Designing a sustainable liberal arts pedagogy for the engineers of tomorrow

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ABSTRACT

ABET’s EC 2000 lists “an ability to communicate effectively” as one of the criteria for engineering education programs. Here is one area where the liberal arts can make a strong contribution to the education of engineers. As they work to solve the grand challenges, engineers will have to persuade reluctant audiences that change is necessary and beneficial. Therefore, educating engineers to solve the grand challenges requires courses grounded in rhetoric.

A valid criticism of writing classes is that they have taught a sterile form of writing that was inadequate in preparing engineers to solve the grand challenges. To address this issue, this presentation advocates what we define as a “pedagogy of networks.” In many scholarly disciplines and workplaces, the expert witness or subject matter expert, a product of Modern thought, continues to be a valid method of knowledge transference. However, the expert witness model is not always effective when communicating with non-engineers. As ABET points out, engineers must be able to do more than present technical data to other engineers.

Drawing on the work of Lyotard, Latour, and field work, this presentation will discuss how postmodern ideas of networks and rhizomatic connections can inform the education of engineers. By shifting to a networked pedagogy and by directly engaging epistemic processes in professional writing classrooms, students can begin to understand the complex relationship among knowledge and networked communities. Networked pedagogy helps situate the engineer in direct conversation with peers, decision makers, funding organizations, and community members.

In addition to Postmodern theories of knowledge, research on how the brain processes information can help students analyze and respond to various rhetorical situations. For example, Kahneman’s work on cognitive ease provides strategies for communicating with audiences who are resistant to change and new ideas. Overcoming resistance to change is a significant hurdle in solving the grand challenges; technical data and its implications must be shaped to so as to engage audiences on both a cognitive and emotional level. As advertising and marketing firms know, research on cognition is quite useful in doing so.

Ultimately, this presentation will suggest pedagogical and workplace training standards which can help engineers communicate with various audiences as they work to solve the grand challenges. Clear strategies and timelines for incorporating a pedagogy of networks into writing courses for engineers will be discussed.

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INTRODUCTION

Our argument in this paper is inspired by bigger picture conversations happening in the US around STEM and STEAM, in which liberal arts, or humanities education, is being paired with other disciplines, such as engineering, medicine, etc, for the mutually perceived benefits. Here, we will speak for one particular aspect of the humanities, writing instruction. Our scope is not to discuss how all humanities disciplines prepare engineers to meet the Grand Challenges. Our scope is to examine the role of writing courses in doing so. As writing instructors ourselves, both with backgrounds teaching writing specifically to engineering students, we believe that what we say here can better inform discussions among engineering departments and the writing program(s) that support them.

ABET’s Engineering Criteria 2000 (EC2000) lists “an ability to communicate effectively” as one of the criteria for engineering education programs. This is one area where the liberal arts can make a strong contribution to the education of engineers. As they work to solve the Grand Challenges, engineers will have to persuade reluctant audiences that change is necessary and beneficial. This is precisely where writing instruction can be better tailored to the needs of tomorrow’s engineers, at the intersection of audience and subject matter.

If we are to see this paper as a conversation between engineering faculty and the liberal arts writing and professional communication faculty, the following questions will set our agenda:

- Does our writing program teach engineering students to only or always position themselves as a SME?
- Does our writing program provide our students awareness of the complexities involved in persuading people to care about and get involved in solving the Grand Challenges?
- Does our writing program teach our students about and how to navigate communication networks?

As we investigate these questions further, this paper will give background on the relationship of SMEs to audiences and content, will highlight a pedagogy of networked communication, and will discuss brain theory on persuasion as a framework to reconfigure the liberal arts writing course. Research will be presented regarding writing instruction in the top undergraduate engineering universities. Findings will show that although there is no one right answer to the liberal arts integration with engineering, writing instruction is a solid start at building sustainable liberal arts pedagogy.

BACKGROUND

Until recently, General Education Requirements (GERs) have not been customized for specific majors. GERs are typically classes in the liberal arts, whether it is a writing intensive (WI) course or a history, sociology, or political science class.

However, within the past 10 years or so, some universities have begun to design GER writing courses to help prepare students to write in scientific and technical classes. For example, Texas A&M and Purdue offer “Technical Writing” or “Technical Communication” courses specifically targeted to engineers.

One way for GERs to embrace interdisciplinary approaches is to have interdisciplinary faculty teach the general courses. One of the top liberal arts colleges with an engineering program is Harvey Mudd College, and they have had success with encouraging STEM professors to teach writing. Their initiative started in 2009, and by now about 40% of their STEM (science, technology, engineering and mathematics) faculty has taught general first year writing courses. Having interdisciplinary instructors, content, and learning objectives no doubt enhances the learning experience for both students and faculty and will ultimately impact outcomes.

