Anti-Racist Pedagogy in Engineering

EGRS 451, Fall 2022

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Introduction

On the Engineering Studies Department website at Lafayette College, this course of study is described as a curriculum that provides students with the skills necessary to combine understandings of culture, technology, society, politics, economics, and environmental issues into a cohesive whole, acknowledging that all of these seemingly disparate yet entwined elements must work in concert for technologies to function well. While having such coursework available for students is a boon for the college, a similar understanding of the interconnectedness of the societal contexts of such technical work does not seem to be valued in the same manner in other engineering disciplines at the college. For instance, the websites of the mechanical, civil, electrical, and chemical engineering departments discuss the many technical aspects of the education that students will be exposed to over their time here, with mentions of the greater contexts of such work conspicuously absent, other than a few brief mentions of electives in the humanities and social sciences.

As many scholars, including professors here at this school have argued, technology is inseparable from the contexts in which it is created and used, critically in the context of racial dynamics. Wendy Hui Kyong Chun argues in her article "Race and/as Technology; or, How to Do Things to Race", that in fact, "Race is a technology and dominant paradigm for societal control", "Humans and technology," as Bernard Stiegler has argued, evolve together. "Race, it therefore follows, has never been simply biological or cultural; rather, it has been crucial to negotiating and establishing historically variable definitions of biology and culture." (Chun, 2009, p.8). Expanding

upon this idea, Smedley and Smedley write in their article “Race as Biology is Fiction, Race as a Social Issue is Real”,

> “In the early 18th century, usage of the term increased in the written record, and it began to become standardized and uniform (Poliakov, 1982). By the Revolutionary era, race was widely used, and its meaning had solidified as a reference for social categories of Indians, Blacks, and Whites (Allen, 1994, 1997; A. Smedley, 1999b). More than that, race signified a new ideology about human differences and a new way of structuring society that had not existed before in human history. The fabrication of a new type of categorization for humanity was needed because the leaders of the American colonies at the turn of the 18th century had deliberately selected Africans to be permanent slaves (Allen, 1994, 1997; Fredrickson, 1988, 2002; Morgan, 1975; A. Smedley, 1999b).8 In an era when the dominant political philosophy was equality, civil rights, democracy, justice, and freedom for all human beings, the only way Christians could justify slavery was to demote Africans to nonhuman status (Haller, 1971; A. Smedley, 1999b). The humanity of the Africans was debated throughout the 19th century, with many holding the view that Africans were created separately from other, more human, beings.”

In *The New Jim Crow, Mass Incarceration in the Age of Colorblindness,* Michelle Alexander develops the argument of Race being a technology of social control that is baked into the basic structures, physical and societal, that pervade today's American

society. Her book specifically discusses how these systems have been used to create an industrial prison complex that provides a labor force for many corporations, effectively continuing systems of oppression that grew out of the chattel slave trade, sharecropping, and the Jim Crow systems.

> "The unfortunate reality we must face is that racism manifests itself not only in individual attitudes and stereotypes, but also in the basic structure of society. Academics have developed complicated theories and obscure jargon in an effort to describe what is now referred to as *structural racism*, yet the concept is fairly straightforward. One theorist, Iris Marion Young, relying on a famous "birdcage" metaphor, explains it this way: If one thinks about racism by examining only one wire of the cage, or one form of disadvantage, it is difficult to understand how and why the bird is trapped. Only a large number of wires arranged in a specific way, and connected to one another, serve to enclose the bird and to ensure that it cannot escape.
>
> What is particularly important to keep in mind is that any given wire of the cage may or may not be specifically developed for the purpose of trapping the bird, yet it still operates (together with the other wires) to restrict its freedom. By the same token, not every aspect of a racial caste system needs to be developed for the specific purpose of controlling black people in order for it to operate (together with other laws, institutions, and practices) to trap them at the bottom of a racial hierarchy. In the system of mass incarceration, a wide variety of laws, institutions, and practices—

> ranging from racial profiling to biased sentencing policies, political disenfranchisement, and legalized employment discrimination—trap African Americans in a virtual (and literal) cage." (Alexander, 2010, p. 179)

