Community-Centric Engineering Curriculum

Engineering Studies Fall 2018 Capstone

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Introduction

Nationally recognized think tanks and academic institutions argue that Western engineering culture has increasingly created a gap between the professional and societal expectations and educational training of engineers (Prados, 1998). Over the past sixty years in American history, the gap between engineers and the communities of people they design for has become increasingly ingrained in our societal norms. After all, understanding the people of the community helps to better “engineer” the community space. As this gap interacts with the specialization of engineering work, engineering design efforts decreasingly align with community wants and needs, as a lack of communication, perspective sharing, and collaboration prevails (Wisnioski, 2012). A series of university programs in the past 20 years have begun to combat these societal norms and disconnects via community-centric engineering training, and our team believes that an additional community-centric engineering course at Lafayette College would be beneficial to the College.

This project focuses on Lafayette College’s engineering department and the implementation of community-centric education within Lafayette’s borders. Community-centric education entails a curriculum which initially teaches engineering students how the cultural emphasis on technical skills came about, why it creates problems in effectiveness and sustainability of engineering design, and how students can use non-technical skills to break from cultural norms and increase the quality of their work. A community-centric course will increase students’ ability to recognize the gap between engineers and society and will help them act as social agents in engineering once they enter the workforce. Additionally, the prominent lack of satisfaction amongst engineering professionals leads this project to focus on the development of a community-centric engineering education course as an effort to redirect Lafayette's Engineering division. Lafayette's engineering department prides itself on the fact that it "not only provides an outstanding technical education, but also prepares students with the ability to think creatively, imagine broadly, communicate effectively and influence change" ("Engineering…, 2017). This curriculum will focus on the understanding, learning, and implementation techniques of community-centric design, in order to increase the explicit community-centric knowledge of Lafayette's graduating engineers.

We address Lafayette engineering's weaknesses by pushing and requiring students to involve the community in their design thinking. A history of engineering culture which emphasizes technical over non-technical skills leaves our team with the opportunity to halt this path within Lafayette's borders, as an increasing number of other engineering programs have started to shift since the 1980s (Prados, 1998). Given this problem, our team used literature review and outreach in the Lafayette engineering community to design a 200-level engineering course that can better prepare Lafayette students for the non-technical components of engineering professions. This course's curriculum aims to show Lafayette students the importance, relevance, and value of this skill set while actively integrating it into their problem-solving strategies.

In creating a thoroughly analytical and concretely focused project, our team focused on three research questions to guide us:

a) What is the most effective way of integrating community-centric education in Lafayette's existing engineering program?

b) In a new engineering community-centric curriculum, how can we define success in a way that elicits support from Lafayette's engineering students and professors?
    i) What are the core takeaways and objectives of this course?
c) In what ways can the integration of a community-centric curriculum change the engineering culture at Lafayette?
    i) How will this community-centric mindset be received and adopted by stakeholders in Lafayette's engineering community, in terms of this class and in future curriculum creation and adaptations?

Through research and community outreach, our team evaluated the many different approaches of solutions to this cultural and educational problem. Our cumulative research led us to design the most effective form of a community-centric course, in the form of a 200-level course. This course will be primarily geared towards Engineering Studies students, but will ideally be open to all engineering students as an engineering elective. The Engineering Studies division aims to "[bring] together the four divisions of campus—engineering, humanities, science, social sciences, for a truly liberal arts education," and therefore is an additionally relevant major for our project ("Program…", 2018). If our curriculum is utilized first in this division, it will gain traction and will be more feasible to adopt by other Lafayette engineering majors in the future. This course will be literature and seminar based, as to sufficiently educate students in sustainable community development and engineering ethics. These students' solid background in these non-technical skills before they participate in their capstone courses will allow them to experientially utilize these developed skills. As our team has determined the general characteristics of this course, future Engineering Studies capstones could potentially expand on this research by furthering course specifics. Future students could also potentially broaden our curriculum idea to incorporating community-centric curriculum in higher level or capstone level courses.

Potential challenges to the successful creation and implementation of this curriculum include faculty support regarding the Accreditation Board for Engineering and Technology (ABET) accreditation of this course. Logistical questions regarding department participants and level of requirement (for which majors would this course be required for, if any?) still exist. Additional uncertainties include syllabus specifics and professor availability. The challenge of "preparing engineers to become facilitators of sustainable development, appropriate technology, and social and economic change" fuels our project, and "meeting that challenge may provide a unique opportunity for renewing the leadership of the US engineering profession as it enters the 21st century" (Amadei, 2010, 84). Our team aimed to overcome these challenges by looking at other schools and what types of sustainable community development courses they have. In addition, outreach with engineering professors regarding accreditation challenges and existing their perspectives guided our course development.

As our project developed, we unwrapped the current and potential relationship between engineering education and community. We considered the social, political, economic and technical contexts of the project. Our social context serves as a thorough literature review on engineering sustainable community development and related engineering practices through historical and cultural perspectives. Our social component also analyses economic benefits to add support as to why this course should be integrated into Lafayette's curriculum. Our political context aims to identify stakeholders, relevant policies, and relevant processes on both national and local scales. We identified key educational policies and codes and their impact on the development of curriculum in the Lafayette Engineering division. Our curriculum design component includes a review of similar curricula at other engineering schools, empirical evidence of stakeholder perspectives on Lafayette's campus, a review of ethical practices in engineering, a potential syllabus, and proposed learning outcomes of this course. The research and outreach involved in each of these contexts helped our team in determining the feasibilities and necessary components of our proposed course and acknowledging that this type of education should be implemented on Lafayette's campus.

Social Context

Our project reviews the history of engineering education and engineering education reform in order to understand the systematic principles and changes throughout time that affect how engineers and engineering education works today. We analyse the history of engineering on both a national level and specifically at Lafayette. Our research then focused on a contemporary scope of engineering: a look into engineering culture. In this report, we describe engineering culture as the dynamic between community-centered work and engineers. We analysed engineering culture in both a national scope and Lafayette-specific scope, and concluded that Lafayette, albeit a liberal arts institution, represents a microcosm of overarching national norms. Lastly, this context explains why our team believes that the implementation of a 200-level community-centric engineering course at Lafayette College will lead to both inwardly-focusing and outwardly-focusing economic benefits to future engineers and the communities they design for and with. A well established, community-centric, non-technical skill set will increase students' professional marketability, helpfulness to community, efficiency, and social impact.

Historical Scope

National History

The Cold War marked a turning point for engineering in the Western world, and more specifically, a turning point in engineering reform in the United States. Before the 1960's, engineers were active members of the community, helping solve societal problems. However, at the peak of the Cold War, engineers lost the trust of society and the American public. Engineers became the key component of government projects, leaving behind their old identity as community members. Society emphasized the need for engineers and "by 1960, engineering was the most common occupation for white-collar males in the United States" (Wisnioski, 2016, 23). The speed in which technology progressed and the increase in demand for engineers made the humanistic and non-technical aspects of engineering fall behind a heightened priority for technological advancements. The workforce and educational focuses in the 1960s illustrated this switch; at this time, the Cold War influenced many schools' curricula. Many programs offered classes that revolved around weaponry and industrial military production. Classes that involved technology and engineering practices that impacted the common person in society did not exist (Wisnioski, 2016, 24).

In the 1960's, engineering education focused on the technical outcomes and neglected the importance of the socio-technical aspects of engineering. This lead to a disconnect between engineers and society because engineers had a lack of understanding of their larger social and cultural impact on society. This lack of trust in the engineering profession led many intellectuals to challenge the approach of engineering education. Many of these philosophers aimed to take control of the technologies that were developing without consideration of impacted communities by taking away the autonomy of technology. This was done by investing in a more collaborative and holistic engineering education after the Cold War. Both professional and educational reforms reflect the notion that "during the 1980s, engineering as a discipline began to recognize the importance of sustainable and community-driven practices" (Vanderburg, 1991; Gilbert et. al, 2015, 257). Specifically, UCLA, Caltech, Harvey Mudd, and MIT aimed to make engineering more holistically minded and to train well-rounded engineers (Wisnioski, 2016, 170-179). This educational reform continued into the 1990s with a "surge in interest and action related to sustainable community development in engineering"(Lucena, Schneider, & Leydens, 2010; Gilbert et. al, 2015, 257). This report will discuss how this reform continues nationally, and within Lafayette's borders.

Lafayette History

Lafayette's engineering department's mindset aligned chronologically with engineering education reforms occurring throughout the country. For instance, a 1969 editorial in *The Lafayette*, "Priorities," detailed some of the changes that the Lafayette community wanted to see. The authors, representatives of the student body, found that the College continued to "exhibit many of the disadvantages and few of the advantages of a small college" (Wilmer & Rehrig, 1969, 6). The editorial outlined a list of priorities that the College needed to change in order to become a more competitive institution. The second priority stated that the entirety of the engineering department and curriculum needed to be re-evaluated because Lafayette could not compete with larger universities which had excelling engineering programs (Wilmer & Rehrig, 1969, 6). This request fits into a historical chronology, as this aligns with a time when professional engineers demanded high quality training for engineers for militaristic, Cold War related jobs. Furthermore, the list requested a change to both the Bachelor of Arts (A.B.) and Bachelor of Science (B.S.) curricula so the requirements were more integrated and liberalized. Another component of the editorial requested an exploration of more interdisciplinary subjects (Wilmer & Rehrig, 1969, 6). Per these requests, in 1970, the Lafayette community saw the emergence of a new interdisciplinary degree, an A.B. in engineering, which is now known as Engineering Studies.

The offical push to reform the A.B. degree from the administration started in 1975 with the proposal to educate and train more interdisciplinary graduates. This curriculum change required students to meet certain outcomes from an array of courses (similar to what Lafayette's curriculum models today with social science, values, global multiculturalism, and more "outcomes"). This proposal largely pushed students pursuing A.B. degrees to strongly grasp quantitative reasoning as well as scientific inquiry. The debates surrounding this new curriculum continued through 1982, when the Lafayette community started to see a tangible emergence of interdisciplinary degrees (Cunningham, 1982, 2). These changes in curriculum made the College's focus more centered on interdisciplinary and liberal learning. Through this, degrees such as the A.B. in engineering strengthened and bridged the gap between the engineering department and a more liberal arts based curriculum.

One commentary in the 1980s stood out as specifically lucrative in uncovering Lafayette's historical outlook in engineering. One student writer for *The Lafayette* complained that Lafayette had "become a place to be trained rather than a place to be educated. Engineers [were] being taught what to think, not how to think" (Cunningham, 1981, 6). This statement represented the student body's disappointment, as this sentiment quickly led to another period of reform at Lafayette. Lafayette soon became much more liberalized with the engineering degree due to a large reform in the late 1980s (D. Veshosky, personal communication, November 10, 2018). Eventually, the program would require students to complete competencies that qualified for more liberal learning, showing the school's receptiveness to the changing era.

While Lafayette experienced reform in the 1980's, this reform does not exclude Lafayette from the overpowering engineering culture that exists today. Our project challenges Lafayette to see that once again we need a change in curriculum. Our B.S. engineers are being taught the how's of engineering instead of the why's. Asking "how" typically results in a methodological solution, rather than a solution that conveys understanding. We, as a community, need to challenge our engineers to ask "why" instead of "how" in order to result in a better understanding of the reasoning behind concepts, as well as an increased awareness of methodology. Our research guides our team in believing that the most important part of our Engineering Studies degree is our ability to understand the why's in engineering. Lafayette has contributed to this type of reform within the Engineering Studies department. The true investment into Engineering Studies began in the mid 1990's when the major began to develop more courses regarding engineering economics and engineering and public policy. This investment in a liberal engineering curriculum was directly observed around 2007 when

Engineering Studies became its own department, separate from the B.S. degrees (D. Veshosky, personal communication, November 10, 2018) . Lafayette continued to invest in the department as its faculty grew five-fold in 2011 (B. Cohen, personal communication, November 8, 2018). We find ourselves in a new age of engineering reform, and Lafayette will need to continue to adapt and change like other universities in order to stay competitive as an engineering department (Wisnioski, 2016, 128-158).

Cultural Scope

The relationship between technology and culture helps us understand the perspective of engineers in academia, in the professional world, and how these engineers interact with the technologies they create. Addressing how professionals in the engineering world view and address sustainable community development (SCD) and community engaged education will help to define how our proposed curriculum can infiltrate this long standing mindset. We look at this culture on a national scale and at Lafayette College specifically.

