

Experiences from the First Cohort of Engineering Students at a Liberal Arts University

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Introduction

In this paper, students in the first cohort of a new engineering program at a liberal arts university share their experiences of studying engineering in the context of a liberal arts institution. In particular the paper reports on what students believe is the reciprocity between the liberal arts and engineering i.e. *what do the liberal arts bring to engineering*, and *what does engineering bring to the liberal arts*. As will be evident in the findings shared in the paper, the students often do not see their engineering and liberal education as separate, but share their experiences at the confluence of the two and how that impacts how they think of themselves and their learning. The narratives presented in this paper were collected as part of a weekly one-hour reflection seminar that all students in the program are required to enroll in each semester. One of the goals of the course is to give students the opportunity to think about the connections between their liberal arts courses and the general liberal arts university experiences, with what they are learning in their engineering specific courses and experiences. In an attempt to create a student-centered body of knowledge that initiates the dissolution of the techno-social dualism prevalent in engineering education, we present here student narratives and a discussion based on these narratives to understand students' experience of the integration of the engineering and liberal arts, which is a focus of the ASEE LEES division.

Rationale and Background

In the pursuit of promoting the integration of the liberal arts and engineering, a voice that is often missing is of the students who are actually experiencing the convergence of the two during their college education. Framing engineering as a humanistic vocation which can be a notable function of a liberal arts education, has the potential to develop and sustain pro-social beliefs among students and also contribute to their holistic formation as individuals and professionals.

There have been voices predicting that engineering will be the liberal arts of the 21st century given the increase in technology use in the world and equating knowledge of technology to knowledge of reading and writing from the past [1]. In contrasting appeals proponents have called to broaden the engineering curriculum to include more liberal arts, and in turn learn more engineering on the job or in graduate school [2]. However, as we stand currently in 2023, we have not witnessed such extreme shifts in either direction in a majority of programs across the United States. Instead and perhaps a more fortunate phenomenon that we have seen in undergraduate education is joint liberal arts and engineering programs which have existed for a few decades now. For example, the Engineering Studies program at Lafayette College which was established in 1970 and brings together in its mission several promising aspects of the convergence of engineering and the liberal arts. In an ASEE paper, Bernhardt & Rossmann [3] write that the program's current mission is "engage students in engineering as a liberal art, recognizing the increasingly complex challenges of engineering in the larger framework of socio-technical systems and examining these systems through multi-disciplinary perspectives" (p.1). In sharing how Rensselaer's Programs in Design and Innovation is contending with instrumentalist rationales, Nieuwsma [4] shares how the program is not merely focused on providing both engineering and liberal arts content to students, but brings the liberal arts into the framing of engineering education itself including the curricular, pedagogical and student experiences. Similarly, with a focus on an engineering thermodynamics course, Riley [5] motivates the use of liberative pedagogies in engineering education by relating pedagogy to

students' prior experiences, student responsibility and authority, including ethics and policy, decentering western knowledge systems.

Institutional and Data Collection Context

The student co-authors of this paper, who are currently in their sophomore year, are enrolled in an undergraduate engineering program developed around the intellectual theme of "human-centered" engineering. The program integrates the university's liberal arts curriculum with an experiential engineering curriculum emphasizing societal responsibility.

For the liberal arts requirement of the university, the students take 15 courses including courses in art, cultural diversity, history, literature, mathematics, natural science, philosophy, social sciences, theology, and writing. The students also complete courses to graduate with a B.S. in General Engineering. In addition to the liberal arts core courses and engineering courses, all students also participate in a weekly one-hour reflection seminar that they are enrolled in along with their peers in the same cohort. An aim for the pedagogy and curriculum in the courses coded as engineering and the reflection seminars is to utilize the affordances of a liberal arts framing to engineering to provide students opportunities to experience a liberal engineering education more holistically.