In her book, *Race After Technology: Abolitionist Tools for the New Jim Code*, Ruha Benjamin makes a case that in the world of automated systems and artificial intelligence, the very engineered world we live in, race continues to be a lens through which data and society is overwhelmingly organized, and through the works of other authors such as Safiya Umoja Noble, it becomes clear that ongoing issues of systemic racism in technical systems are reinforced and constructed by the very infrastructural and socio-technical landscape that forms the engineered foundations of today's society. Taking such analyses into account it becomes clear that the basis of any engineering education must include an understanding and analysis of the racial and societal implications of its impacts in order to mitigate the continued dominance of white supremacy and avoid the reinforcement of existing racial hierarchies. Throughout the rest of this project, we worked to create an understanding of the necessity for the integration of a racial justice framework into the entirety of the engineering program here at Lafayette and worked to develop potential avenues through which such lessons could be added to the curriculum.

In order to develop approaches to this issue, we sought to answer several questions in our work. First, we asked, "What current practices does Lafayette college have that promote anti-racist education and what limitations exist at the college that may inhibit these practices? Are there currently systemic racial issues within the engineering

department?" By answering this question, our intent was to develop an understanding of the current climate at the school, and whether there were existing programs that could be expanded or further developed to accomplish such goals. In addition, we intended to uncover any existing issues that may hamper efforts to develop an antiracist pedagogy in the broader engineering department. To further address this we also asked the question, "How does the current state of race & technology education at Lafayette reinforce and/or address racist paradigms?"

To develop approaches to anti-racist education that the professors and administration of the school could use, we attempted to determine how to integrate anti-racist pedagogy into a technical discipline. Drawing from already existing resources on the subject, we looked to other schools and institutions that have made similar efforts to incorporate lessons of racial justice and an understanding of community and environmental contexts into their engineering programs. We interviewed professors in the Lafayette engineering department including Professors Rossman and Sanford, student organizations, and facility centers such as the Hanson center to better understand what can be done to better incorporate anti-racist pedigogy into STEM education. In these interviews, we found that it does not seem to be the new faculty that is having the most trouble with this transition, it is those who have gone through generations of teaching that did not include the human perspective. Through our interviews we found the most common trend to be that the human part of engineering needs to be re-emphasized. ABET Accreditations recently changed Engineering Curriculum standards to also include a section on DEI. While this is not the end all be all solution, it will certainly push curriculum creators and department heads to change their focus from purely technical. In

order to create an engineering program that effectively avoids and seeks to equip graduate with the tools needed to address the systemic injustices that have been present throughout the history of engineering as a discipline, professors must teach their students that understanding and centering on the contexts of their work is just as, if not more vital than the technical design concepts that they are learning. That engineering as a discipline is inherently not objective and removed from the surrounding world, but that by its nature engineering is a discipline that is ingrained in shaping the very foundations that communities, from neighborhoods to the globe, are built upon.

To address these issues, we created several potential options for professors and the administration to draw on. We developed a syllabus review program for the school to use, with an example lesson plan for a class on urban development and electrical engineering which can be found in the technical section. This solution was based on the conclusion we came to through our research and interview with Professor Rossman where we determined that approaching this issue by giving professors the tools necessary to integrate lessons into their preexisting classes would be the most sound approach within the constraints of time and money that we had.

Social Context

Introduction

In this section, we explore the social construction of race and racist structures in sociotechnical and educational spaces. More specifically, this section outlines how race—in its contemporary definition—affects engineering, education, and the future of technology by ingraining itself within the foundation of these social systems. The scope of our project focuses on the Bachelor of Science and BSE engineering programs at Lafayette college; however, it is necessary to take a step back from this focus to understand race and its expansive effects on STEM education–both nationally and at Lafayette. For this reason, we begin with an exploration of the definition of race and how it has been colloquially accepted in post-eugenics society. We then move to conceptualize race itself as a technical system. In other words, this section of our analysis explains how race has been used as technology and where it fits into our proposed educational solutions. Finally, we take a brief examination of current anti-racist pedagogical efforts being done at Lafayette. From here, we move on to the various success and limitations of these in the context of anti-racist education. We affirm that equipping professors with tangible training in implicit bias will allow courses and discussions across the disciplines to create a safer space for students of all backgrounds.

