CHAPTER 13

Critical Reading Across the Engineering Disciplines

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Introduction

Henry Petroski stated, "Science is about knowing, engineering is about doing."[1] In no area is this statement as prescient as with finding and critically reading information. Information gathering in the engineering fields is a distinct set of skills and behaviors that requires use of wide-reaching sources and the development of critical reading practices, which enable individuals to take in vast quantities of information. This is particularly relevant in engineering design: "A systematic, intelligent process in which engineers generate, evaluate, and specify solutions for devices, systems, or processes whose form(s) and function(s) achieve clients' objectives and users' needs while satisfying a specified set of constraints."[2] Engineers must be able to appropriately select and justify all aspects of their design process through the application of the relevant standards, scientific knowledge, self-discovered knowledge and methods, and technical specifications within their own project context.[3] Importantly, the engineering fields rely heavily on stakeholders as sources of knowledge, including users (product testing and validation) and external (clients) and internal (colleagues, engineers, mechanics, electricians, management, etc.) sources of input. In fact, incorporating knowledge from different stakeholders and industry standards is critical

to ensure that design decisions are well-researched, appropriate, and justifiable and that professional expectations regarding due diligence are met.

When reading engineering-specific types of resources, including blueprints, patents, standards, technical documents, white papers, academic publications, and other relevant forms of technical and non-technical communication, engineering students must learn to become critically engaged with engineering literature.[4] Engineering students often assume that their information behaviors are better developed than they are, often resulting in comments like "We'll just Google it."[5] The underlying assumption when "Googling" is that the "right" information will be in the first few links and that the primary goal is to find an "appropriate" citation as opposed to fully reading the identified resource. Within engineering, information gathering and processing is done primarily to meet the needs of the design process, and in many practice-based settings, finding good enough information is encouraged.[6] Therefore, failure to apply critical reading skills can lead to inappropriate and poorly informed design decisions, which can have drastic consequences for the public at large.[7] Despite the potential negative consequences, critical reading as a foundational professional skill is often taken for granted.

Engineering education is strongly influenced by the accreditation bodies and program requirements. ABET (the Accreditation Board for Engineering and Technology, Inc.), the accrediting body in the United States, requires programs to produce graduates with the abilities "to communicate effectively with a range of audiences, to recognize ethical and professional responsibilities in engineering situations and make informed judgments, and, to acquire and apply new knowledge as needed, using appropriate learning strategies."[8] These abilities, including a specifically identified communication attribute, are seen as essential in developing undergraduate students prepared to meet the needs and challenges of the engineering profession and work toward their professional engineering license (PE, PEng).

Often, information literacy (IL) skills in engineering are taught in a tangential way through one-off presentations, as part of communication-focused courses with limited integration across the curriculum, or as co-curricular enrichment activities such as micro-credentials.[9] Engineering students are focused on becoming licensed professionals, and to align their goals with the librarian-focused goals of building critical reading skills, we must rethink how we approach and frame IL and critical reading in a manner that resonates with students' professional goals. Specifically, critical reading and IL are terms that are used widely in library contexts but are not easily or effectively translated to engineering-specific contexts.[10] This is compounded by a lack of consensus around the terminology as a whole, an inconsistent level of engagement in teaching these skills within the broader curriculum, and ultimately a notable gap in engineering students' abilities with information-seeking and critical reading.[11]

This chapter focuses on how we have successfully integrated aspects of critical reading into engineering courses. We present the RADAR (Relevance, Authority, Date, Appearance/Accuracy, and Reason) method, which we find to be effective because it is easily understood, easily translated to different concepts, and easily scaffolded by faculty into various assignments.[12] To move students to a more meaningful approach to critical reading, we use design critique, which allows librarians to present reading as an important, practical, professional skill.