National Culture

The historical push for mastery of technical skills in engineering is perpetuated by the established lack of willingness to learn technical skills from the non-engineer's perspective, as well as a lack of educational push for non-engineers to fill this gap (Phase, 2005). As discussed later in our report, our curriculum aims to break down this barrier so that eventually, engineers and non-engineers alike will redefine the engineer as a social agent, an intellectual, and a technological representative. Although those within the engineering community would ideally adopt this shifted mindset willingly, doubts arise surrounding this adoption because "either public or private engineering schools can find additional funds to implement new educational paradigm" (Prados, 1998, 7). This notion perpetuates the technical emphasis in engineering culture, and opens an avenue for our project to halt this perpetuation, via successful implementation of this curriculum on Lafayette's campus.

In contemporary engineering culture, there exists a common sentiment of disconnect between engineers in industry and their community. On one side, this barrier between the design process of the physical technology and its usage leaves consumers and community members on the receiving end of this technology unaware of who engineered their product and how the technological systems work, beyond the surface level (Phase, 2005). In this current mindset, technologists view their work in solely a technical context, rather than as a part of an outreaching, social, economic, and political technological system. A book about the potential for engineering education in 2020 notes that "the public is unclear about what most engineers do and secondary students (and their parents and advisors) have poorly formed ideas about what an engineering education offers and how they can serve society through engineering practice" (Phase, 2005, 4). Engineers have disassociated from their old roles as "social agents" and the public views them more to technical creators due to their lack of interaction (Gilbert, Held, Ellzey, Bailey, & Young, 2015). This shows that engineering culture pushes technology and culture apart, from both the perspective of the engineer, and the non-engineer.

While contemporary engineering culture emphasizes and exhibits successful technological productivity, this solely technical push creates setbacks in overall efficiency and productivity as well. On top of the general sense of disconnect, this lack of efficiency manifests in multiple ways: engineering project outcomes, professional engineering settings, and engineering education. In terms of project outcomes, a typical setback of the separation of engineers and the communities they work for is simply that they work for, and not with, these communities (Lucena et. al, 2010). One study found that "often the language used by engineers reinforces the inherent power differential between the developers themselves and communities being served," therefore illustrating a manifestation of the barrier discussed above (Gilbert et. al, 2015, 5). Because "community participation in development projects is an element that is largely lacking in the engineering educational arena," once graduated engineers enter the workforce, they lack explicit training in community engagement skills, and rely predominantly on just their technical backgrounds (Gilbert et. al, 2015, 4). The technical skills that engineers have could gain legitimacy, efficiency, and influence if they were incorporated with the skills needed for proper community evaluation, communication, and an ultimate ability to listen and work alongside a community (Gilbert et. al, 2015).

Contemporary engineering culture aligns with Western capitalistic outlooks in that "small-scale technology has never been attractive to the engineering profession, despite the need for it at the international level. Appropriate technology has been mostly promoted by NGOs and non-engineers" (Amadei, 2010, 86). This lack of excitement and emphasis on community engagement as an attractive and necessary component of the 21st century engineer's job, leads to an ultimate lack of "endorse[ment] by the mainstream engineering profession and is rarely integrated in engineering education" (Amadei, 2010, 86). In order to change this trend, engineering education needs to shift in educating a new wave of socially aware, willing, enthusiastic, and adequately trained engineers, ready to work alongside the communities in which they design for (Amadei, 2010).

One of the specific disconnects in engineering education manifests in the longevity and follow through in community-based products. While Sustainable Community Development (SCD) projects exist, the traditional Engineering Problem Solving (EPS) educational strategy does not emphasize the non-technical skill set necessary to successfully implement SCD projects all the time (Lucena et. al, 2010). Nieusma and Riley (2010) evaluate the effectiveness, or lack thereof, of engineers in sustainable community engagement while considering the current state of engineering culture. They conclude that traditional engineering culture and education leads to an emphasis on "product over process" (p. 36). By valuing product over the process, the community's needs and existing capabilities often falls back to the engineer's technical, solution based, focus (Lucena et. al, 2010).

The book, *Engineering and Sustainable Community Development (ESCD)* presents several case studies that demonstrate the failures of community development projects due to this lack of focus on process. An example of this describes an engineering firm that was funded to implement a water supply and sanitation system, in an underdeveloped village. The engineers implemented the sanitation system and left under the impression that they made a lasting impact on the sanitation of the community through their design. However, five years after the engineers implemented the systems, only 30% of sanitation units were still in operation. Furthermore, only 12% of these units were still in operation after fifteen years. Even though these engineers believed they made a positive impact on the community, when looking long term, these engineers did not consider the need for the maintenance of the system. Their inefficiencies in working alongside the community neglected the long term sustainable solutions that this community needed (Lucena et. al, 2010).

This short case study reveals how the engineers overlooked community needs. The engineers in this case took a generalized approach to water sanitation solutions and immediately expected their designs to work for a specific community (Lucena et. al, 2010). There are many case studies within *ESCD* that highlight this disconnect between engineers and end-product users. Through these examples of engineering failures, *ESCD* illustrates the cultural gap in engineers' ability to understand community wants and needs.

In addition to the negative reflection of engineering culture in SCD, a cohort of literature focuses on the wants and needs of engineering professionals from graduating engineering students. The Accreditation Board for Engineering and Technology (ABET) guides engineering curriculum in providing both technical and non-technical requirements for all ABET accredited schools, however, Western engineering culture has lead to a far more thorough emphasis on the development of a technical skill set (Shuman, Besterfield‐Sacre, & McGourty, 2005). The early 1990's discussions surrounding the training of engineers in undergraduate education were prevalent. These conversations noted that, in order to be fully prepared for the professional engineering world, students would need "professional skills, including the ability to work in a team environment, communicate effectively, work with customers, and manage projects; awareness of the many issues affecting any engineering project, including ethical, legal, and environmental issues; and the ability to work with people from many different backgrounds and in many social settings" (Coyle, 2006, 1). A community-centric education in engineering addresses all of these current disregarded and undervalued skill sets. Community-centric education decreases the gap between engineers and their technologies, and society, therefore breaking from "traditional engineering labor pattern(s)" (Wisnioski, 2012, 27).

Nationally, the "traditional engineering method" of education utilized by professors no longer adequately "create[s] global citizen engineers who have the skills to address complex geopolitical and economic problems" and the "complex problems of our society," therefore creating a gap for the curriculum (Amadei, 2010, 86). While professional engineering dynamics and project outcomes encompass a large portion of the post Cold War changes in engineering culture, this historical shift "also produced a major shift in engineering faculty culture away from its traditional roots in professional practice toward academic science perspective" (Prados, 1998). We aim to break from this trajectory by teaching students that a shift exists and how to mitigate the effects.

Lafayette Culture

Our team investigated the specific expressions of Western engineering culture through outreach directed towards Lafayette faculty and students in the Engineering division. This outreach included both surveys for engineering students and professors at Lafayette, respectively. These surveys gauged the level of importance that faculty and students allocate to the development of non-technical skills in the context of engineering classes. As predicted by our literature based research and experiences, survey results indicated that students care about their community, however, they feel as if they have not yet made a community-based impact through their engineering classes. Empirical survey results from students and professors are located in this report's technical context.

Aside from survey results are additional observational reports from a mechanical engineering community engaged senior design course, also found in our technical context. These observations uncovered a lack of knowledge amongst students regarding procedural norms when conducting research and outreach in the community. In addition to survey results and classroom observational reports, Lafayette's engineering culture is reflected in a seemingly small but telling colloquialism, the "pretendgineer." This term is used to describe Engineering Studies majors, and alludes to the lack of respect that contemporary engineering culture gives to non-technical engineering skills, specifically at Lafayette.

Economic Scope

Engineers tend to design in regards to a solely technical context. Although traditional engineering understanding does not explicitly state this knowledge, industrial metrics, in particular, have motivated engineering education and practice for over a century. The economic conditions that design work affects are inherently tied to broader political structures. Additional economic conditions relate most closely to effects within communities and have the potential to positively influence local economies.

Economic benefits to community-centric design exist in both a community-based, outwardly-focused context and a professional, inwardly-focused one. We outlined these benefits to clarify the legitimacy and value of our proposed course. The economic benefits appear in the work that graduated engineers pursue in the future, including marketability, efficiency within the workforce, and longevity of engineering design impact. The potential increase in efficiencies of engineering graduates with a knowledge of community-centric and non-technical skill sets justify the necessity of incorporating our proposed course into Lafayette College's offered curriculum, and its benefits.

Community Impacts

The primary outwardly-focusing economic impact of a community-centric course includes an ultimate betterment of SCD projects for the community at hand. While SCD projects are inherently designed to positively impact the lives of community members, the current use of Engineering Problem Solving methods in SCD projects inhibits engineers' ability to make sustainable impacts (Lucena et. al. 2010). The economic benefit of a community-centric skill set would divert engineers from using traditional, inefficient, solution-oriented, engineering problem solving tactics and therefore increase potential in efficiency and effectiveness for community impacts.

Engineers invest both time and money while working in SCD projects. As our brief case study review shows, these efforts can lead to a lack of product acceptance amongst the community or end with a disconnect between communities and the final design product. In community outreach, the community's "adoption of the [technology] [could] mean changing their lifestyle, habits, values, and interests" (Lucena et. al, 2010, 98). Teaching engineers how to recognize and work with existing cultural, economic, and infrastructure-based barriers, they can increase their impact and reduce their potential to harm communities. While monetary investments remain crucial in the success of SCD projects, "the critical resource for enhancing social capital is not money—rather, the critical resources are trust, imagination, the relations between individuals and groups, and time, the literal currency of life. Many of the social issues that people relate to most intimately—family, neighbourhood, community, decompression from work, recreation, culture, etc.—depend on these resources at least as much as money" (Roseland, 2000, 98). Although "good intentions" exist in SCD, a non-technical skill set would make these efforts more worthwhile, for both the engineer and the community (Lucena et. al, 2010).

As traditional technically-focused training tends to ignore community perspectives and is "not neutral with respect to incorporating a diversity of perspectives," community-centric education aims to teach students how to communicate with communities to best understand and work alongside them to fulfill their needs and to adopt their perspectives (Lucena et. al, 2010, 92). As engineering culture evolves, a body of literature regarding the disconnect between engineers and the communities that they design for recognizes that "focusing solely on money to provide security is using 19th century thinking to address 21st century challenges," and that a better holistic understand of community needs results in a better use of project investments (Roseland, 2000, 98). As engineers work, they need to understand the dynamics of the communities at hand so that once they leave, communities remain well equipped to sustain their respective projects. Specific examples include "converting to greater reliance on renewable energy sources; increasing community self-reliance (e.g. food and energy production); and sustainable management of natural resources (e.g. community forestry). [Economic demand management] shifts our economic development emphasis from the traditional concern with increasing growth to instead reducing social dependence on economic growth" (Roseland, 2000, 95). If community needs remain unmet, community members and economies could suffer, however, a community-centric education could decrease the risk of this failure.

While SCD most explicitly entails a combination of engineering design and community outreach, a subset of the economic benefits to the community at hand rest in the concept of "community economic development." This entails " a process by which communities can initiate and generate their own solutions to their common economic problems and thereby build long-term community capacity and foster the integration of economic, social and environmental objectives" (Roseland, 2000, 97). Training Lafayette engineers more holistically will reframe them as not solely design managers, but as social agents, equipped to help communities once engineers physically leave these sites. Longevity of the specific design of the product and the outreaching technological system that each physical technology includes relies on the engineer's ability to understand the economic impacts and ripple effect that their work has on the community at hand.

Professional Engineer Impacts

The second economic consideration is the impact that this type of education would have on the professional engineer and marketability. Changing the way that engineers approach traditional problems by challenging them to understand different perspectives and to think with a more interdisciplinary mindset will lead to producing more holistic engineers in society. Making our engineers better thinkers rather than just better problem solvers will lead them to be able to take on more challenging problems with an array of perspectives.