What is "Race"?

As defined by Smedley & Smedley in their article Race as Biology is Fiction, Race as a Social Problem is Real, race is a socially-constructed ideology that inherently

"seeks to explain human population differences in health, intelligence, education, and wealth as the consequence of immutable, biologically based differences between 'racial' groups." They elaborate that racial distinctions are not genetically discrete, measurable, or scientifically relevant (Smedley & Smedley, 2005). Despite strenuous efforts from eugenic-supporting scientists, there is no biological categorization or measurement that can be placed on racial differences. In contemporary culture, race has come to classify human groups by skin color separating this identity from human ethnicity and culture creating shared experiences for racial groups. The definition of these racial lines has been blurred and redefined countless times as policy has changed and evolved. However, through all definitions, race fulfills its function to divide classifications of people and inherently create systems of hierarchy in social settings. This leads to public policy coming to fruition around the racial formation to serve the needs of the privileged "racial groups". Racial formations themselves are used as political power to brand certain racial groups as beneath others (Omi & Winant, 3). Here is where we begin to see racial definitions bleeding into technical systems and engineering education. Due to the fact that certain racial groups have not been privileged to have a seat at the table, our social and technological advances have been created to serve white individuals. By analyzing our own racial identities and how we interact with technology, we are able to see how the two cannot be separated and should be redefined in tandem. It will additionally highlight how race has permeated nearly every aspect of our society.

As Langdon Winner writes in Do Artifacts Have Politics? Political technology is the notion that technology can be not only analyzed for its societal benefits and impact "but also for the ways in which it can embody specific forms of power and authority"

(Winner, 1980). Drawing upon the definition of race, racial structures lend themselves to hierarchy and prejudice. Race exists in order to cause separation and division between humans. Political technology acknowledges that science will follow the same hierarchical systems as race. Since white individuals hold the power and agency to completely influence innovation, the systems they create will uphold the status quo. For example, Robert Moses was the city planner for New York and held great influence on city infrastructure for nearly half a decade. Most importantly, he commissioned the construction of Long Island parkways' indicatively short overpasses. Moses intended these overpasses to prohibit mass transit travel to the Island and keep what he claimed were "lower class" families segregated from the beaches (Winner, 1980). This is an example of explicit bias within technology caused by the inventor. In essence, political technology can be used synonymously with technology. Because of the implications in our society and human influence, no technology can be fully removed from its prejudices and bias.

Technological determinism is another aspect of technological society-making that is being debunked by scholars in the field. This is the notion that technology and technical systems determine the course of human development void of human interference or direction. In their book "The social construction of technological systems: New directions in the sociology and history of technology", Bijker, Hughes, and Pinch define technological determinism as "the claim that technology causes or determines the structure of the rest of society and culture. Autonomous technology is the claim that technology is not in human control, that it develops with a logic of its own. The two theses are related" (Bijker et al., 2012). This 21st-century Manifest Destiny is yet another

obstacle to breaking down racial prejudice in sociotechnical and educational spaces. Innovators may believe that engineering progress translates directly to social progress when this could not be further from the truth. In discussing the ways determinism can present itself, Jonas Hallström writes “Technological determinism can take the form of an idea, theory, or a way of explaining technology development in history or the present, but it can also take the form of actual material structures that—implicitly or explicitly—permeate and influence society, or, at least, this is what some researchers and scholars claim” (Hallström, 2022). If technology is not questioned, the already present prejudices will snowball and expand exponentially without any structural reassessment. Integration of racial prejudices and discrimination with technology is our first largest obstacle to combatting racist pedagogy.