During one of the reflection seminars in Fall 2022, the students that were present that day, between 20-25 students, created a word cloud in response to two questions about becoming human-centered engineers: what do the liberal arts bring to engineering; and what does engineering bring to the liberal arts? Each student was suggested to add a few (2-3) words to the cloud. Notably, an exact definition for what defines liberal arts and what defines engineering was not given to the students, but was left up to the students' own conceptions of each. These conceptions were likely informed by the engineering and liberal arts courses that the students had taken. In the sessions following in November and December, the student co-authors populated a shared document with their personal stories relating to the themes that came up in the word cloud as part of the course. The themes were chosen based on the frequency of phrases/words in the word clouds. Themes relating to what the liberal arts brings to engineering include *perspective, reflection, creativity, empathy, balance, and humanity*. Themes for what engineering brings to the liberal arts include *technical knowledge, critical thinking, problem-solving, truth, technology, and cooperation*.

Approach

Figures 1 and 2 below show the students' responses to an open-ended quiz activity where we used an online polling application to populate word clouds.

Based on the responses above, the instructor had a discussion during the seminar about submitting a paper based on the previous exercise and further reflections to expand upon the key themes identified. All students in the seminar (26) agreed to participate as co-authors at which point the instructor created a shared document with the most popular themes that came up in the previous exercise. All the student co-authors contributed their experiences in the form of written narratives to at a minimum of two identified themes. Pseudonyms (e.g. Cool Cucumber, Charming Cantaloupe) were used when capturing these written reflections after a discussion about how the students would feel more comfortable with sharing honest reflections if the reflections could not be tracked back to the exact person. These narratives were written over the course of three reflection seminars in November - December 2022.

One of the student co-authors took the lead on data analysis and organized this paper in collaboration with the instructor. They conducted an analysis of narratives [6]–[8] to unpack the key ideas within each of the identified themes. These key ideas are presented below.

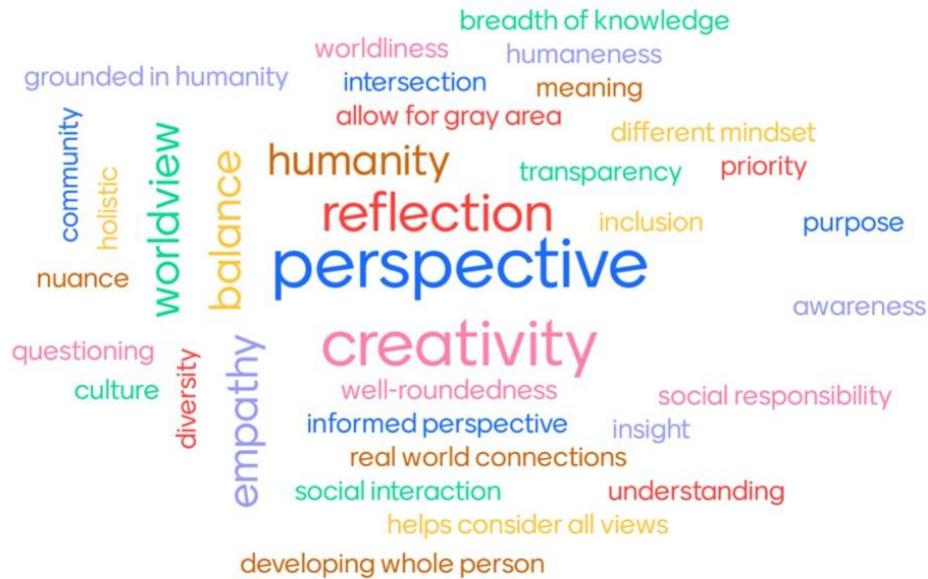


Figure 1. Student responses to “What do you think the liberal arts bring to engineering”



Figure 2. Student responses to “What do you think engineering brings to the liberal arts”

Findings

Contributions of the Liberal Arts to Engineering

After students were given the opportunity to fill in a word cloud about what the liberal arts brings to engineering, the ideas of perspective, reflection, creativity, empathy, humanity, and balance were chosen as the primary foci of the stories that the students shared.