Andersson (2010) claims that there is a dissatisfaction with the quality of the common engineer in the workforce. Naturally, this requires companies to invest in training for their new college graduate hires. Studies have found that nearly half of employees have said that they need to provide additional training for new engineers that goes beyond the job type experience (Andersson, 2010). This training revolves around non-technical skills that should be taught in undergraduate programs. Training requires a lot of money no matter what the specifics of the training entails, especially for large engineering companies that hire many new engineers every year (Andersson, 2010).

This dissatisfaction is due to a lack of development of quality engineering education that focuses on non-technical skills which correlate to professional skills in the workforce. Primarily, these skills fall under five qualifications including, “communication, interpersonal skills, analytical ability, self-confidence, and willingness to adapt to change” (Dahir, 1998, 2). While Lafayette trains their engineers to have strong communication and analytical abilities, there is still room for improvement. Our course would shed light on developing these non-technical skills within the topics of interdisciplinary thinking and external contexts. This ability to think outside of the technical perspective is a skill that is highly desired within the workforce.

As a more straightforward economic measure, we investigated the top-ranked bachelor’s programs based off of early salaries as well as mid-career salaries. The four schools (Harvey Mudd, Stanford, MIT, and the California Institute of Technology) mentioned in *Engineers for Change* in reference to reforming their engineering curriculum to more interdisciplinary programs are all ranked in the top five of the “The Best Universities For a Bachelor’s Degree” list on *payscale.com*. Additionally, the Colorado School of Mines is ranked eleventh on the list. The high rankings of these programs on this salary report show that investing in bettering engineering via interdisciplinary education pays off in more than just helping communities and the professional skills of engineers. This shows that investing in more holistic engineering education can potentially lead to better jobs for graduates in the industry because they have more fine tuned non-technical skills paired alongside the technical fundamentals. Their graduates are earning more than other schools’ graduates throughout the country. It is important to note that

Lafayette is ranked fifty-eighth on this list. This shows that we can economically benefit our graduates through investing in a more holistic approach to engineering education (Payscale, 2018).

Engineering for a Changing World (Duderstadt, 2010) highlights the engineer's role in society is correlated with the growing impact of technological innovation (Duderstadt, 2010). As this increases, engineering has to adapt to the society's changing expectations. As Duderstadt states, "technological innovation plays an ever more critical role in sustaining the nation's economic prosperity, security, and social well-being, engineering practice will be challenged to shift from traditional problem solving and design skills toward more innovative solutions imbedded in an array of social, environmental, cultural, and ethical issues" (Duderstadt, 2008, 2). Engineers' changing identity from the "traditional engineer" to the "urban engineer" is highly dependent on their understanding of their role within technological innovation. Therefore, "the key to the ability of engineers to develop the products, systems, and services that are essential to national security, public health, and the economic competitiveness of the nation's business and industry is the knowledge base created by engineering research" (Duderstadt, 2008, 28). In order to adapt to this shift, the engineering curriculum must go through a large change.

Our research and ultimate curriculum design aims to help Lafayette in beginning to change its culture around engineering. By identifying the historical shift in engineering culture, triggered by the Cold War, we better understand the root of this disconnect. With an understanding of contemporary engineering culture, we can analyse how this disconnect manifests in present day design flaws. Lastly, by identifying both community-based and professionally-based economic benefits of community centric design, we began to define what necessary components are needed in our course, and why this course will be beneficial to Lafayette. In order to create the best curriculum with the best potential traction and support, we investigated relevant stakeholders. These stakeholders exist both within and outside of Lafayette's borders and provided our team with the necessary input for our curriculum design.

Political Context

The political context of our project plays a significant role in assessing the feasibility and effectiveness of a re-imagined engineering curriculum at Lafayette College. This research mainly focuses on analyzing studies from academic articles, policies, and regulations. It is divided into two overarching scopes: the national perspective and Lafayette's perspective. The national scope focuses on the analysis of literature and case studies from renowned institutions, think tanks, and universities across the United States. Lafayette's scope highlights initiatives and policy within the College's Engineering division. In addition to the literature review, stakeholder analysis holds a considerable amount of weight in re-thinking Lafayette's engineering divison's curriculum and objectives. Survey results from the engineering faculty, found in the technical context of this report, are used as a strong point of insight into the engineering culture. The insight from students, faculty and the administration contribute to the development and definition of the current Lafayette engineer's identity. After all, engineering with people is focused on working together as a community to create lasting change. (Fila, Hess, Hira,Tolbert, and Hynes, 2014).

National Scope

Outside of the Lafayette engineering program, literature from institutions that specialize in engineering education or otherwise defined in this report as, engineering education institutions show a national interest in challenging the "traditional engineering model." Renowned institutions such as: the American Society of Engineering Education (ASEE), the National Academies of Sciences, the American Society of Civil Engineers, the National Science Foundation (NSF) and US National Academy of Engineering (NAE) have contributed to this conversation. *The engineer of 2020 (2004)* called the attention of many academic and professional circles as it defined the "engineer of the century." It emphasized that "in 2020 and beyond, the engineering profession will need to develop solutions that are acceptable to an increasingly diverse population and will need to draw more students from sectors that traditionally have not been well represented in the engineering workforce" (Phase, 2005, 28). Since then, national conversation has devoted efforts to tackle the definition and role of today's engineer in accordance with the needs of society. Although the integration of entrepreneurship and innovation in engineering dominates this conversation, our course proposal on community-centric engineering highlights an equally important theme within the national conversation.

Over a decade ago, the American Society for Engineering Education and the National Science Foundation partnered in a two-part project on shifting engineering culture through research on engineer's perspectives on engineering education and the current state of engineering culture. This initiative resulted in a published report titled, "Innovation with Impact: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education" focuses on answering the who, what, and how of scholarly and systematic educational innovation in phase one and using that framework in phase two to build understanding on the current "state of [engineering] culture" (American Society for Engineering Education, 2012). This report encourages administrators "to merge the long-standing entrepreneurial spirit of engineering faculty to introduce educational innovations into their engineering programs with the confirmed theories and practices on how people learn" (American Society for Engineering Education, 2012). The final report emphasizes the application of research into political and educational systems. It highlights the large gap in United States perspective on engineering stating that, "while the engineering profession has become an important component of the national capacity for innovation, the same cannot be said for engineering education" (American Society for Engineering Education, 2012).

National academic institutions recognized the correlation between economic prosperity and progressive high technology (Kayumova, Savva, Soldatechenko, Sirazetdinov & Akhmetov, 2016**)**. This nationalist perspective has driven the popularity of research and applications of entrepreneurial approaches to engineering education. This change in engineering standards " [is] driven by the emergence of a connected, competitive, and entrepreneurial global economy, in which successful engineers increasingly need technical competency and professional skills that differ from what worked in the past. The stage is set for a Renaissance period for engineering education." (Apelian, 2013, 5)

Student demand for entrepreneurial education has grown with the rise in the reputation of the entrepreneurial process as "the country's future success and global leadership" (Byers, Seelig, Sheppard, & Weilerstein, 2013). Engineering colleges and universities have responded to this demand. Olin College states that their program, "deliberately want[s] to mix the DNA of engineering students and entrepreneurial business students" (Olson, 2013, 4). This call for change is not only beneficial to students, but to the engineering companies that recruit engineering students. For example, Boeing, an aircraft manufacturing company, emphasizes that they employ well-rounded engineers. It highlights desired characteristics such as creativity, teamwork, effective communication, flexibility, critical-thinking skills and curiosity. Although these skills can be achieved through a variety of approaches, entrepreneurial models achieve both educational and American capitalistic standards (Olson, 2013, 14-15).

Despite the growing entrepreneurial approach to reforming engineering education, there are other strategies that equally satisfy the demands of reforming engineering to fulfill the standards of today's engineer. The integration of community-centric values within engineering education not only provides engineers the professional and technical tools necessary in the workforce, but challenges them to understand the contextual purpose and influence of their work on society.

Community-centric engineering education fulfills the aspirations and attributes of engineers as described in the book, *The Engineer of 2020* (2004). The modern engineer is expected to have developed and strengthened skills in analysis, practical ingenuity, communication, leadership, professionalism, high ethical standards, curiosity and flexibility. (National Academic Press, 2004, 53-57) In addressing the aspirations and demands of engineers, the standards of education, as stated by the NAE report, *Innovation with Impact*, must adapt to the rigor of this generation's necessities.

One of the strategies of community-centric learning addresses the modern societal challenge through contextual engineering methods. This strategy is manifested through the US National Academy of Engineering's Grand Challenges. This initiative was developed to perpetuate the idea of the engineer as an influence for a better future. Accounting for the greatest problems of today, a large panel of subject-matter experts worked to identify fourteen grand challenges that satisfy the engineering mind while challenging them to achieve sustainable and community focused solutions. The NAE emphasized the "people part of engineering" in their work (NAE Grand Challenges for Engineering, 2008). Grand challenges breaks down into four themes that are pertinent to the future of humanity: sustainability, health, reducing vulnerability, and joy of living. The committee honed in on "placing the people's and planet's needs before personal fulfillment." The NAE committee reiteratively emphasized that "engineering was about helping people" (Fila, Hess, et al., 2014).

Since the user-centered design objective is strategically similar to that of community-centric design, implementing a more user-oriented design process in engineering courses would achieve the goal, "to deliver highly usable systems that satisfy users experience while reducing the waste and cost of delivery" (Guerra, and Shealy, 2018, 1) This design process has five steps: empathizing, defining, ideating, prototyping, and testing. In the article, this method produced more diverse solutions with a "focus predominantly on user experience in an effort to change behavior and shift demand". (Guerra, and Shealy, 2018, 2-3) Therefore, the design method is one of many strategies aimed at focusing engineering education and projects on the user or community.

In order to get a better understanding of how community-centric development based courses are organized, we researched programs that have incorporated this type of curriculum into their engineering programs. We did this in order to gain a sense of what other institutions such as Harvey Mudd, Olin, Purdue, MIT, Carnegie Mellon and Colorado School of Mines are doing in order to produce more “well-rounded” engineers.

One of the most successful programs that integrates engineers with their community is the Engineering Projects In Community Service (EPICS) program at Purdue University. EPICS aims to bridge the gap between engineering education and community service. The program was designed so that engineering students receive class credit while working on long-term and large scale real world design projects that benefit the community. The program’s goal is to have the community benefit from low-cost technical expertise to address problems that they face. EPICS organizes student teams, each focusing on certain projects in the community surrounding Purdue University. The teams consist of ten to twenty students each ranging from each of the four class years. When seniors graduate, first-year students in the incoming class take their spots on the team. EPICS allows for students to understand context of the community and for the project to develop at a pace beyond the limits of a fifteen week semester. The academic goal of the EPICS program is to develop students’ technical and professional skills that they need to be successful in the professional world. It teaches students to see engineering not just as equations but rather as a way to help mankind. This program allows students to see the importance of the community’s needs by working in partnership with the community to define and solve a problem (Coyle, 2006).

The Colorado School of Mines (CSM) has another effective community-centric engineering program. Juan Lucena, author of *Engineering and Sustainable Community Development* and a professor at the Colorado Schools of Mines is in charge of CSM's Engineering and Community Development minor. This program offers a mix of many social science and engineering courses paired with a student's main major while also offering many courses that teach students about community-centric design. These courses helped guide the construction of the 200-level course that our team designed. Beyond the Engineering and Community Development minor, CSM seeks to prepare all of their graduates to further their understanding of the contexts in which technological and engineering development occur. The goal of the common curriculum at CSM is to help students "develop interdisciplinary perspectives on the ethical, social, and cultural contexts within which engineering takes place" (Colorado School of Mines, 2018). CSM and Purdue are just two schools that have made the step to educate engineers with a more community-centric approach. In order for Lafayette to stay competitive with these types of engineering programs, we must adapt our curriculum to encompass a more holistic approach to engineering.

Shuman argues via ABET accreditation criteria that "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context" as well as "an ability to communicate effectively" (Shuman, 2005). We expand upon the technicalities of ABET in our curriculum proposal context, but it is important to note here that ABET still influences the perception of the course within engineering education and its standards. ABET's professional skills criteria further validates the impact of community-centric engineering education in the development of the Lafayette engineer.

Lafayette Scope

The co-habitation of engineering and liberal arts education at Lafayette is often amplified to prospective students and partner institutions. The Engineering division's site explicitly states that "the programs are grounded in Lafayette's traditional strength in discipline-specific engineering and complemented by the College's excellence in the liberal arts" ("Program...", n.d.). Academic and pedagogical initiatives led by faculty indicate that there is an overall interest in furthering the esteemed motto of Lafayette engineering.