Racist Histories & Methodologies in Technical Spaces

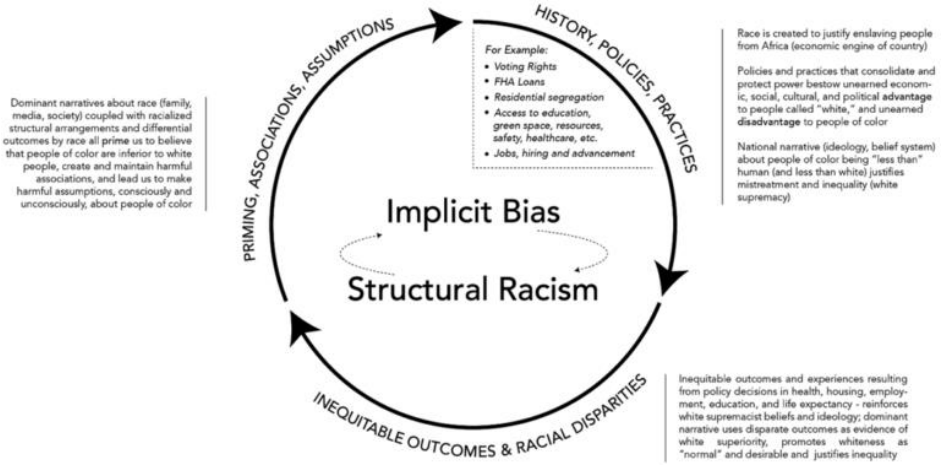

Figure 1: Implicit Bias and Structural Racism, A graphic depicting the interaction between implicit bias and structural racism, National Museum of African American Culture & History

Access to STEM & Engineering Education

With an understanding of racialized sociotechnical systems, we can now cover key definitions for conceptualizing race as its own technology and furthermore what role it plays in an undergraduate-level engineering classroom. Firstly, it is important to understand that racist education and engineering of the past can be both passive and active. The biases ingrained in these systems can be explicit, usually the action of individuals with discriminatory motives, or implicit coming from within the system as symptoms of overlooked prejudice. Implicit bias is a subconscious and structural form of racism that allows bias systems to continue. Examples of implicit bias are present in technologies such as facial recognition or automatic soap dispensers which were only given white skin tones as data and could not perform properly for dark-skinned individuals. The engineers may not be inherently making conscious racist choices, however, the lack of representation and inclusion has allowed the systems to exclude minority groups (Mone, 2016). Explicit bias in engineering is present when engineers and innovators are making knowledgeable choices that disadvantage certain groups. This is less common, and for the purpose of our capstone, we will primarily focus on implicit biases in engineering education.

From childhood, there are significant differences in access to STEM education between white and POC students. In a recent study published in the Journal of Engineering Education, authors London, Lee & Ash found notable disparities in sustained academic interest in STEM fields based on access to early childhood education. From their findings, they were able to link Black imposter syndrome and lack of

engineering resources to inadequate exposure to STEM learning in elementary schools. Additionally, the journal highlights that Black students' largest reasons for avoiding technical field aspirations are due to "not feeling smart enough" or feeling inadequately "prepared[…]to succeed in STEM" (London et al., 2021). This systemic, rather than systematic, disadvantage for Black and Brown students is one of the many examples in which current racial biases in engineering education struggle to represent the diverse whole. Colloquial segregation of schooling is how race asserts itself in the technical and educational realm. This discrimination against Black students is set as a precedent and follows students into higher-level education. A 2019 report by the National Science Board found that 60% of all engineering degree recipients identified as white. Black students comprised the second least represented group at less than 10% (NSB, 2019). This not only limits the ability of the workforce to fully incorporate diverse perspectives, but it upholds a biased and segregated system that must be entirely restructured to address bias.

Lafayette Demographics

We can use this information to now view Lafayette's Engineering Division as a case study and analyze the current state of diversity efforts. Following the murder of George Floyd in 2020, colleges and universities across the nation ramped up efforts to tackle racist biases in educational settings. Lafayette was no exception to this call to action. Across the division, professors and students alike worked to increase the awareness of potential biases and injustices within Acopian.

Our first analysis was of the current demographics of the Lafayette engineering division. According to Lafayette Engineering's Diversity and Inclusion website, nearly 25% of engineering students are from "underrepresented groups"(Diversity and Inclusion · Engineering · Lafayette College, n.d.). It is unclear exactly what this term represents, however this certainly falls below the 40% average of non-white engineering degree recipients. The division also highlights its partnership with the Posse Foundation to increase accessibility and representation of underrepresented groups in engineering. There are a variety of multicultural, extracurricular groups focused on creating cohorts within the engineering majors. Some of these include the Association of Black Collegians, Society of Hispanic Professional Engineers, Society of Women Engineers, and Minority Scientists and Engineers. Due to their extracurricular status, these clubs are limited to working from an outside perspective.

