their impact on military technology deployed in global conflict zones. While these technologies and contexts are not at the center of this paper, they are part of our broader interest in attending to the practice of context-making as central to what the liberal arts tradition can contribute to the engineering classroom.

References

[1] K. Johnson, J. A. Leydens, J. Erickson, A. M. Boll, S. Claussen, and B. M. Moskal, "Sociotechnical habits of mind: initial survey results and their formative impact on sociotechnical teaching and learning," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019. Accessed: Jan. 21, 2026. [Online]. Available: https://peer.asee.org/sociotechnical-habits-of-mind-initial-survey-results-and-their-formative-impact-on-sociotechnical-teaching-and-learning

[2] K. A. Neeley, C. D. Wylie, and B. Seabrook, "In search of integration: mapping conceptual efforts to apply STS to engineering education," presented at the 2019 ASEE Annual Conference & Exposition, Jun. 2019. Accessed: Jan. 21, 2026. [Online]. Available: https://peer.asee.org/in-search-of-integration-mapping-conceptual-efforts-to-apply-sts-to-engineering-education

[3] K. Johnson *et al.*, "The development of sociotechnical thinking in engineering undergraduates," presented at the 2022 ASEE Annual Conference & Exposition, Aug. 2022. Accessed: Jan. 21, 2026. [Online]. Available: https://peer.asee.org/the-development-of-sociotechnical-thinking-in-engineering-undergraduates

[4] E. A. Reddy, M. S. Kleine, M. Parsons, and D. Nieusma, "Sociotechnical integration: what is it? Why do we need it? How do we do it?," presented at the 2023 ASEE Annual Conference & Exposition, Jun. 2023. Accessed: Jan. 21, 2026. [Online]. Available: https://peer.asee.org/sociotechnical-integration-what-is-it-why-do-we-need-it-how-do-we-do-it

[5] J. Tonn, B. Shields, R. Hearty, and A. Voskuhl, "Pedagogical choices for navigating and teaching sociotechnical landscapes in engineering education," in *Proceedings of the 2025 ASEE Annual Conference and Exposition*, Montreal, Canada: ASEE, Jun. 2025. Accessed: Sep. 29, 2024. [Online]. Available: https://peer.asee.org/pedagogical-choices-for-navigating-and-teaching-sociotechnical-landscapes-in-engineering-education

[6] C. Carson, A. Edmundson, L. Yan, and A. Strang, "Sociotechnical integration in data science education," presented at the 2025 ASEE Annual Conference & Exposition, Jun. 2025. Accessed: Jan. 21, 2026. [Online]. Available: https://peer.asee.org/sociotechnical-integration-in-data-science-education

[7] M. S. Kleine, K. Zacharias, and D. S. Ozkan, "Contextualization as virtue in engineering education," presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul.

2021. Accessed: Jan. 16, 2026. [Online]. Available: https://peer.asee.org/contextualization-as-virtue-in-engineering-education
[8] M. S. Kleine, K. Zacharias, and D. Ozkan, “Contextualization in engineering education: a scoping literature review,” *Journal of Engineering Education*, vol. 113, no. 4, pp. 894–918, 2024, doi: 10.1002/jee.20570.
[9] M. Wisnioski, “Engineers make their own context: vision-making in the profession,” in *Engineering Identities, Epistemologies and Values: Engineering Education and Practice in Context, Volume 2*, S. H. Christensen, C. Didier, A. Jamison, M. Meganck, C. Mitcham, and B. Newberry, Eds., in Philosophy of Engineering and Technology. , Cham: Springer International Publishing, 2015, pp. 347–359. doi: 10.1007/978-3-319-16172-3_19.
[10] S. H. Christensen, B. Delahousse, and M. Meganck, Eds., *Engineering in Context*. Copenhagen: Academica, 2009.
[11] B. Barnes and D. Edge, Eds., *Science in Context: Readings in the Sociology of Science*. Cambridge, MA: MIT Press, 1982.
[12] D. LaCapra, *Rethinking Intellectual History: Texts, Contexts, Language*. Ithaca: Cornell University Press, 1983.
[13] P. Burke, “Context in context,” *Common Knowledge*, vol. 8, no. 1, pp. 152–177, 2002.
[14] P. Burke, “Context in context,” *Common Knowledge*, vol. 28, no. 1, pp. 11–40, Jan. 2022, doi: 10.1215/0961754X-9713549.
[15] S. Shapin, “Discipline and bounding: the history and sociology of science as seen through the externalism-internalism debate,” *Hist Sci*, vol. 30, no. 4, pp. 333–369, Dec. 1992, doi: 10.1177/007327539203000401.
[16] L. Daston, “Science studies and the history of science,” *Critical Inquiry*, vol. 35, no. 4, pp. 798–813, Jan. 2009, doi: 10.1086/599584.
[17] S. Jasanoff, “A field of its own: the emergence of science and technology studies,” in *The Oxford Handbook of Interdisciplinarity*, R. Frodeman, Ed., Oxford University Press, 2017, p. 0. doi: 10.1093/oxfordhb/9780198733522.013.15.
[18] N. Seaver, “The nice thing about context is that everyone has it,” *Media, Culture & Society*, vol. 37, no. 7, pp. 1101–1109, Oct. 2015, doi: 10.1177/0163443715594102.
[19] P. Hoyningen-Huene, “Context of discovery and context of justification,” *Studies in History and Philosophy of Science Part A*, vol. 18, no. 4, pp. 501–515, Dec. 1987, doi: 10.1016/0039-3681(87)90005-7.
[20] M. Seo and H. Chang, “Context of discovery and context of justification,” in *Encyclopedia of Science Education*, R. Gunstone, Ed., Dordrecht: Springer, 2015, pp. 229–232.
[21] L. Marx, “Technology: the emergence of a hazardous concept,” *Technology and Culture*, vol. 51, no. 3, pp. 561–577, 2010.
[22] R. Kline, “Technological determinism,” in *International Encyclopedia of the Social & Behavioral Sciences*, N. J. Smelser and P. B. Baltes, Eds., 15495-15498: Elsevier, 2001.
[23] L. Winner, *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT Press, 1978.
[24] D. MacKenzie, “Marx and the machine,” *Technology and Culture*, vol. 25, no. 3, pp. 473–502, 1984, doi: 10.2307/3104202.
[25] M. R. Smith and L. Marx, Eds., *Does Technology Drive History? The Dilemma of Technological Determinism*. Cambridge, MA: MIT Press, 1994.