Although each professor has their own definition of community, their research and teaching interest in community work guides their influence on students inside and outside of the classroom. As Prados mentions, "engineering faculty view themselves as mentors dedicated to nurturing and developing students; develop and use advanced educational materials that promote student based learning" (Prados, 1998, 5). Faculty's commitment to students and their research influence their role in identifying the Engineering division's gap in utilizing the liberal arts opportunities available.

Select engineering professors stand out in their initiative to embody in practice the motto of a "well-rounded" education. They lead initiatives such as the Bachelor of Science in Engineering (BSE) proposal and the integration of Community Based Learning and Research (CBLR) initiative in their engineering courses. Professor Lauren Anderson and Professor David

Brandes led the BSE proposal. The B.S. Engineering degree is a response to the "growing demand from many students and faculty for increased opportunities for study in interdisciplinary engineering fields such as bioengineering, environmental engineering, energy, materials, and robotics" ("BSE CEP...," n.d.) Aside from her leadership in this proposal, Professor Anderson shows her commitment to creating supportive communities for female engineers and work-life balance through her mentor role in the Clare Boothe Luce Research Scholars Program. Professor Brandes actively participates in and leads local projects on campus through the school farm, LaFarm, and the bird collisions project, amongst other community-centric initiatives.

The Landis Center for Community Engagement created the CBLR Initiative in efforts to "provide the infrastructure to support academic service-learning and community-based research at the College" ("Community-Based...", 2018, n.p.). This initiative directly responds to the ongoing challenge of developing sustainable and mutually beneficial partnerships between the campus and the surrounding community. In targeting faculty to commit to service learning, CBLR is slowly growing in recognition and impact. Dr. Kney, the director of the Landis Center, shares his aspirations model for this initiative. Kney notes that "[Landis Center leaders] plan on using one time visits as an introduction [to community engagement] in hopes that there is a growing partnership and eventually show students and faculty benefits of working with communities" (A. Kney, personal communication, November 28, 2018). Professor Kney embodies Lafayette's community-centric, liberal arts mindset, and our proposed course aims to further this concrete manifestation of Lafayette's values.

In practice, engineering courses that support CBLR include Engineering 101, select engineering senior design projects, the Engineering Studies capstone, Introduction to

Environmental Engineering and more. Professors Rachel Koh in the Mechanical Engineering department and Benjamin Cohen in the Engineering Studies department are strong advocates for community-centric work. Professor Koh has shown, " commitment and service to diversity on campus to promote awareness and a positive learning environment for all students" through their leadership in the Community-Engaged Mechanical Engineering Senior Design Project class and an ES 101 course that draws connections between current events and engineering ("College Honors…", n.d., n.p.). Professor Cohen's Engineering Studies capstone course directly discusses engineering and Sustainable Community Development using local projects as case-studies and as an exposure to these community engaging work strategies. Other engineering professors are also strong advocates and members of communities near the College.

The Technology Clinic at Lafayette provides students with similar initiatives as those described above. It was founded to solve problems through the work of a multidisciplinary team. Students who are a part of the team engage in real-world challenges and address the needs of the community in focus. The Tech Clinic currently works with the Borough of Weatherly, Pennsylvania to develop a technical system to connect trails as well as a project on improving the communications system at Lafayette. As the Tech Clinic Director, Dr. Lawrence Malinconico has insight into working with clients and supporting students throughout their design and implementation process ("About...," n.d.).

Two additional faculty initiatives on campus that play an influential role in the development and realization of our engineering course on campus are the Meta Mindset and the Center for the Integration of Teaching, Learning, and Scholarship (CITLS). Faculty aim to foster creative and bold entrepreneurial design thinking for their students through The Meta

Mindset. This initiative is supported by the Kern Entrepreneurial Engineering Network (KEEN), the entrepreneurial program at Lafayette. KEEN develops the Entrepreneurial-Minded Learning as a method to prepare Lafayette students for the demands of contemporary society. Therefore, the "Meta Mindset invites faculty to deliberately create opportunities for students to practice this journey, building skills for recognizing opportunities, managing risks, seeking effective collaborators, and understanding the intrinsic and extrinsic value of thinking like an entrepreneur" ("Meta Mindset," n.d., n.p.). As this initiative works towards addressing the demands of the modern engineer, it is important to note its focus on entrepreneurship as a strategy to accomplish this goal.

Through a pedagogical perspective, the Center for the Integration of Teaching, Learning, and Scholarship (CITLS) supports the development of new and experienced professors' pedagogical skills. This center serves as a strong reference in the development of curricula and a large contributor in the potential implementation of a community-centric course proposal ("About...," n.d.).

Since the College's administrative staff and policies are crucial when developing and approving a proposed course, we considered the role they play in the design and prospective future of our course. We discovered that a few key players' goals for the College align with our pursuit of integrating community-centric design within the engineering curriculum. They include but are not limited to: the Board of Trustees, the Provost's Office, the Presidential Cabinet, the director of the Engineering division and the Registrar's Office. The Board of Trustees has the final say on all large decisions pertaining to campus life, including academic programs. The Provost's Office and the Presidential Cabinet have the power to make administrative decisions about the future of academics at Lafayette. Our proposal focuses on a strategic shift in Lafayette's culture similar to the mission of the President's campaign, " Live Connected, Lead Change." The director of the Engineering division, Scott Hummel, is on several course proposal committees and guides the division in the direction he sees for engineering at Lafayette. After speaking with him, he expressed interest in our course proposal and advised us on the process of course approval and his vision of Lafayette's Engineering division. Lastly, the Registrar's office manages the course proposal process and provides information on the development and submission of proposals.

Looking Ahead

Our project challenges the norms of the traditional engineering identity by placing community at the center of engineering education's values. Our political context identifies the stakeholders who are both in agreement with our objectives and who are decision-makers in Lafayette's academic course evaluation and approval process. From studies and reports conducted by engineering education institutions to faculty initiatives, there are many stakeholders with varying perspectives regarding our project. This section emphasizes the role that policies and academic conversation have on the definition of the "urban engineer." Our report's historical scope highlights the leadership of intellectuals in the shift in rethinking the definition of the "engineer of the century". As this report continues to develop the necessary research and analysis to design a thorough community-centric course, the roles of students and professors' voices are crucial in understanding and developing community-focused engineering design. In the curriculum design context, we will analyze students' survey results and observations as direct recipients of the engineering curriculum to gain a better insight into the Lafayette engineering culture and demand for our proposed course.

Curriculum Design Context

The curriculum design context of our project centers around the specifics of our team's proposed course curriculum. Our team designed this curriculum as a culmination of the research and outreach discussed in our social and political analyses. Through our outreach process, we aimed to further understand Lafayette's wants and needs for a community-centric engineering course. This outreach included an engineering student survey, an engineering professor survey, and an observationally-based analysis of a mechanical engineering community engaged senior design course. We reviewed a series of successful community-centric engineering curricula at other institutions to guide the curriculum for Lafayette College such as two relevant minors at the Colorado School of Mines, one of the leading institutions with regards to community-centric design. We also researched the baseline practices of engineering ethics to guide our curriculum. This input, in conjunction with our research, helped us to discover the necessary Lafayette-specific components for our proposed course. Furthermore, the course is guided by the principles of Sustainable Community Development (SCD) and ethical engineering practices.

Stakeholder Outreach

We used student and faculty surveys to gauge the manifestations of engineering culture at Lafayette and to gain a better understanding of how our engineers feel connected with, or disconnected from, the community. We sought to identify the non-technical components our engineering professors and students feel they are teaching or being taught, respectively. The results of each survey are detailed below.

Student Survey Results

Our student survey generated 34 responses, representing all majors within the engineering department. Of the students surveyed, a majority were juniors and seniors, as these students have a better understanding of their undergraduate education at Lafayette. We conducted most of the student survey orally, while the faculty survey was electronically administered to the engineering professors. Figure 1 shows the distribution of respondents for the student survey.

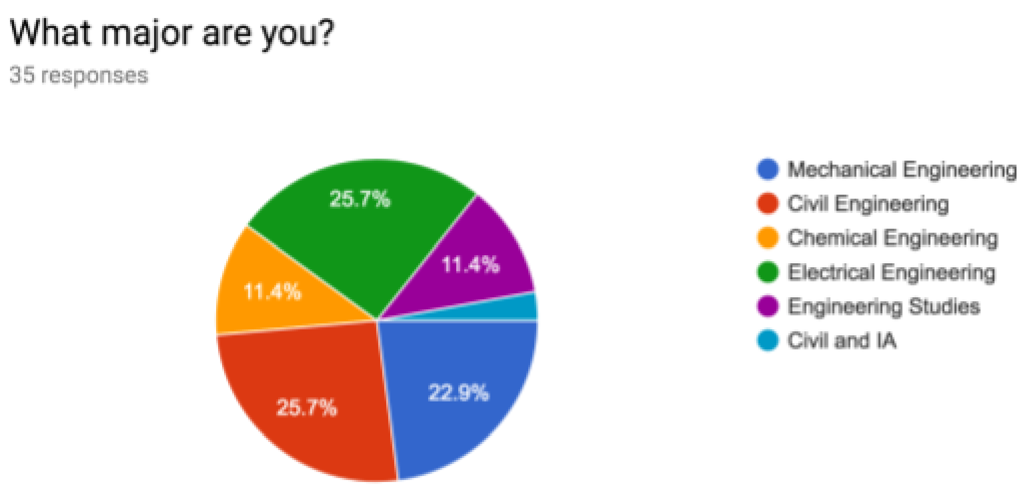

Figure 1. Distribution of majors for student survey. This figure illustrates the percentage of students surveyed within each engineering major.

The first question of the student student survey asked: "do you feel that as an engineer you have an impact on the community?" "Community" was defined as the people that are affected by the respondents' engineering designs. Respondents were asked to rate their current impact as well as their expected professional impact on the community. The respondent was given a scale from one (1) to five (5), where one represented no impact on the community while five represented a strong impact on the community. After providing a numerical answer, we asked the respondent to elaborate on their response to gauge a deeper understanding of "why" and allow them to explain if they felt there was a discrepancy between the current state and future state of their impact. In total, 88.2% of the engineering students surveyed responded with a ranking of three or higher, indicating they feel they will have an impact on the community. More specifically, 58.2% of respondents ranked their impact as a four or a five meaning they perceive they have and will have a strong impact on the community. Figure 2 below shows the specific distribution of responses to this question.

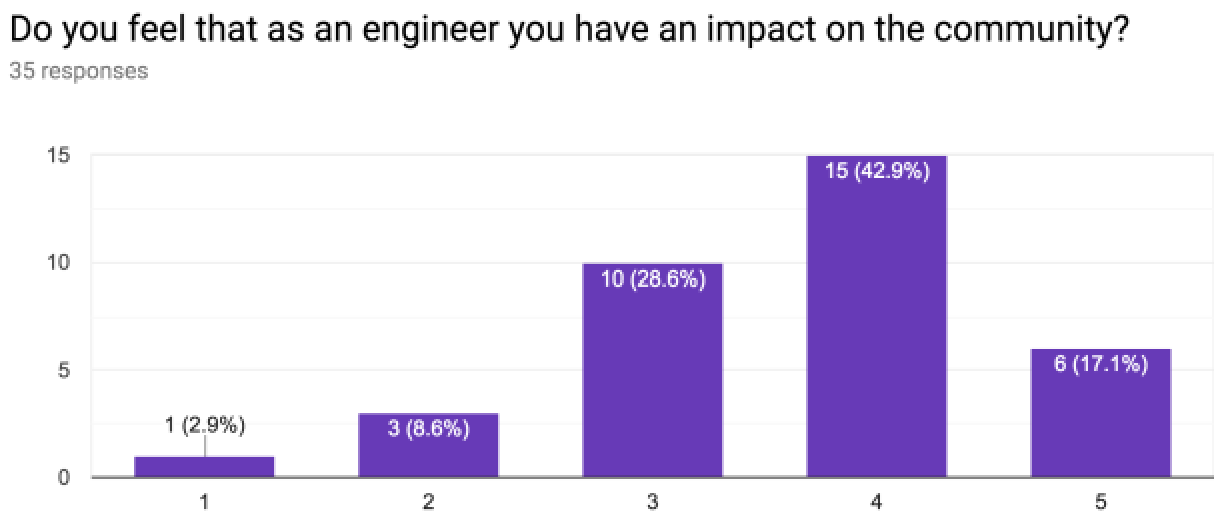

Figure 2. Question 1 of student survey. This figure represents the responses to the first question in the student survey: Do you feel that as engineer you have an impact on the community? One (1) indicates no impact and five (5) indicates a strong impact.