Perspective. On the topic of perspective, the most commonly referred to example of how it applies to engineering was that it helps them make connections between what they are learning about in their STEM classes and how that can be applied into the real world. Riffing Cuttlefish and Sniffing Pomegranate gave examples of how they were able to see the connections between engineering and communities, which was explored in a literature class, or how their engineering classes gave them a deeper understanding of climate change. Additionally, Grappling Grape suggested that taking liberal arts courses help them overcome the challenge of “los[ing] sight of why we are spending so much time and energy on a seemingly unattainable goal” since several students experience a lack of connection with the real world in introductory courses such as calculus I, calculus II, and introduction to physics. The students appear to be able to make a connection with the liberal arts more easily than engineering sometimes since the liberal arts courses they have taken by this point in their curriculum have more notable effects in their daily lives. If the student is taking the recommended path for the university liberal arts core requirements, they would have taken their writing and literature requirements by their second year. We believe that after taking these courses, they likely saw an improvement in their writing and literature analysis skills, which arguably have more daily use than their calculus or physics skills which might not appear to have as much use in daily life.

Reflection. The next idea that was covered was reflection. The individuals that chose to share about this idea had fairly similar comments. Reflection gave people time to think about “how am I positively contributing to society and how can I use engineering to positively contribute to society (Skipping Orange).” An example of the most notable projects being a wind turbine project that was given as an assignment in a reflection session and again during a class. In the first case, students were asked to determine which areas on a plot would be the most ethical to place an anchor to not disturb the community, and then the second time, students were asked to calculate where it would be possible to place the anchors. There were also general contributions concerning reflecting on contribution to society, empathy, and designing for oneself versus all. Whimsical Watermelon found that reflection was particularly helpful because “taking that time to unwind and to reflect is incredibly beneficial. It allows you to appreciate the positive experiences and learn from the negative.”

Creativity. The idea of creativity was one that students believed that engineering did not have enough of. Gassy Grapefruit said, “Sophomore year, there aren’t any offered engineering courses that allow students to be creative...try to set time aside on weekends...to paint or draw. I also have been able to sign up for a few Hatchery (BC’s makerspace) training sessions.” Another perspective that was offered was the relationship between CAD and previous art activities. Foraging Fox said that “CAD gives me a way to draw and create in three dimensions, and allow my ideas to become reality... CAD is how I want to try and solve problems as a human centered engineer.” Of the students that chose to discuss course content, they thought that the liberal arts were refreshing and “sparked creativity” that engineering courses sometimes could not because they were too rigid (Silly Strawberry). Notably, the students that

chose to refer to creativity as an idea did not have any suggestions about how to increase creativity in engineering. Though more creativity was added into the curriculum in their second semester through Engineering Foundations V, where students had a semester-long engineering analysis project in a topic of their interest.

Empathy. Most students thought that empathy was not something that most engineers would consider as important during the design process. Pondering Watermelon suggests that this is due to how people cannot live the same lives as others, so it is hard to imagine what they are going through, and thus how to design for them. Another example is when a student was having a bad day, a professor brought chocolate which “reminded [her] how much of a difference empathy and compassion can make on someone’s day (Foraging Fox). Another idea that was mentioned was the idea of “do no harm,” meaning that the best course of action is one that does not hurt others, even if it means doing nothing or a minor change. Many of the ideas mentioned in this section are ideas that students learned about in their introductory design courses. Another student also mentioned how the idea of empathy can also connect to the Jesuit tradition of educating the whole person. Specifically, they talked about the practice of “examenitos,” or short contemplative reflections about their day, that allowed them to “practice mindfulness, gratitude, and reimagine our own experiences and conditions... all of which create a more holistic brand of engineering (Mystical Mango).”

Humanity. The idea of humanity is highly related to the idea of empathy. Grappling Grade and Alarmed Guava thought that most engineering curriculum does not have enough emphasis on the actual types of problems that they will encounter. As Grappling Grape said, “When given a problem set for physics, mathematics, or other STEM heavy courses, the problem is often given with little to no context. Solve for x, find the force, not what is the society impact of the problem...” Silly Grape thought that there is also a lot to be learned from liberal arts classes such as overcoming biases that might get in the way of our understanding of other people.

Balance. Balance is a theme that students seem to appreciate. Aqueous Solution said that “being able to take perspectives is an invaluable experience...The way I try to see it, being a “good” engineer, a “good” athlete, and a “good” human being are not mutually exclusive...larger idea of what it means to live a “good life.” The idea of balance is also appreciated because in the eyes of some of the students, the liberal arts and engineering use different types of thinking. The kind that is used in the liberal arts has more to do with creative thinking, like what the best way to express an idea for a paper is, while most pure sciences expect a problem-solving approach that has more to do with finding a singular correct solution. However, engineering appears to be in the middle. Meditating Mouse said, “In my Intro to Human-Centered Engineering class, we were tasked with developing a prototype to address issues students at the Campus School experience with their biweekly coffee shop... foreign and new experience for me. But as my group and I came up with ideas...I was surprised how similar the process felt with coming up with [a] theses for a paper.” There were also examples of when the thinking was combined, such as in a writing course where a student was allowed to pick a topic of their choice, which in some cases, was something that students thought was more valuable.