[26] D. Edgerton, “Innovation, technology, or history: what is the historiography of technology about?,” *Technology and Culture*, vol. 51, no. 3, pp. 680–697, Aug. 2010, doi: 10.1353/tech.2010.0007.

[27] P. Forman, “The primacy of science in modernity, of technology in postmodernity, and of ideology in the history of technology,” *History and Technology*, vol. 23, no. 1–2, pp. 1–152, Mar. 2007, doi: 10.1080/07341510601092191.

[28] S. Wyatt, “Technological determinism is dead; long live technological determinism,” in *The Handbook of Science and Technology Studies*, 3rd ed., E. J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, Eds., Cambridge, MA: MIT Press, 2008, pp. 165–80.

[29] G. Schott, *P. Gasparis Schotti Regiscuriani e Societate Jesu, olim in Panormitano Siciliae, posteà in Herbipolitano Franconiae Gymnasio ejusdem Societatis Jesu Matheseos Professoris, Technica curiosa: sive Mirabilia artis, libris XII. comprehensa ...* Sumptibus Wolfgangi Mauritii Endteri. Excudebat Jobus Hertz typographus Herbipol., 1687.

[30] W. Pain, *The Practical Builder: Or, Workman's General Assistant; Shewing the Most Approved and Easy Methods for Drawing and Working the Whole Or Separate Part of Any Building; As, the Use of the Tramel for Groins, Angle Brackets, Niches, &c. ... Ruled of Carpentry, to Find the Length and Backing of Hips Strait Or Curved; Trusses for Roofs, Domes, &c. ... The Proportion of the Five Orders in Their General and Particular Parts ... With Plans and Elevations of Gentlemen's and Farm-houses, Barns, &c*, 4th ed. John Norman, 1792.

[31] É. Hospitalier and C. J. Wharton, *Domestic Electricity for Amateurs*. London, New York: E. & F.N. Spon, 1885. [Online]. Available: https://catalog.hathitrust.org/Record/101660907

[32] L. Senarens, *Jack Wright, the Boy Inventor, Exploring Central Asia in His Magnetic Hurricane*. in The Boys' Star Library, no. 166. F. Tousey, 1901.

[33] T. Kavanagh, *Age of Innocence: The Rebirth of Iron Man*. Marvel, 1996.

[34] G. L. Downey, “The engineering cultures syllabus as formation narrative: critical participation in engineering education through problem definition,” *U. St. Thomas L.J.*, vol. 5, no. 2, pp. 428–456, 2008.

[35] W. M. Sullivan and M. S. Rosin, *A New Agenda for Higher Education: Shaping a Life of the Mind for Practice*. San Francisco: Jossey-Bass, 2008.

[36] S. D. Sheppard, K. Macatangay, A. Colby, and W. Sullivan, *Educating Engineers: Designing for the Future of the Field*. San Francisco: Jossey-Bass, 2009. Accessed: Jan. 21, 2026. [Online]. Available: https://www.academia.edu/download/102673110/4255c008dc623d62a9ba03335a384dc67bd4.pdf

[37] K. R. Popper, “The demarcation between science and metaphysics,” in *The Philosophy of Rudolf Carnap*, P. A. Schilpp, Ed., Open Court, 1963, pp. 183–226.