When asked to explain, respondents' answers began to exhibit a gap between engineering students' expect impact in the professional world and what they learn through Lafayette's engineering curriculum. One conclusion we drew based on the large number of the responses was that students "know" that as engineers in the professional world they will be in a position to directly impact communities. This response corresponded with the high ratings given in response to the first question. However, in their current position as undergraduate students, they do not feel that they have enough experience or exposure to their potential impact. Some examples of these responses are illustrated below:

- “Here at Lafayette, I feel like you have no impact on the community. However, in the real world, I believe that my career choice will have a huge impact on the community”
- “I feel that at some point I will have an impact at some point but I'm still in college”
- “I think that presently I do not have an impact on the community. However, in the future, I believe that I will be able to have a very large impact.”
- “I feel like to get a good grasp on that I would have to test it out, which I have yet to do, but I think I could find a job where I could impact the community.”

Many of the respondents’ additional comments were similar to those listed above, illustrating that engineering students notice a gap in Lafayette’s engineering curriculum. Our students are graduating with the knowledge that they will have an impact on people and communities, but without the interdisciplinary experience or training to properly approach that impact. The students who saw their direct impact on community, gained this perspective through internships and research opportunities. This disconnect between how we are preparing our engineers to impact communities and how they expect to impact communities is the gap this proposed course attempts to bridge with a focus on SCD and ethics. Ideally, this class will help students understand how engineers impact communities and encourage them to start to see the impacts that their projects and designs have on local and global communities.

The second part of our survey focused on gauging the technical skills Lafayette engineers perceive they are learning from Lafayette’s program. We asked our participants to “list their top 3 non-technical skills that they feel they have developed/refined through Lafayette’s engineering program". Many of our Bachelor of Science program engineers struggled to list 3 non-technical skills, often responding with long pauses and comments like "ugh this is hard" or "I don't have any skills." While the second comment was meant for comedic effect, these long pauses and inability to readily list non-technical skills show a need to emphasize the importance of non-technical skills in our classrooms. The word cloud in Figure 3 depicts the responses provided for this question. Words that are larger correlate to the words' respective appearance in a greater number of responses.

Figure 3. Word cloud of non-technical skills in student survey. This figure depicts what Lafayette College engineering students believe to be their strongest non-technical skills.

Additionally, it is important to note that 41% of the non-technical skills given included the specific words such as teamwork, communication, and writing skills. While these are important skills for engineers to develop, there are much more important non-technical skills that should be more prevalent in students' answers. Lucena et. al describes the important non-technical skills that are crucial to understanding end-user needs and community needs. These skills mentioned in his book include active listening, empathy, thinking creatively, and understanding different perspectives (Lucena et. al, 2010). Our proposed course will give our students the opportunity to learn and realize the importance of these specific non-technical skills in engineering. Utilizing this information, students can actively use these skills during future projects which will then strengthen the engineers that we are producing from Lafayette.

Faculty Survey Results

To gain a holistic view of the culture within the Lafayette Engineering division, we conducted a survey with twenty two professors with a balanced amount of perspectives from each department. 70% of the faculty surveyed have served at the College for at least five years. The survey focused questions around their personal views on community and their incorporation of community and non-technical skills in their teaching. Considering professors' variety of experiences, we attempted to keep questions equitable between ratings and open-ended questions. Figure 4 shows the distribution of respondents across the engineering departments for the faculty survey.

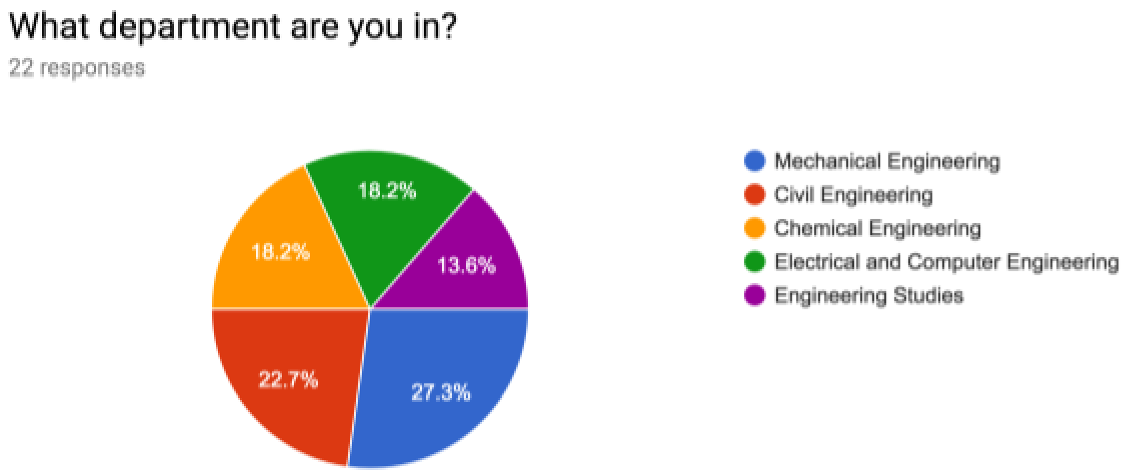

Figure 4. Distribution of departments for faculty survey. This figure illustrates the percentage of faculty we surveyed in each engineering department.

Overall, questions surrounding community-engagement that focused on faculty's teaching and academic research provided insight into the faculty's perceptions of community. They received a greater range of varied responses than questions about non-technical skills. The question: "Does community-centric design play a role in your teaching? If so, how?" was one of the most explicit questions about their community impact on the survey. Five professors said it does not play a role in their teaching while the rest saw a general connection to an end-product user as a defined community. 60% of professors who responded yes taught either a 400-level engineering course (mainly senior design projects) or an Engineering 101 course. These courses are mainly project-based with a less rigid course structure. Project-based courses allow for flexibility in methods of teaching and evaluation of relevant skills. Also, most research conducted about community-centric engineering education are structured through a project-based approach rather than lecture-based. (2014 International Conference on Interactive Collaborative Learning (ICL), 2014,414)

The responses to the following two questions: “As an engineer, do you feel that you have an impact on the community? (the community that you design/ research for)” and “As an engineer, do you feel closely linked to the community in which you design/research for?” were closely correlated. 60% of participants felt that they have a fairly strong impact on the community and 50% felt they are closely linked to the community in which they design/research for. Figure 5 and Figure 6 display these results below.

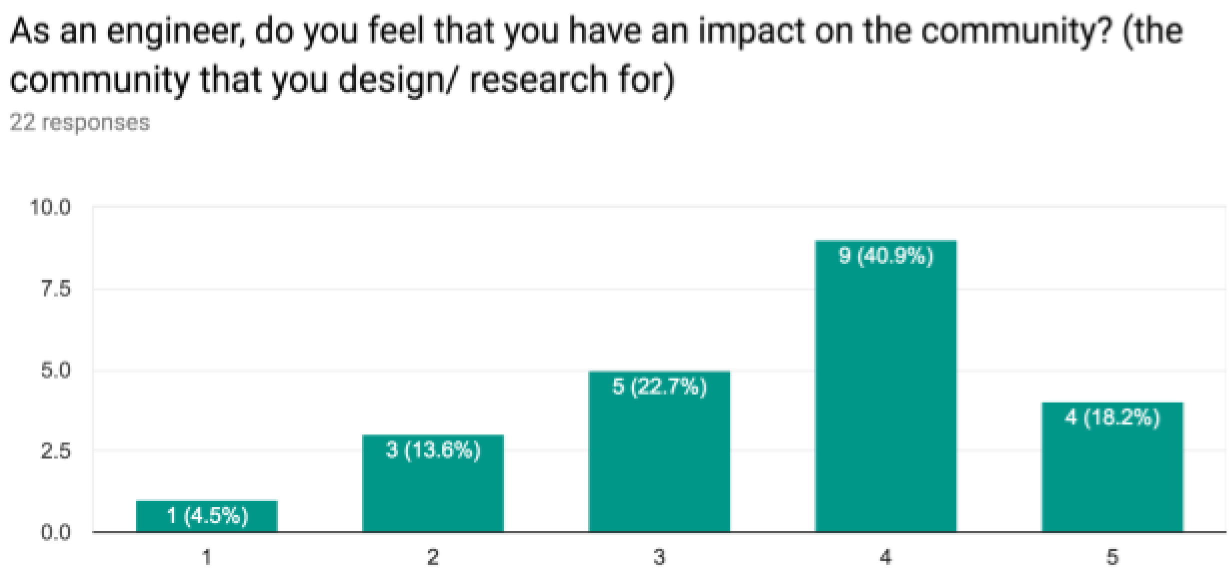

Figure 5. Faculty responses to “As an engineer, do you feel that you have an impact on the community? (the community that you design/research for). This figure displays Lafayette engineering faculty's level of influence on the community they design for.

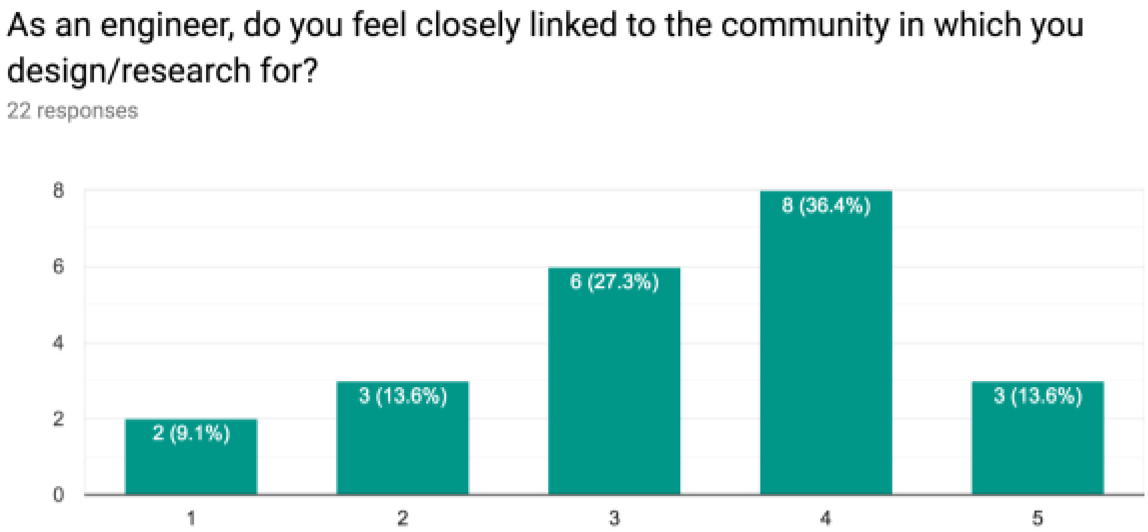

Figure 6. Faculty responses to "As an engineer, do you feel closely linked to the community in which you design/research for?" This figure displays the strength of Lafayette engineering faculty's connection with the community they design for.

The following responses to an open-ended follow up question to the above questions show a generally positive reasoning for their responses:

- "I do projects with and for the community, based on collaboration with members of the areas of relevance."
- "I feel it is my obligation to find solutions that impact the global and local communities however sometimes in research and teaching it feels a bit far removed."
- "My previous two answers were predicated on me doing community-centric design. I believe that engineers doing that work should be closely connected to the community in order to have a strong impact. However, that is just not a focus of my teaching or scholarship."

- "My responses would depend on how one defines "community." My design work does not impact the general public. It impacts the client. So, neutral responses were given."

The above responses portray a general understanding of community in a general sense. Faculty acknowledge the significance of community within engineering even though their work is not directly connected to communities. Their critical considerations of these questions were evident through questioning the definition of community and strong statements explaining their positions. One response illustrated the distinct view they have about their definition of and interaction with "community." This professor stated, " I reject tribalism and condescension and elitist hubris." The interpretation of this response can be inferred through their responses in the survey. Considering their responses to the survey, their engagement with community is minimal, if not, insignificant to their identity as an engineering professor. This may explain their view of community as an underdeveloped arrogant term. Although their colleagues mainly shared positive support of community engagement, this professor challenged that idea and voiced an unpopular opinion.