The STEM to STEAM movement is a recent development that highlights a shift to a more fully integrated curriculum. STEAM adds an “A” for arts into STEM. The STEAM educational approach is being discussed at secondary and post-secondary levels in the US. The goal of STEAM is to blend arts and sciences so that the seemingly divergent disciplines collaboratively and complimentary support each other. Proponents of STEAM note that the arts often bring a subjective perspective to a problem, whereas STEM seeks to apply objective research to solve the problem. Bringing these two approaches together provides a more complete understanding of how humans perceive, interact with, and feel about the products, designs, and solutions developed through STEM.

The mouthpiece of STEM has historically been an expert witness or subject matter expert (SME), but this is changing. Seen as a valid method of knowledge transfer since the Enlightenment, a conduit of
the truth so to speak, the expert witness throughout history has been largely male, white, and situated within an academic context. Because of today’s social media age, the networks of knowledge have expanded far beyond the traditional university environment. Engineering problems are being solved in rural Africa and India that students in Big 10 Midwestern universities can now witness online, through social media, short films, and networked collaboration. Taking the power out of the hands of the expert witness gives rise to the possibilities of knowledge exchange not seen before in history. And this collaboration is exactly the kind of interdisciplinary, cross-cultural, cross-spatial intellectual exchange promoted by STEAM.

This STEAM exchange within the context of engineering education can be seen as a site of networked pedagogy. Key features of a networked pedagogy include:

- Integration of social media to connect with learning sites outside of the traditional classroom
- Interdisciplinary approach, particularly among STEM and liberal arts
- Focus on writing, critical thinking, and communication

Networked pedagogy reaches farther than the traditional classroom, and into the networks of social media, global learning communities, and even on the ground in remote research stations. Theories of communication networks and rhizomatic connections directly engage students with epistemic processes in liberal arts classrooms. In this way, liberal arts and STEAM education can teach and expand on the complex relationships among knowledge, power and communities. Networked pedagogy helps situate the STEAM learner in direct conversation with peers, decision makers, funding organizations, and community members.

**RESEARCH PROBLEM STATEMENT**

Liberal arts courses should integrate interdisciplinary approaches to engineering that engage students in thoughtful investigations about the humanities. Right now, very few universities have such programs, particularly in response to STEM education. If such integrated courses and programs are not instituted, engineering students will be less able to meet the Grand Challenges. Perhaps ABET should consider requiring a certain number of interdisciplinary, engineering-oriented liberal arts courses.

In response to this clear challenge to the liberal arts, we will discuss our research regarding leading universities’ approaches to liberal arts education and how this connects to the education of tomorrow’s engineers.

**RESEARCH METHODS**

Our research methods consisted of a study of the liberal arts requirements of the top 5 undergraduate engineering programs in the US.

We examined the 2014 top undergraduate engineering programs in the US. This list (Table 1) shows that MIT, Stanford, UC Berkeley, California Institute of Technology, and Georgia Institute of Technology hold the top 5 spots. We broke down the General Education Requirements (GERs) for each university. This is described in three ways in the table: first, required liberal arts courses, then within that, communication or writing intensive, and also within the liberal arts courses, whether or not any of those required liberal arts courses are contextualized, multidisciplinary courses that align with STEM fields.

<table>
<thead>
<tr>
<th>Rank</th>
<th>School</th>
<th>Liberal Arts (Humanities and Social Sciences) Courses Required</th>
<th>Writing Intensive Required</th>
<th>Contextualized, Multidisciplinary Requirements in STEM (STEAM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MIT</td>
<td>8</td>
<td>4 (2 First Year Writing, 1 Upper Division Writing)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Stanford</td>
<td>11</td>
<td>3 (2 First Year Writing)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>UC Berkeley</td>
<td>7</td>
<td>2 (2 First Year Writing)</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>California Institute of Technology</td>
<td>14</td>
<td>10 (All humanities courses require at least 4,000 words of composition)</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Georgia Institute of Technology</td>
<td>8</td>
<td>2 (2 First Year Writing)</td>
<td>0</td>
</tr>
</tbody>
</table>
RESULTS

Results show that out of the five universities studied, only one, Stanford, has contextualized courses that meet the interdisciplinary approaches of STEAM. The other schools all offer and require intensive writing courses for engineering students, while one school, California Institute of Technology, requires 10 humanities courses that all have a minimum requirement of at least 4,000 words of composition in each class.

Three out of the five schools require writing intensive courses beyond the first year level, showing a strong institutional commitment to meeting the challenges of learning to communicate well. The average of liberal arts GERs for each of these schools is 9.6, with the lowest being 7 at UC Berkeley and the highest being 14 at California Institute of Technology.

Overall, the results show that California Institute of Technology has the highest number of liberal arts courses and the most required writing intensive courses. Stanford ranks next in terms of number of liberal arts courses required and their contextualized STEAM courses, also referred to as “Ways”.