[38] K. R. Popper, “Remarks on the problems of demarcation and of rationality,” in *Problems in the philosophy of science*, I. Lakatos and A. Musgrave, Eds., Amsterdam: North-Holland, 1968, pp. 88–102.

[39] *Thomason Civil Engineering Calendar*. Roorkee, 1872.

[40] M. Kamdar, *Planet India: How the Fastest Growing Democracy is Transforming America and the World*. New York: Scribner, 2007.

[41] J. Nehru, “The middle way,” in *Jawaharlal Nehru's Speeches: 1949-1953*, vol. 2, New Delhi: Publications Division, Ministry of Information and Broadcasting, Govt. of India, 1958, pp. 15–20. [Online]. Available: https://archive.org/details/jawaharialnehrus00unse

[42] M. Gandhi, *The Gospel of Swadeshi*. Bharatiya Vidya Bhavan, 1967.
[43] S. Pitroda, "Development, democracy, and the village telephone," *Harvard Business Review*, Nov. 01, 1993. Accessed: Jan. 21, 2026. [Online]. Available: https://hbr.org/1993/11/development-democracy-and-the-village-telephone
[44] "Why IIT's are important to the nation?," *IIT Review*, pp. 1–13, 2004.
[45] R. Bassett, "MIT-trained swadeshis: MIT and Indian nationalism, 1880–1947," *Osiris*, vol. 24, no. 1, pp. 212–230, Jan. 2009, doi: 10.1086/605976.
[46] C. J. Phillips, "The politics of math education," *The New York Times*, Dec. 03, 2015. Accessed: Jan. 21, 2026. [Online]. Available: https://www.nytimes.com/2015/12/03/opinion/the-politics-of-math-education.html
[47] J. Badham, Santa Monica. *WarGames*, (1983).
[48] S. R. Schulte, "'The WarGames scenario': regulating teenagers and teenaged technology (1980—1984)," *Television & New Media*, vol. 9, no. 6, pp. 487–513, Nov. 2008, doi: 10.1177/1527476408323345.
[49] C. Mehrstam, "WarGames and the refamiliarization of the hacker," *Genre*, vol. 55, no. 3, pp. 235–258, Dec. 2022, doi: 10.1215/00166928-10146764.
[50] J. Carroll, "From Yale to Hollywood: a journey in film directing with John Badham," *Film Matters*, vol. 14, no. 2, pp. 72–76, Sep. 2023, doi: 10.1386/fm_00286_1.
[51] A. A. Berger, *Narratives in Popular Culture, Media, and Everyday Life*. SAGE Publications, 1996.
[52] R. Hirani, Beverly Hills. *3 Idiots*, (2011).
[53] C. Bhagat, *Five Point Someone: What Not to Do at IIT*. New Delhi: Rupa Publications, 2004.
[54] E. van der Vleuten, R. Oldenziel, and M. Davids, *Engineering the Future, Understanding the Past: A Social History of Technology*. Amsterdam: Amsterdam University Press, 2018.
[55] J. E. Goldstein, "Toward an empirical history of moral thinking: the case of racial theory in mid-nineteenth-century France," Jan. 03, 2015. Accessed: Nov. 16, 2019. [Online]. Available: https://www.historians.org/about-aha-and-membership/aha-history-and-archives/presidential-addresses/jan-e-goldstein
[56] T. De Pree and R. Hearty, "Engineering studies," *Encyclopedia of Science & Technology Studies*. Edward Elgar, Cheltenham, pp. 357–67, 2024.
[57] B. K. Jesiek, N. T. Buswell, and S. Nittala, "Performing at the boundaries: narratives of early career engineering practice," *Engineering Studies*, vol. 13, no. 2, pp. 86–110, May 2021, doi: 10.1080/19378629.2021.1959596.
[58] J. Trevelyan, *Learning Engineering Practice*. London: CRC Press, 2021. doi: 10.1201/b22622.
[59] J. Trevelyan, *Learning Engineering Practice*, 2nd ed. Boca Raton: CRC Press, 2026.
[60] W. B. Carlson, "Toward a philosophy of engineering: the role of representation," in *2003 Annual Conference Proceedings*, Nashville, Tennessee: ASEE Conferences, Jun. 2003, p. 8.1203.1-8.1203.8. doi: 10.18260/1-2--12063.
[61] J. Trevelyan, "Technical coordination in engineering practice," *Journal of Engineering Education*, vol. 96, no. 3, pp. 191–204, 2007, doi: 10.1002/j.2168-9830.2007.tb00929.x.
[62] D. G. Johnson, *Engineering Ethics: Contemporary and Enduring Debates*. New Haven: Yale University Press, 2020.
[63] I. van de Poel and L. Royakkers, "The ethical cycle," *J Bus Ethics*, vol. 71, no. 1, pp. 1–13, Mar. 2007, doi: 10.1007/s10551-006-9121-6.