Critical Reading Connection

Critical reading itself has long been linked to critical thinking[13] and deep understanding through information synthesis and the development of a "critical disposition" toward information, personally and professionally.[14] Critique, at its core, is when a designer presents their work and feedback is given. In education, students are most often critiqued in terms of formal assessments from their professors, but other modalities exist, including peer critique and formative feedback. In classroom settings, the potential benefits of a design critique may not be immediately obvious to students, as these skills are not as easy to identify. The process for developing these skills (feedback, listening, openness, being critical) is closely tied to the process necessary to develop critical reading skills. At present, the idea of critical reading is not widely discussed or practiced in the engineering disciplines, and engineering students are generally reticent to develop reading as a skill.[15]

Teaching Strategy

RADAR for First-Year Engineering Students

Engineering is about doing, and to build the connection between research and practical skills, we must give students frameworks where they can actively engage with these ideas, and not just in relation to academic sources. In introductory engineering courses, librarians at our institution introduce students to critical evaluation of information, which uses ideas modified from health research's critical appraisal framework.[16] Specifically, we introduce the students to how to use an evaluative framework—in our case, RADAR—to guide them in drawing together critical reading and critical evaluation skills.[17] We chose to use RADAR because it works equally well for peer-reviewed sources as well as non-peer-reviewed resources, but any evaluative framework could work for this pedagogical approach. For example, when looking at *authority*, engineering students can use any metrics they like: Does the author have a PEng, a PhD? Are they a well-known blogger or

Title Author	
R (Relevance)	
A (Authority)	
D (Date)	
A (Accuracy)	
R (Reason)	
Is this a '*good*' source?	
Would you use this article?	

Figure 13.1
RADAR sample worksheet

Redditor? Are they employed at a known firm? Essentially, is this source of information one that you would stake your reputation and license on? We intentionally teach them that different authorities may have different backgrounds and expertise, and place equal value on institutional knowledge (such as from Google), professional knowledge (PEng), academic knowledge (PhD), and community stakeholders (lived experiences).

The introduction of critical reading is done in an interactive lecture format, connecting critique to information read in personal and academic contexts. Within the class-based workshop, we discuss the need for using "good" information through open-ended questioning. We highlight that "good" information is wide-ranging and reflective of professional practice, emphasizing the value of secondary research sources in their careers. Next, we ask students to select a topic, find two pieces of information, and use the evaluative framework to help determine quality. We then lead a discussion about the process and what students found from the application of the evaluative framework while echoing the values of critical reading, such as taking time to absorb pertinent information, seeking the knowledge in the resource, and making notes to facilitate future reference to the source.[18] Directing students toward analysis of sources through the lens of critical reading allows students to simultaneously contextualize the information they find and build their engineering skills. Engineers must be able to find and evaluate information quickly and ensure that it is the correct information they must use to make practice-based decisions.[19] For example, is the method they are using to evaluate correct? Have they found the correct standard for their purposes? Have they sufficiently searched existing patents? Are they doing the correct weight-bearing calculations? In many cases, practicing engineers use their lived experience or peer-to-peer discussions as a first line of information-seeking.[20] While students are building this knowledge, they must learn to critically read information.

A Design Critique of Sources Approach

In upper-level undergraduate and graduate engineering courses, engineering students identify (or are provided) a problem space to address by developing an appropriately designed solution. For example: How can an electric wheelchair go off-roading? How can you determine optimal watering times in home gardens? How can you make purchasing clothing online more accurate? The first step of this process is identifying, contextualizing, and utilizing information from a variety of sources appropriate to the problem space. In their design skill development, engineering students are taught that, as they design their projects, they must be critical of the information they use, whether they are defining their situation of concern, specifying requirements and constraints, performing an impact assessment, selecting specific materials and tools, or applying appropriate methodologies and techniques to develop and test their designs.