DISCUSSION

In most one or two semester first-year composition sequences, students are taught to use the basics of rhetoric—ethos, pathos, and logos—to analyze written and visual texts and to write a variety of texts. Some universities have more specialized first and/or second semester writing classes that focus on preparing students to write in their engineering classes. Some universities have upper-level writing classes designed to help students write a capstone project. Because the goal of most composition classes is to introduce students to the basics of persuasion and to prepare students to write in academia and in the workplace, these classes cannot adequately prepare students to meet the communication challenges inherit with solving the Grand Challenges.5,8

In their “Introduction to the Grand Challenges for Engineering,” the National Academy of Engineering argues that protecting the environment is at the core of the Grand Challenges:

Foremost among the challenges are those that must be met to ensure the future itself. The Earth is a planet of finite resources, and its growing population currently consumes them at a rate that cannot be sustained. Widely reported warnings have emphasized the need to develop new sources of energy, at the same time as preventing or reversing the degradation of the environment. (http://www.engineeringchallenges.org/cms/8996/9221.aspx)

The sustainability the National Academy of Engineers discusses will likely entail lifestyle change for those of us in more economically developed countries (MEDC). Convincing people to change their lifestyles is a daunting task. Thus a central problem with solving the Grand Challenges will be persuading people that: a problem exists, engineers have developed solutions, and the solutions should be implemented even if doing so means changing how we live our lives.

Communicating the urgency of solving the Grand Challenges is a complex psychological task that requires much more knowledge than an understanding of ethos, pathos, and logos and the ability to produce solid technical documents. Postmodern theories of knowledge, power, and networked communities are useful in analyzing the complex factors involved in inducing people to care about and act on the Grand Challenges. Another useful area is research on persuasion and human cognition.

For the sake of illustration, we will draw on the work of Daniel Kahneman6 and Gerald Zaltman7. Kahneman received a Noble Prize in Economic Sciences for his research that challenged the rational model of judgment and decision making. Zaltman is a Professor of Marketing in the Harvard Business School and is a Fellow at Harvard’s Mind, Brain, Behavior Initiative. Here are some of the key ideas from Kahneman and Zaltman:

- The human brain is designed to operate efficiently
- Concepts such as the anchoring effect, confirmation bias, and the halo effect influence cognition without humans realizing it
- Metaphors can be used to create strong brand loyalty and influence behavior
- “Rational decisions” are often actually hasty conclusions
- Effort is required to shift the brain from unconscious decision making

The work of Kahneman, Zaltman, and others,6,7,10 shows how knowledge of the brain is essential to understanding how to persuade people. As Kahneman and Zaltman points out, humans can be
influenced by a number of factors without realizing it. Knowledge of these factors will be essential to raising public concern for solving the Grand Challenges.

In most engineering curriculums, it is likely impractical or impossible to add classes. Even if it were possible to add classes, who would teach a class on how to persuade the public to change their paradigms? Many disciplines contribute to our knowledge of decision making, changing paradigms, and postmodern theories: psychology, political science, economics, business and marketing, linguistics, rhetoric and composition, literature, and cultural studies to name a few. Concepts such as priming, hind-sight bias, metaphors, placebo effect, embodied cognition, don’t belong to a specific discipline.

Clearly with the rigorous demands of their professional qualifications, engineering students cannot become experts in the complex cognitive facets of persuasion. Professors across the disciplines could engage in a dialogue to discuss how their class material relates to persuasion. This discussion should be of benefit to other majors as students from many majors will find themselves having to engage in persuasion in their careers. This is an area where learning activities could be used to induce students to explore the connections between course material and communicating with the public on the Grand Challenges or whatever other persuasion challenges students may face in their careers. These activities would be one way to induce students to think about communication networks.

Another way would be to introduce students to organizations that work on solving issues similar to the Grand Challenges. For example, the website of the Yale Project on Climate Change Communication: Bridging Science and Society presents scholarly research on how people react to and act on scientific data on climate change. Other sites include: George Mason University Center for Climate Change Communication; FrameWorks Institute; Stanford Social Innovation Review; and the National Association for Environmental Education.

CONCLUSION

We have tried here to argue that technical knowledge alone is not enough to solve the Grand Challenges. At the same time, we acknowledge that traditional liberal arts, or humanities course offerings may not be giving engineers the background in communication, audience awareness, etc. that they need in their tool belt. The intersections of the liberal arts and engineering extend much further than a technical writing course. For liberal arts to be diverse yet also productive enough for engineers, the curricular pedagogy and outcomes need to be carefully examined. We do not have the one true way of using humanities or writing classes to engineer engineers for the Grand Challenges, but we hope that the possibilities we have outlined can lead to a more connected model of STEAM education, particularly for the engineers of tomorrow.

REFERENCES

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