Lafayette Status Quo

Beginning this project, we had a discussion with Professor Jenn Rossmann of the Mechanical Engineering department about her own work and experiences with integrating anti-racist technological teaching into the classroom. Last spring, she taught a course entitled "Race & Technology" which tackles these exact issues. While this course offers invaluable insight into the potential disadvantages of current technical practices, it is still its own separate entity presenting issues of accessibility to registration for most students and especially B.S. engineers. Our project again is hoping to work towards the integration and existence of anti-racist practices across all engineering classes and curricula. Prof. Rossmann was able to share with us the current practices of the

engineering departments for expectations of anti-racist teaching. Currently, all new professors undergo a year-long training program tackling several different areas of social justice and equitable education training. Additionally, there are voluntary workshops and discussions throughout the academic year tackling how to handle these conversations in an engineering context.

When we focused our project on professor training and workshops, Prof. Rossmann presented some of the potential obstacles that we may face moving into a professor-centric solution model. Firstly, mandatory training may not be received well by an entire faculty. Mandating these forms of workshops is one of the ways to ensure the material is being received by all faculty; new and tenured. Additionally, in an engineering course, professors will already be set on a schedule to tackle a large amount of material in 15 weeks. Adding discussion topics and external material to this already large workload will prove daunting to some professors and unappealing to others. This insight was incredibly valuable in shaping how we plan to implement and strategize our solution workshops moving forward.

Political Context

Historical Context

With the rise of the Black Lives Matter movement in 2013, there has been a growing understanding within the social consciousness of the importance of addressing the issue of systemic racism within American society. This has been reflected in Lafayette's efforts for diversity and inclusion, with the creation of programs such as the Portlock center, the Hanson Center for Inclusion in STEM, and the introduction of seminars on systemic racism for incoming professors. However, these efforts have not had the same fervor within the more technical disciplines of the engineering department, leaving a gap in the effectiveness of such education at this school. This gap has been somewhat filled by courses such as the Race and Technology class led by Professor Rossman, and efforts from the Hanson Center and student-led organizations such as the National Society of Black Engineers and the Society of Hispanic Professional Engineers. However, the lack of an interdisciplinary approach in the technical engineering majors leaves students in a position where they lack the context to understand engineering as a whole and their place and role in it and how the tools they learn as part of their engineering education can contribute to societal issues.

As Smedley and Smedley describe in their article, Race emerged as a concept around the 16th to 18th centuries, becoming cemented as a technology for social control by the 18th century. (Smedley & Smedley, 2005) Around this time the engineering discipline began to emerge as well. Lucena, Schneider, and Leydens go into detail in their book *Engineering and Sustainable Community Development* describing how, "when

countries developed as empires and colonies during the 18th and 19th centuries, engineers worked both for the internal organization and expansion of the empires and in the colonies as agents of imperial development." (Lucena et al., 2010) These two concepts, race and engineering, along with the underlying social structures of empire and colony developed in tandem with one another, giving empires the technical abilities necessary to carry out their projects and simultaneously othering the indigenous inhabitants of the colonized territories. Spencerism developed around the same era, the view that societies evolve and progress from simpler states to more complex ones, and as societies evolve it necessitates the presence of a state, a governing body to keep the whole organized. (Lucena et al., 2010) This was tied to similar concepts such as Social Darwinism and manifest destiny. These ideas combined with the mechanisms of race were employed to facilitate the projects of extermination of indigenous peoples as well as serving as a justification for chattel slavery. Thus, the role of the engineer as an agent of state-building has historically gone hand in hand with white supremacist projects and conceptions of Race as a biological truth. Lafayette College itself played a role in the state-building project in the early United States, established in 1826 as a military and civil engineering school that taught courses in extractive industries such as mining and railroad construction. In World War 1 the college housed and trained soldiers further cementing its underlying role as a military institution. (*150 Years of Engineering,* Lafayette College) From its inception as a school these same values for what makes an engineer have been baked into the very bones of this school.