In the non-technical skills portion of the survey, most faculty were more responsive and familiar with the topic. When asked to identify the top three non-technical skills they focus on implementing in their courses, the most commonly mentioned skills were writing and communication in various contexts. These focuses show that engineering students are encouraged to develop the professional skills necessary in the corporate setting. The community-oriented skills mentioned the least were understanding contexts, empathy, engineering ethics and self-motivation. These are competences that are uncommonly highlighted within engineering curriculum but as equally important to the traditional non-technical skills popularly mentioned.

In the last three questions of the survey, faculty responses reflected stronger connections with the implementation of non-technical skills. When asked how they teach non-technical skills in their classes, all professors selected "in projects." Following this method, "in assignments" received 68% of votes, "through lecture" followed with 50 % of votes, "in homework" with 50% of votes and "other" with the least amount of votes at 18%. These results are displayed in Figure 7. Those who selected "other" included presentations and laboratories in the explanation section. These responses show that interactive tasks like projects and presentations allow students to explore and develop their non-technical skills better than other forms of evaluation. Projects are flexible and multidisciplinary facets of showing students the engineering design process.

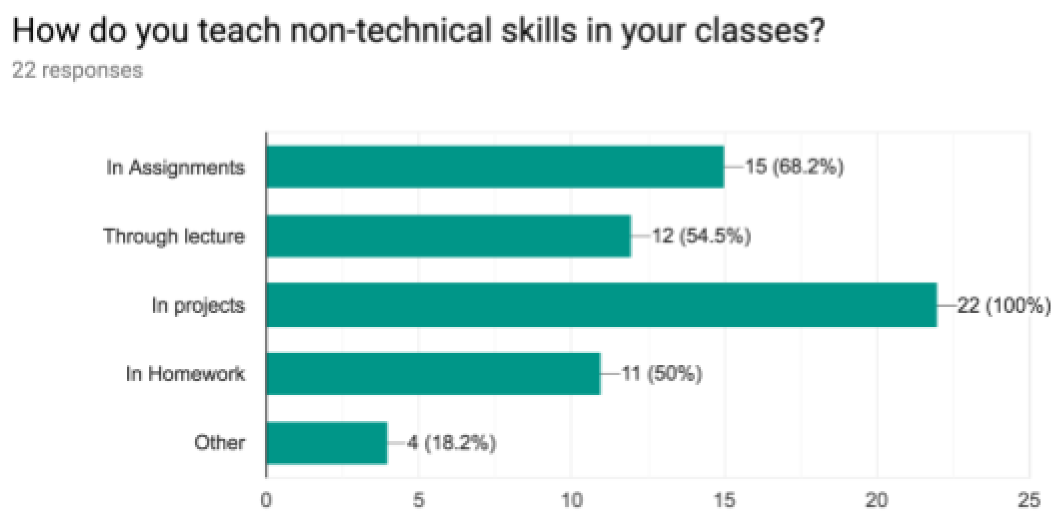

Figure 7. Faculty responses to "How do you teach non-technical skills in your classes?." This figure displays the distribution the methods in which non-technical skills are incorporated into existing classes.

The next question, “When students are conducting group work/projects, how would you rank the importance of non-technical skills implemented during the process?,” received ranking mainly between four (4) and five (5), as seen in Figure 8. 95% of respondents ranked non-technical skills as either important or extremely important. Considering this high positive response, professors understand the relevance of developing these skills for students' professional careers. Lastly, 85% of faculty selected their emphasis on “professional” ABET skills in their classes between a three (3) and five (5). This question shows professors' competence in ABET criteria and active implementation of these skills. The following graph shows the results of the importance of non-technical skills.

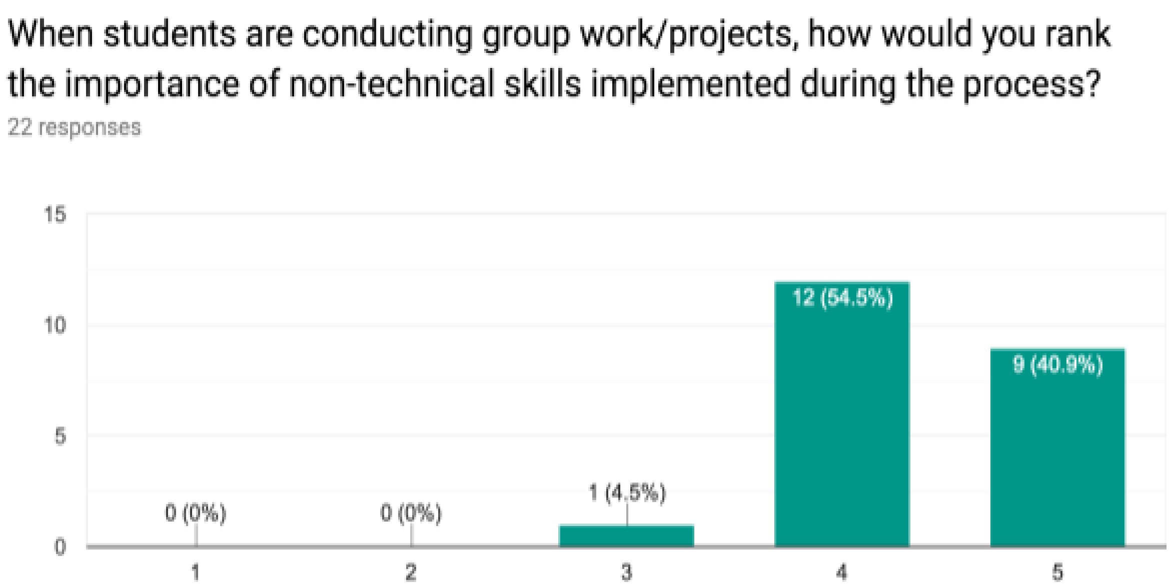

Figure 8. Faculty responses to “When students are conducting group work/projects, how would you rank the importance of non-technical skills implemented during the process?.” This figure displays professor perception of the development of non-technical skills.

Observational Reports from ME 497

In addition to formal surveys, our team analysed engineering culture at Lafayette through observational analysis of a 400-level mechanical engineering senior design course. This course includes a “multidisciplinary team of engineers - in a Community Engaged Scholarship senior design project”(R. Koh, personal communication, April 8, 2018). This course aims to combine skill sets associated with “(1) working on a multidisciplinary team, (2) working with community partners, and (3) centering societal impact in the selection of our design problem” (R. Koh, personal communication, April 8, 2018). These principles aligned with community-centric engineering practices, however, as two of our team members participated in this course, we have a more in depth understanding of how these practices and principles played out during the course. Our team members (Ava and Fanessa) observed a general gap in understanding the difference between the design process of a community engaged project and a standard engineering project.

During the first week of the course, Professor Koh assigned readings about shifting the traditional engineering perspective such as, *Engineering to Help: The Value of Critique in Engineering Service* (2009) with the goal to establish a base from which to work off of during the design process. Class reflections were focused on thoughts about the article reading and common stereotypes of engineers. Based on these reflections, B.S. engineering students were in agreement with the idea of “engineering to help” but participated more when sharing common stories and jokes about engineers than when discussing sustainable community design.

For the first five weeks of the semester, the group struggled to balance between problem generation and stakeholder outreach. Most B.S. engineers in the group were greater advocates for identifying a problem and solution before conducting a thorough amount of interviews. For example, a few students wanted to identify an interesting problem based on the team's interest and then identify stakeholders to support this project. Other students challenged this idea by emphasizing the definition of sustainable community development (SCD) and the problems associated with these students' perspectives on community engaged engineering work.

Throughout the semester, the team faced a few recurring challenges such as a disproportionate ratio between mechanical and non-mechanical engineering students, difficulty communicating as a group, overpowering solution driven work and a tendency to frame the community as a secondary focus. Since this is a mechanical engineering senior design project, the project team consists of a greater number of mechanical engineers than civil engineering and Engineering Studies majors. The ratio is four non-mechanical to eleven mechanical students. The team's overall difficulty communicating was reflected in the process of writing design proposal reviews. In the drafting of the reports, there was greater written bias towards a "solution," grammatical and structural errors as well as challenging writing sequencing (not clearly structured). During weekly team meetings, project discussions were geared toward solution generation and design planning. An overall view of community as a secondary focus of the project was made known through conversations during team meetings surrounding community affordability, a focus on product development, and project metrics. Conversations about project feasibility and metrics led to members worrying about "the affordability constraint limiting the creative process," preference for a consumer product for market sales over a public or infrastructure-based product. Teammates held novelty as a central focus rather than community. The team's focus on profit marketability and novelty shows there is a gap between engineers' personal definitions of their roles and society's definition of the role of engineers as community agents.

These observations of the Community Engaged Senior Design Project show that there is a gap in engineering education's relationship with community. Aside from the surveys' direct confrontation of the role of community in engineering, this capstone engineering design course provides insight into the mindset of a Lafayette mechanical engineering student's understanding and values placement of community within the engineering context. From these analyses, we conclude that integrating a community-centric engineering course into the Lafayette engineering curriculum would further students' understanding of their role as aspiring engineers in society.

Ethical Scope

Engineering ethics entails "the study of the moral issues and decisions confronting individuals and organizations engaged in engineering" and the "study of related questions about the moral ideals, characters, policies, and relationships of people and corporations involved in technological activity" (Martin & Schinzinger, 1983, 3). Engineering ethical practices combine the applications of "engineering and society" and "culture and technology" in a way that puts practice and application to the identified societal issues, as described in our social analysis. Engineering ethics addresses the connection between engineering and society in terms of aligning engineers' jobs with societal needs and the need to reclaim their role as social agents. Additionally, it connects culture and technology by addressing the need to create technology with cultural concerns in mind. We used the analyses of ethical practices to understand what engineers tangibly need to change to best fit the wants and needs of the community at hand, and to stray from societal norms of engineers. As ethics include the “justif[ication] of moral judgments,” our team identified the necessity for engineers to understand ethics to best assess and design for communities (Martin & Schinzinger, 1983, 3). We used this research to understand the necessary components of our course, and to ultimately determine that we should dedicate a large section of this course to teaching ethical practices.

In comparing the ethics behind engineering and social work, Shuman reminds engineering educators that “if the vision for understanding ethical and professional responsibilities as articulated in ABET is to become reality, educators must now answer a number of questions: What is appropriate content? What teaching methods and curriculum is preferred?” (Shuman, 2005, 46). We used these practices to understand what necessary lessons and practices to include in our course curriculum. Our course aims to embody a “well designed course in professional ethics [that] may well contribute something to the ethical development of students, at least in making them aware that technical choices have implications for the basic needs and legitimate expectations of others” (Kirkman, FU, & Lee, 2017, 1). This course will focus on the ethics of SCD, ethical concerns in more corporate-based design applications, and the ultimate redefining of the engineer as a social agent through ethical practices.

Since student run projects regularly reflect the disconnect between engineers and the communities that they design for, ethical principles in engineering apply to student approaches and the execution of SCD (Lucena et. al, 2010). Teaching ethical values can increase student and professor interest in the development of non-technical skills, and effectively work as social agents. A curricular realignment with ethical practices is timely because the ABET criteria calls for more attention towards professional skills (Shuman, 2005). The ABET criteria that Shuman discussed in 2005, "call[s] for ensuring understanding rather than demonstrating that graduates are ethical... students should be evaluated on knowledge and skill, not values and beliefs," therefore pointing our curriculum in the direction of theoretical ethics explanations, rather than jumping into action based projects without student mastery of an analytical background (Shuman, 2005, 46). A class which explicitly focuses on "social justice, equality, work humanisation, and the principles of sustainable development," rather than subsequently focusing on these lessons can help Lafayette in training well rounded and highly marketable engineers (Gilbert et al., 2015, 6).

The relevance of ethics does not shift when focusing beyond strictly SCD and humanitarian design in engineering into general engineering problem solving. The technical skills currently emphasized in engineering education remain critical in training. However, an additional focus on "human centered approach[es] and user centered approach[es]" in education broaden non-technical skills to all subsets of engineering, not just humanitarian (Walter, 2005). These "human-centered" approaches place stakeholder and community wants and needs as central to design, and these lessons apply to all design contexts (Walther, 2005). Our course aims to train engineers to centralize community needs, regardless of the type of community.