We use information critique to engage students through mirroring the known process of a design critique. To do this, we have small group meetings with the students at the library and complete a design critique of the information sources they used to validate their problem space. A problem space is fundamentally asking, Are you solving the right problem for the right audience?[21] By turning this process into a critique, we have a deeper, more meaningful discussion with the students about what information

they found, where they found information, different sources that could be used, and the validity of those sources. Beyond these issues, these information critiques, grounded in Connor and Irizarry's *Discussing Design: Improving Communication and Collaboration through Critique*, can further assess student critical reading skills by probing their collective synthesis of found information and establishing gaps in understanding.[22]

Critical reading becomes a foundational skill that develops into a more holistic critical analysis interwoven through the design process. In class, we often develop this skill with the Socratic method through questions such as "How did you come to this design?"; "Why are you using these testing methods?"; and "What else could you do to improve this?". In addition, critical reading questions are asked, including "Why did you use this source?"; "Is this a valid source?"; "Does this source give accurate information?"; and "Did you identify conflicting information?". This approach encourages students to consider questions they may have previously overlooked and to incorporate critical analysis and reading into their design processes.

Discussion

When we teach critical reading to engineering students as librarians, we work within the existing systems of their curricula. We routinely use the RADAR framework to teach critical reading skills in one-shot instruction sessions across engineering. After exposure to RADAR, students quickly find it valuable for analyzing the sources they read and use it regularly. By mirroring the systematic approach of RADAR, we also use the design critique process, mimicking existing structures that students understand, to emphasize the importance of critical reading. There are several opportunities for engaging with students using design critique. The most successful avenue is joining the faculty member, giving a design critique as an embedded librarian to include elements of critical reading in an official critique session. Giving students an opportunity to describe the nature and aspects of the text, using evidence and terminology from the information to validate their design, is one way to encourage this scenario. As with all embedded approaches, the partnership between the instructor and the librarian is fundamental to the success of this approach.

Incorporating critical reading into existing design critique frameworks helps address both the context of knowledge-gathering and student engagement with information sources. By framing questions such as "Why did you choose this method?"; "Why this standard?", instead of "Go to the library catalog and search for your topic," we encourage students to be critical of the sources they use. Students often default to using Google, Wikipedia, and Reddit to find information for their design work, and we know that, in professional settings, they will be encouraged to use these sources in addition to peer-based knowledge. A critique format helps students correctly contextualize critical reading, with a focus on ensuring that the original source is high quality, up to date, and relevant to their design through a less formal interaction, ultimately supporting lifelong learning.

Running in parallel to library-focused interventions, engineering faculty members may also support critical reading throughout design curricula. For instance, impact assessment is an important part of the design process where engineers consider the potential

societal, economic, and environmental impacts of their final solutions. During impact assessments, critical reading skills are particularly important as students identify known and potential impacts of technologies on economy, society, and the environment. This requires students to engage with information sources that represent emerging areas of engineering knowledge where uncertainties are still present. Navigating this uncertainty and reaching an appropriate, balanced conclusion is an important professional skill and a societal expectation for engineers: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[23] Strong recommendations in the presence of uncertainty require an appropriate presentation and incorporation of differing, conflicting information in a nuanced manner that demonstrates a clear understanding of both the information and the quality of the underlying sources. We provide students with the opportunity to perform extensive research on the known and potential impacts of both current and emerging technologies with the goal of developing appropriate, balanced recommendations. This process requires the application of both critical reading and critical analysis skills and fosters professional development.

Conclusion

Critical reading can be taught using a variety of pedagogical strategies common in the engineering fields, including case-based learning, problem-based learning, scaffolded assignments, and cognitive apprenticeship. The outlined pedagogical approaches have been identified as high-impact educational practices, which create stronger collaborative learning experiences and demonstrate larger gains in student learning.[24] Furthermore, high-impact practices can increase diversity in classroom settings by intentionally presenting students with viewpoints different from their own.[25] Critical reading presents an active model for application and practice of critique coupled with the presentation of varied perspectives, offering an opportunity to communally interrogate existing ideas and build knowledge about solving design problems. Grounded by the theory of cognitive apprenticeship, expert practitioners can model critical reading skills through this generative aspect of critique, but only if integrated intentionally throughout the engineering curriculum.[26]

Notes

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