Contributions to the Engineering to the Liberal Arts

After students filled in a word cloud about what the liberal arts brings to engineering, they filled out a word cloud for what engineering brings to the liberal arts. In this case the most prominent words on the word cloud were critical thinking, problem solving, truth, technology, and cooperation.

Critical Thinking. The idea of critical thinking was one that students thought engineering brought to the liberal arts. As mentioned earlier, students seem to think that the type of critical thinking used in the liberal arts and engineering are different from each other since “the process for, say, integration differs greatly from the process for the Socratic method,” but in the end stem from the same idea (Mystical Mango). The different methods can also help with each other. Riffing Cuttlefish said, “The critical thinking and general analysis skills that I have learned in my engineering classes have allowed me to approach these works through an unbiased lens...deconstructing them like I would deconstruct an engineering problem has allowed me to find my own individual truths from within the works.” This is an interesting reflection since it implies that engineering can help approach philosophical texts with an unbiased lens, which most would argue is improbable since all human perspective has some bias based on several factors including prior experience. Though perhaps the connection that Riffing Cuttlefish is making is a more fundamental one where unlike subjects like philosophy, in engineering there are certain laws and theories that all engineers take as a given when working on a problem (e.g. laws of thermodynamics). However, the use of the word *truth* (even though as “individual truths”) as opposed to *perspective* is still interesting and needs to be unpacked further.

Problem Solving. Another idea that students related as an idea that engineering brought to the liberal arts was problem solving. Charming Cantaloupe says, “If I see something that needs to be solved I do everything I can do to solve it., I don’t just accept what we are doing now but what we could possibly be doing to better solve the problems of the world.” Other students also suggest that the first solution is not necessarily the best solution and that a good solution involves working with many different kinds of people. Rebellious Lettuce says, “Take a sidewalk for example ...Liberal arts .. very cool...but no regard for physics of reality...if you ask a mechanical engineer to design you will most likely get a super efficient design, so long as everyone is okay with walking in a line at the pace of 556 mph.” Their views on liberal arts and engineering appear to be severe generalizations of their opinion of how engineers and people in the liberal arts would view the issue of creating a sidewalk. They later also suggest that “...either [sic] side won’t acknowledge [for a successful project].” This idea is concerning because the whole idea about what engineering brings to the liberal arts, while they suggest that they do not mix well. The general idea that Rebellious Lettuce suggests goes along with what Fluffy Fox said, “Engineering brings some structure, guidance, and clarity to the world of the search for truth.” This “..search for truth” that Fluffy Fox suggests is an interesting view about engineering. More often than not, there is a search for practical solutions based on scientific principles as opposed to looking for a “truth.”

Truth. The idea of truth was not as popular as the themes above. Aqueous solution talked about the idea of truth in understanding the world. “Engineering has given me the perspective that the real world is quantifiable. To a large extent, it [real world] can be represented and understood with the help of math and science... If the liberal arts are a tool for us to engage with the problems facing the world, then engineering is the means by which we can hope to work with others to find solutions to these problems.” The first point that Aqueous solution brings up about how engineering makes the world quantifiable is

something to note given that most examples in engineering at the introductory level assume ideal conditions, which are not accurate to real world conditions.

Technology. The idea of technology was an idea that students associated with something that engineering brings to the liberal arts. Most of the ideas that were mentioned in this section had to do with applications of technology in learning. For example, Sitting Plum talked about a time where they used a program called DALL-E 2, a text-to image generator for a class to illustrate James Joyce's *Ulysses* for a literature elective. Jammin Banana talked about how technology surrounds us and the way that we learn. “Besides instruments for note taking, things, such as the desks, you’re sitting at or the chair you’re sitting in have been engineered to be useful yet comfortable.” These ideas are related to topics that students have learned in class as students have learned about neural networks in machine learning and about how items are made.