While ethics may not appear explicitly in traditional engineering problem solving, they can qualitatively measure efficiency in design implementation and community or client acceptance. An understanding of engineering ethics practices amongst engineering students would mitigate the continuation of the historical lead up to present day engineering culture. Ethical conversations touch on the fact that in engineering design "there will be times when [engineers'] activities will ultimately lead to a product that is unsafe or less than useful" as a result of " [intention], [pressure], or in ignorance"(Martin & Schinzinger, 1996, 6). The current cultural framework surrounding engineering education enforces the notion that "any non-technical concerns such as public welfare are irrelevant to real engineering work," however, empathetic design could mitigate this assumption (Walther, 2005). A knowledge of engineering ethics enforces the sentiment and, more importantly, the skills that reverse this mindset and its lasting effects by acknowledging that empathetic design is necessary beyond explicitly SCD projects (Walther, 2005). Instead of continuing in the technologically determinant path of Engineering Problem Solving methods , "an understanding of how the growing social consciousness around the world is making it imperative that engineering students understand the implications of their work" would help to train more well rounded and holistically trained engineers (Shuman, 2005). Engineering students can develop these user-centric design approaches in empirical ways and empathetic ways, all while considering human factors as a subset of engineering ethics.

In reviewing the history of engineering, our team has drawn a connection to issues in contemporary engineering culture. This culture has become deeply ingrained in the definition, productivity, and expectations of the 21st century engineer, however, it also leaves gaps in efficiency and sustainability. Martin and Schinzinger explain that ethics should be analyzed on both micro and macro levels, including everyday ethical questions, as well as larger, societal questions. They suggest that "we need ongoing attention to both, and a scrutiny of how one may affect the other in an engineer's professional and personal life." Therefore, our curriculum aims to teach students this societal awareness (Martin & Schinzinger, 1983, 5).

Ethical practices in engineering aim to tackle the long existing gap between engineers and society, which alludes to this lack of sufficient productivity. Both nationally and within Lafayette's borders, engineering education reflects the technical values of contemporary engineering culture. While technical skills remain important, ethical principles guide our curriculum in that "[engineering education] calls for a suite of cognitive skills associated with moral imagination" (Kirkman et al. 2017, 6). Through our proposed curriculum, our team diverges from this trend and hopes to help Lafayette train well rounded and uniquely marketable engineers.

Curriculum Proposal

Our team's research and outreach process led us to the ultimate proposal of a semester long, 200-level engineering course, based in the principles of SCD and engineering ethics. The first half of the course primarily provides lessons specific to SCD, because a community-centric course relates most explicitly to SCD. As our team believes that these principals benefit engineers in all fields, the second half of this course then expands these lessons to more traditional, consumer-minded, engineering practices through an introduction to engineering ethics.

Our team suggests that this class be open to all Engineering divisions as a general engineering elective. This course will gain traction if it were additionally cross listed as a 200-level Engineering Studies course. Currently, the Engineering Studies capstone course is organized in two sections: the first part of the course teaches SCD and historical engineering perspectives for the first five to six weeks in a purely analytical perspective and transitions into student led community-centric engineering projects. The incorporation of a 200-level community-centric course would alleviate capstone courses from both teaching these principals and applying these lessons. Our proposed course would thoroughly teach the ethical practices needed to lead community-centric projects and provide the capstone course with five to six additional weeks for project work. This course is designed to lay a groundwork of an ethical mindset and knowledge base so that “outcomes associated with ethical responsibility might be taken up in a stand-alone course in ethics *and* in core engineering courses *and* in the capstone design course, just as other professional skills might be integrated into what is otherwise a stand-alone ethics course” (Kirkman et. al, 2017, 1). In these additional weeks, capstone students could develop deeper relationships with their respective communities and more comprehensively apply non-technical skills. This course would provide the background knowledge necessary for students to participate effectively in experientially-based capstone projects, specifically in Engineering Studies.

The SCD-focused first half of this course starts with a brief history of engineering. Students will read *Engineers for Change* as the central reading for this portion of the class (Wisnioski, 2012). From the historical background, students will dive into an analysis of engineering culture, practices, and contemporary approaches, as to understand the current gaps between engineers and society. The course analyses engineering culture early on so that engineering students best understand the gap in skills left by contemporary engineering culture, and the necessity to fill this gap. In this portion course, students will have the opportunity to also read *Engineering and Sustainable Community Development* as a second keystone reading (Lucena et. al, 2010). This book not only outlines principals specific to SCD, but also reviews multiple SCD case studies. Many of these case studies are flawed in execution, due to the technical emphasis of engineering skills, and will help students begin to understand the do's and don't of SCD (Lucena et. al, 2010).

The second half of the course focuses on engineering ethics in both SCD settings and in more consumer-based, professional engineering settings. The engineering ethics portion of this class also provides a brief introduction into human factors practices, as these practices relate to community engagement in an empirical way and in a context outside of strictly the SCD application. A review of engineering ethics will further students' understanding of engineering culture in terms of existing sociotechnical systems. Kirkman notes that "navigating non-trivial problems in ethics and in design calls for more than static judgment, mechanical procedures or

Table 1: Potential Course Schedule

	Focus	Main Reading		
Week 1	Introduction to Community Centric Design			
Week 2	History of Engineering Culture	Engineers For Change		
Week 3	History of Engineering Culture	Engineers For Change		
Week 4	Contemporary Engineering Culture	Readings related to current events in engineering		
Week 5	Contemporary Engineering Culture	Readings related to current events in engineering		
Week 6	What is Sustainable Community Developm	Engineering and Sustainable Community Development		
Week 7	What is Sustainable Community Developm	Engineering and Sustainable Community Development		
Week 8	What is Sustainable Community Developm	Engineering and Sustainable Community Development		
Week 9	Introduction to Engineering Ethics			
Week 10	Ethical Practices in Engineering			
Week 11	Introduction to Human Factors Practices			
Week 12	Case Study Analysis Workshop	Engineering and Sustainable Community Development		
Week 13	THANKSGIVING BREAK			
Week 14	Case Study Analysis Presentations			
Week 15	Case Study Analysis Presentations			

Table 1. Potential fifteen-week schedule for proposed course. This table outlines potential chronological course structure.

simple decision rules. Rather, it calls for a suite of cognitive skills associated with moral imagination" (Kirkman et. al., 2017, 3). This course aims to infiltrate students' mindsets in a way that explains the importance of ethics and community-based perspectives in any engineering project. Table 1 shows a potential fifteen-week schedule for our proposed course.

Students will learn how engineering culture currently restricts engineers from engaging adequately with the communities they design for, and how this can be detrimental to efficiency and longevity of engineering projects. The non-technical skill set that aligns with engineering ethics practices will help students understand their professional and ethical responsibilities. Through reading literature about ethics, reviewing case studies, and reading about useful practices, "students can become more aware of the ethical implications of their work, they can learn ethical standards, they can become better judges of ethical conduct, and they can become more willing to put their ethical knowledge into action" (Shuman, 2005, 5). Our team believes that engaging students with a community-centric skillset in the context of a seminar-based, reading and writing intensive course will lead to a thoroughly formative understanding of the ethical practices necessary for experiential community-centric projects in the future.

Whether this future "community" entails an underprivileged community or a private client, this added skill set can increase efficiency in their work. This course provides students with a background of knowledge, which will advance their skills in "understanding rather than demonstrating that [engineering students] graduates are ethical" (Shuman, 2005, 5). This provides an opportunity in this course to "evaluate [students'] on knowledge and skills, not values and beliefs" (Shuman, 2005, 5). The engineering ethics portion of this class will also provide a brief introduction into human factors practices, as these practices relate to community engagement outside of the SCD application.

In order to thoroughly teach students the necessity of community engagement in SCD and other design settings, students will analyse case studies as a final project. *Engineering and Sustainable Community Development* discusses a plethora of case studies, each with unique flaws. A cumulative project which analyses such case studies in a literature-based format will better prepare engineering students for capstone courses. It applies the lessons gained in this literature-based class. Students will "effectively used case studies to teach not only design, but ethics," as well (Shuman, 2015, p. 6). By picking out flaws, strengths, and providing better techniques in community engagement in these case studies, students will be better prepared for future opportunities when working with communities.

Class Structure and Course Description

In the political section of this report, we mentioned the Colorado School of Mines (CSM) as one of the leading engineering institutions pursuing sustainable community-centric design education. Specifically, CSM has two unique minor programs that teach their students about this type of design. The first program is a minor in engineering and community development (ECD). The goal of ECD is to prepare students to become leaders in community development through engineering. This minor prepares students to work within the field of humanitarian engineering. Leadership in Social Responsibility (LSR) is the second minor at CSM that helps graduates understand the integration of engineering into the real world. The LSR minor focuses more on social responsibility within a corporate organization ("Engineering….Society", 2017).

Both minors and the courses required to fulfill the minor are listed on the CSM website. We read through the course descriptions to become familiar with the type of courses these minors entail. For this project, we knew that we would have to develop a course description as well as learning outcomes for the proposed course. In Table 2 are a few of the course descriptions from CSM. These course descriptions detail some goals and outcomes for the classes within the ECD and LSR minors.

The CSM course descriptions helped us gain a better understanding of the types of concepts and ideas we should be pushing for in a course that helps students better understand community-centric design. Pairing our knowledge from the literature reviews and the course descriptions, we were able to distinguish important phrases and themes from CSM's courses that we want to include within our 200-level course. First, understanding the concept of sustainable community development is crucial to the courses at CSM and likewise will be integral to the core of our course development. In order to understand sustainable community development, students need to understand that context matters. Engineers' thorough consideration and integration of historical, political, economic, social, and cultural perspectives into their solutions will deem development sustainable. CSM highlights the importance of social responsibility within the course descriptions. The ability to understand the wants and needs of stakeholders is another important aspect that we want to incorporate within our course. These stakeholders can vary from investors, end-users, coworkers, and many other types of people. Part of the purpose of our

Table 2: Colorado School of Mines Course Descriptions

Course Title	Course Description
ENGINEERING FOR SOCIAL AND ENVIRONMENTAL RESPONSIBILITY	This course explores how engineers think about and practice environmental and social responsibility, and critically analyzes codes of ethics before moving to a deeper focus on macroethical topics with direct relevance to engineering practice, environmental sustainability, social and environmental justice, social entrepreneurship, corporate social responsibility, and engagement with the public. These macroethical issues are examined through a variety of historical and contemporary case studies and a broad range of technologies
ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ideological, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of community and sustainable development and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving, design, and research for working in SCD. Students will learn to research, describe, analyze and evaluate case studies in SCD and develop criteria for their evaluation.
ENGINEERS ENGAGING COMMUNITIES	Engineers and applied scientists face challenges that are profoundly socio-technical in nature, ranging from controversies surrounding new technologies of energy extraction that affect communities to the mercurial "social license to operate" in locations where technical systems impact people. Understanding the perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides students with the conceptual and methodological tools to engage communities in respectful and productive ways. Students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project.
CORPORATE SOCIAL RESPONSIBILITY	Businesses are largely responsible for creating the wealth upon which the well-being of society depends. As they create that wealth, their actions impact society, which is composed of a wide variety of stakeholders. In turn, society shapes the rules and expectations by which businesses must navigate their internal and external environments. This interaction between corporations and society (in its broadest sense) is the concern of Corporate Social Responsibility (CSR). This course explores the dimensions of that interaction from a multi-stakeholder perspective using case studies, guest speakers and fieldwork.
ANTHROPOLOGY OF DEVELOPMENT	Engineers and applied scientists face challenges that are profoundly socio-technical in nature, ranging from controversies surrounding new technologies of energy extraction that affect communities to the mercurial "social license to operate" in locations where technical systems impact people. Understanding the perspectives of communities and being able to establish positive working relationships with their members is therefore crucial to the socially responsible practice of engineering and applied science. This course provides students with the conceptual and methodological tools to engage communities in respectful and productive ways. Students will learn ethnographic field methods and participatory research strategies, and critically assess the strengths and limitations of these through a final original research project.

Table 2. Course descriptions from CSM's ECD and LSR minors ("Engineering….Society", 2017). This table details the important concepts and ideals that the mentioned CSM minors programs instill in their students.

course is to help educate engineers on the different types of stakeholders and develop an understanding of how stakeholders can take different forms depending on the type of project. It is also important for our engineers to understand that the weight each stakeholder has varies on the conditions of the project.

Another key component of sustainable design that CSM's courses outlines are students understanding the impact that technology has on communities and end-product users. This is an important concept that we have touched upon in our capstone class throughout the semester. Our goal for the students of this course is for them to understand the impact of their work beyond just the technical. We want students to understand how their work impacts people in communities. CSM also has a course description that explains how they approach teaching engineering ethics. The CSM class first shows the students the engineering code of conduct and explains ethics with regards to engineering on a personal level. However, then the course focuses on macro ethical issues which entails the collective social responsibility of the engineering profession. For our specific class, we feel that focusing on macro ethical concepts will help us integrate the concept of engineering ethics and impact of technology which will help engineers think more holistically about the products that they are designing.

Based on our research, our course description is as follows:

This course focuses on the development of non-technical skills amongst engineering students. Students will use seminar-based discussions, reading, and writing to better understand the integration of engineering projects into society by incorporating historical, political, economic, social, and cultural contexts. Students will understand stakeholder perspectives, their needs, and their participation in the engineering design process. This course is divided into two main sections: an analysis of sustainable community development and an analysis of engineering ethics. Students will learn how to take this community-centric skill set and later apply it to their future academic and professional careers.

Accreditation and Course Outcomes

When speaking with professors about the creation of this course, it was mentioned that it might be hard to get faculty on board. The course is not easily ABET-accredited due to the completely non-technical emphasis that the course will have. Through literature reviews on courses that revolve around sustainable community design and engineering ethics, there are certain ABET criteria that can be met by this type of class. The outcomes that this course would fulfill under criterion 3 of ABET are listed below:

- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
- An ability to function on multidisciplinary teams;
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility;
- An ability to communicate effectively;
- A broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; and
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (Amadei, 2010, 87)

The hope for our course is to help strengthen education that occurs within these categories of ABET accreditation at Lafayette College. The first criterion above alludes to the ability to design a system with realistic constraints. An important point to note is that engineering is made up of important non-technical constraints and contexts such as historical, political, social, safety, etc. This course would help train our engineers to think outside the box and understand that context does matter with regards to engineering projects. The second focuses on being able to work on multidisciplinary teams. Once this course is taken off the ground, one of our hopes is that engineers from different disciplines will be enrolled in this course. This would include engineers from the BS program but also students from EGRS. This will allow engineers to understand different perspectives and different experiences that other students have had during their time at Lafayette.

The third criterion listed above details the ability to identify and formulate engineering problems. This course will help engineers approach problems from more than one perspective. It will teach students to think about engineering from an interdisciplinary mindset rather than just a technical mindset. In turn, our hope is that this will allow engineers to better understand problem identification and also become better solvers because they will think more holistically. The next criterion touches on the ethical responsibility that engineers will learn. Our proposed course will have a full section on engineering ethics and the social responsibility that engineers hold in their profession. We strongly believe that this course will help enrich this criterion because, based on current feedback from students, engineering ethics is glossed over in the current curriculum, especially those from civil engineering. The fourth criterion focuses on understanding the impact of engineering solutions in a well-rounded scope rather than just focusing on the technical aspects. In our course description, we plan on showing how engineering has interdisciplinary impacts on different stakeholders within the project as well as society. The last criterion details that engineers should have the ability to use techniques, skills, and tools for engineering practice. This course will equip our students with the ability to approach engineering through different perspectives. In addition, this course will challenge students to think about engineering in a completely different way than what they are used to, as this course will have minimal technical aspects to it. These skills will carry with the students as they advance in their educational and professional careers. In our previous sections of this report, we see that this course will change and benefit the way in which students approach solving engineering problems.

Thinking about this course within the context of ABET accreditation has helped us formulate our learning outcomes for the class. These learning outcomes expand upon the course description and will help future EGRS capstone students and faculty design a syllabus to go alongside with the work that we have done thus far. These outcomes paired with the understanding of the specific ABET criteria listed above will give this class the credibility it deserves within the engineering department at Lafayette.

Our Specific Learning Outcomes

By the end of the course, students should be able to:

1. Identify and analyze the contexts in which engineering and technology are built in.
    - Recognize how these contexts influence engineering and how engineering impacts these contexts
2. Recognize the different ways in which to approach an engineering problem
    - See both the strengths and weaknesses to Engineering Problems Solving
3. Be able to discuss and write about sustainable community development (SCD)

- Understand different perspectives of community members and end-users as well as stakeholders throughout the design process

4. Understand how SCD and macro ethics interact with one another
    - Analyze recent case studies
5. Analyze the important non-technical skills associated with understanding and solving engineering problems

Through our literature review and outreach process, our team believes that our proposed course with the above learning outcomes has the potential to sufficiently provide Lafayette engineering students with an introduction into community-centric design. As Lafayette enters a potential new stage of reform, this course can kick start Lafayette's new wave of holistic engineering.

Conclusion

Community-centric engineering education is a strategic and effective approach to preparing the "modern engineer" for the societal demands of the 21st century. Throughout our final report, we used social, political, ethical and technical contexts to explore the national and Lafayette-specific conversations about shifting the goals of engineering education. Our research and community outreach provided us with a solidified purpose for reimagining engineering education and a concrete strategy to advance engineering at Lafayette. Our course proposal addresses the undeniable gap that exists between engineers and society.

Our findings identified large issues in engineering culture and with the existing methods of addressing the shift in the identity of the “Engineer of the Century.” These large issues center around the consequences of engineers’ loss of trust in society and vice versa during the peak of the Cold War. As a result, the definition of the contemporary “traditional engineer” became solidified during this historical shift. The effects of the traditional engineer have influenced the shift in redefining the modern engineer. This historical phenomenon connects directly to Lafayette’s engineering education and its manifestation of national engineering culture.

The Cold War’s influence on workforce and education influenced the definition of the traditional engineer. The workforce’s focus on fast and cheap production and the emphasis of engineering education on the development of technical skills led to the formation of the engineer’s “black box,” a candid disconnect between engineers and the rest of society as engineers’ lack of understanding of their impact on society grew. As a result of this divide, intellectuals’ push to invest in holistic education led to educational reform within engineering schools such as MIT and Harvey Mudd. Contemporary engineering culture perpetuates the struggle between technical and holistic value curriculum. While students are trained to focus on the technical aspects of engineering, there is a growing demand of the engineers’ professional and non technical abilities.

At Lafayette, the engineering division adapted at the same pace as engineering educational reforms across the nation. The A.B. degree in Engineering was created to engage a greater interdisciplinary work strategy. However, the college’s shifting identity of the engineer was also influenced by technical dominance in the field. Through student and faculty surveys, we gained insight into personal accounts and perspectives relating to current engineering culture at Lafayette.

Furthermore, we drew connections between the national conversation on engineering education and the current Lafayette engineering culture through these student and faculty surveys as well as classroom observations. Both surveys focused on understanding respondents' perspectives of and relationship with community and non-technical skills. Overall, we concluded that despite Lafayette's engineering division's introductory and 400-level project-based courses, there is a lack of consistent integration of community and community-oriented skills within engineering courses. While student survey responses concluded that Lafayette engineering students understood their potential future impact on community, they felt that their engineering experiences and courses have not prepared them for those interactions. Faculty survey responses, on the other hand, were mainly positive; they emphasized a recognition of the importance of interacting with the end-user throughout the design process. However, a few respondents challenged the definition of community and its relevance within engineering. Student and professor survey responses received similar results in regards to the development of non-technical skills implemented in the classroom such as communication, writing and presentation skills. There was a clear lack of community-oriented skills such as contextual learning and empathy. Our observations of a 400-level mechanical engineering senior design class reflected our survey conclusions. Technical engineering students were more focused on solution-generation than engaging the community. Although the two focuses are not mutually exclusive, we observed a clear detachment between engineering students' idea of the role of the engineer and the role of community. This skewed approach to community engaged engineering design is reflective of the training received by these students.

Currently, education is shifting towards a greater focus on the ethical development of engineering students. This training allows them to better understand, assess and design according to the needs of the community. As an integral part of ABET accreditation criterion, ethics are a necessary component in the development of engineers' non-technical skills. An outlook based in engineering ethics connects societal purpose to engineering design. The ethical context of this report showed the integral role of empathetic design in all projects, not just SCD. There is a growing demand for professionals to adapt to growing global social consciousness at both local and international scales. We consider ethics the "missing link" between community-centric work and engineers' acceptance and actions towards this emerging shift in education and design.

Our research led us to develop a curriculum proposal that achieves economic, professional and cultural benefits for the Lafayette engineering division. We concluded that a 200-level engineering course focused on community-centric design through SCD and engineering ethics would best start the process of reforming Lafayette's engineering curriculum. These two main themes will guide engineering students to better understand the connection and relevance of society and technology. Our focus is to train engineers to think about the non-technical concepts of engineering projects as a key predictor of success within design. In developing our curriculum, we incorporated pedagogical frameworks from two minors programs from the Colorado School of Mines: Engineering and Community Development and Leadership in Social Responsibility. Colorado School of Mines' courses guided us in deciding the key concepts that would best teach students about community-centric design. Key ethical concepts such as social responsibility and the impact of technology on community and users are inherent in this course, as well.

This course will develop students' nontechnical skills with reference to ABET accreditation and learning outcomes. We define success as the achievement of developing students into social agents who recognize that context matters and use community to further their development and success in the field. From the list of relevant ABET criteria provided in the curriculum design context, we explained how our course will achieve and advance the educational goals of ABET. These criteria include the development of skills such as teamwork, ethical responsibility, communication, contextual analysis and problem-solving along with the implementation of technical engineering techniques. Learning outcomes for this course reflect the attainment of these criteria through the course's concentration in the contextual analysis of society and technology, the study of SCD and ethics and the partnership of both conceptual themes. Ultimately, students should be able to use their developed non-technical and analytical skills with community-centric design to increase the efficiency of their engineering work an use of technical skills.

Lafayette students' participation in this community-centric engineering course not only connects the technical and non-technical aspects of their discipline to achieve a holistic undergraduate engineering education but increases their marketability in the emerging global markets. Students will be prepared to take on any challenge through their acquired transferable skill set. As community needs becomes central in companies' outreach and communities rise in external dependence and advocacy, multidisciplinary engineers are in high demand. Our course provides the tools for students to strive towards finding context-based solutions that deconstruct and address social inequities.

The research and design of this course proposal, however, would benefit from further analysis into community-centric education. As we attempted to combat the challenges we identified at the beginning of the report, more technical challenges arose such as the time-constraints of the study, the comprehensivity of the group of respondents and limited structural guidance in the process of bringing this course into full fruition. The duration of this project was only a quarter of the time we needed to thoroughly strengthen the details of this curriculum. A longer project would have allowed us to strategize different methods of achieving a greater amount and quality of survey participation, whether it be through the attractiveness of the survey or the phrasing of questions. We also lacked project support from Lafayette's engineering division. We hoped that this support could ignite the conversation of community and engineering in partnership with the Engineering Studies department and engineering organizations to gain great support in reforming Lafayette's current engineering curriculum. Through this support, we could encourage the legitimate expansion of the department to allow for greater progress within achieving interdisciplinary focuses in engineering.

This project is testimony to the growing cultural demand for a holistic engineering education with community needs as a core value. As we reflect on the future considerations to implement this course at Lafayette, we recognize the continuous research, time, communication and review needed to achieve this goal. In hopes of further course development of this project through future Engineering Studies capstone groups, we encourage future project contributors to consider the the following questions: How does the positionality of students and professors' primary purposes at this College influence research and successful communication within the engineering division? How does identity play a role in the course proposal? Should it be implicitly or explicitly integrated into the course? As an intended Engineering Studies course, can this course address and fit in with the current structure of the department's curriculum? Through these questions, our curriculum research, and our established proposal, we hope to ignite a discussion within Lafayette's engineering departments to seriously consider how they can train engineers and develop society's future engineers to tackle society's most pressing issues. We believe that the foundations of this 200-level engineering course will help begin to bridge the gap between engineering and society and begin to train Lafayette engineering students to become the social agents they are meant to be.

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