Cooperation. The idea of cooperation was an idea that students associated with something that engineering brings to the liberal arts. Jammin Banana stated, “ in the Human Centered Engineering program cooperation is emphasized heavily, and we are put in situations where cooperation is necessary so early. I could see a difference in ability/willingness to work cooperatively between myself and my partners for my Chemistry project. This led to me stepping up and helping to lead the lab period while making sure that my lab partners could contribute when they had an idea.” This idea of cooperation was contradictory to what Crazy Tomato would have thought. They stated, “I feel like a lot of students in STEM come from their high school with very different expectations...The competition extended to the various group assignments assigned...it cost someone else their grade...” Cooperation is also useful because in the future, as engineers, students will have to work with others to come up with the most humanistic solution (Rebellious Lettuce).

Discussion

As a whole, students generally found that engineering and the conception of the liberal arts complement each other. They are able to see the connections between the two and integrate skills that they learn from one area into another. Notably, several areas that the students commented on as a contribution of the liberal arts to engineering, are ideas that the human-centered engineering program seeks to inculcate into the students’ engineering experience, for example the ideas of perspective and reflection. *Perspectives* is a class that sophomore engineering students can take to fulfill the Philosophy and Theology requirements; and weekly reflection is part of the engineering program and also several of the liberal arts core courses offered by the university.

In terms of engineering, a notable theme that was brought up was that of cooperation. Cooperation is usually not an idea that most students thought they would associate with pursuing engineering in college. There was a general consensus about the idea that college was going to be cutthroat, but upon arriving at the program, students found that the experience was much more collaborative than anticipated.

A significant trend in the data was that students generally associated liberal arts and engineering with courses as opposed to ideas. This largely could be due to the fact that no definitions were given to define them. Though, students did consider courses like calculus I, calculus II, and introduction to physics as engineering courses, even though introduction math and sciences are still considered to be part of a

traditional liberal arts education. This could be due to the fact that those classes were required for the major and were classes that the cohort took together in the same sections that were primarily engineers.

A large portion of the students when thinking of the connection between the liberal arts and engineering referenced examples of connections between humanities or “non-technical” courses and engineering courses. When it came to referencing how skills were applied there were many instances of liberal arts being associated with courses like “humanities and literature.” This could be attributed to the fact that the recommended course sequence for the university requirements suggests that students should take writing and literature first and thus are the only courses they would compare and contrast their experiences in engineering with. The large numbers of people who made connections between the humanities and technical courses could be due to the fact that the example they were given suggested that art, a humanities course, could help them in an engineering class by helping develop creativity or how your knowledge of CAD/machine learning impacts how you make sense of your philosophy/technology courses.

The idea of having students think across disciplines has been a topic of reflection seminars during the students’ first year, but since it was an engineering reflection, most students most likely thought that the connections of how subjects are interdisciplinary should be made between engineering classes and non engineering classes. Another possibility for why there is a lack of connections made between more non engineering classes is that students have not taken enough non engineering courses for them to make connections. At the time of answering the two main questions that the paper is about, some students would only have had about four courses that were not part of the engineering major requirements.

There were also some ideas such as critical thinking and creativity, which are skills that could be associated with both engineering and the liberal arts. Whether students thought of these ideas as liberal arts or engineering or both could have been influenced by prior experiences with a subject in school or previous conceptions. Similarly, the idea of empathy was notable. Interestingly, it was categorized as an idea that the liberal arts brought to engineering, but several of the main ideas related to empathy that individuals referenced were from an engineering course, Introduction to Design Thinking.

Conclusion

In this paper we share narratives to understand students’ experiences of liberal engineering education. The experiences shared are limited to those from students enrolled in the same program and within the same cohort. Yet, in addition to the recognition by the students that both the liberal arts and engineering stand to gain from one another, it is interesting to note which aspects students think are related to the liberal arts and which to engineering. There appears to be some blurring of boundaries between the two which in the long term might lead to redefining what counts as knowledge and skills in both. Also, this work provides a novel perspective from individuals who might not have necessarily experienced traditional conceptions and practices of engineering, which are often artificially separated from societal contexts and responsibility.

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