Continuing into the 20th and 21st centuries, engineering has continued to be used as a tool for disenfranchisement and segregation along the lines of race. For instance, in

the 1950s and 60s developers such as Robert Moses used interstate development as a means to entrench already existing segregation of neighborhoods. In an interview between Noel King and Deborah Archer on the National Public Radio show Morning Edition they discuss how,

> "The highways were being built just as courts around the country were striking down traditional tools of racial segregation. So, for example, courts were striking down the use of racial zoning to keep Black people in certain communities and white people in other communities. And so the highway development popped up at a time when the idea, the possibility of integration in housing was on the horizon. And so very intentionally, highways were sometimes built right on the formal boundary lines that we saw used during racial zoning. Sometimes community members asked the highway builders to create a barrier between their community and encroaching Black communities." (King, 2021)

Given how the concept and identity of what makes an engineer has been shaped throughout (even recent) history, to teach engineering techniques without elucidating the importance of examining social context risks or even guarantees the potential for negative engineering outcomes on social issues of race. As Lucena et al. ask later in their book on page 134, "Does [Engineering] problem solving facilitate certain habits of mind, ways of knowing, and methods of inquiry while unintentionally marginalizing others?" (Lucena et al., 2010) The answer, they find, is that yes, teaching students to solely engage with engineering problems through the lens of quantitative problem solving can severely hamper their ability to approach problems from a more holistic perspective that takes into

account the social relations surrounding an issue. By continuing to teach students that the context of the problems they work on is irrelevant, these classes are preparing students to go out into the world and approach issues again from a quantitative perspective that ignores any social issues at play. In a school that is 80% white where there is already a lack of diversity of perspectives, avoiding confronting this issue head on does a disservice to the students in the engineering department and their future ability to address these vital issues in the contexts of their future workplaces.

Campus Context

In the time since the Black Lives Matter movement started, Lafayette College has made efforts to address these issues, giving incoming professors training on social justice education and organizing workshops and seminars on the topics of race in engineering. These initiatives, as well as the creation of the Hansen Center are solid steps in the right direction, however, there are still many policies and systemic issues present at the school. That courses such as Professor Caleb Gallemore's dual listed International Affairs/Environmental Studies course, "Mapping Environmental Justice" have been moved into Acopian is a promising sign for the future of the integration of the humanities and engineering departments at this school. Yet as Professor Rossman explained when we interviewed her, there has been some push-back from faculty around these initiatives. Many, if not all of the technical engineering courses still lack any integration of context based approaches into their curriculums. In a society where the identity of "Engineer" has become married to the idea of solving issues simply through a quantitative technical lens, to not combat this through a radical adjustment of how engineering is taught at this

school is a tacit acceptance of that status quo. The engineering department at Lafayette is in a position to lead this school into the forefront of socio-technical perspectives on engineering. The resources this school has available all provide the opportunity to better the school for the benefit of students, professors, and the administration alike, however, it will not be easy to work against generations of entrenched biases held within the very foundations of this school. Regardless, in order to uphold the ethical values that define the goals of engineering as a discipline, Lafayette College must take initiative to become a leader for this kind of change.

Technical Context

Abstract

In this section, we analyzed what it meant to teach with an anti-racist pedagogy and how to best adapt it to a technical classroom. Professors must adopt an anti-racist pedagogy into STEM education to ensure that future engineers know how to form and argue opinions, and be critical and social thinkers (Gurin, Dey, Hurtado, Gurin 2002). When adopting this pedagogy, we understand that each professor comes at this with a different comfortability level and perspective. Once an editor at *Rethinking Schools* Magazine, Bill Bigelow believes it is important to start each professor with the right toolbox to adopt an anti-racist pedagogy. To start, all educators need to note that neutral and inoffensive language disregards the conflicts and diversity endured to achieve the end product (Bigelow, 1978). For example, for a professor to teach about modern gynecological tools without discussing the enslaved women on whom these tools were non-consensually tested would be a gross injustice. Students and professors must welcome the discomfort of many of these conversations because racism is ingrained in our society. Ignoring it is ignorant and a disservice to the students trying to obtain a fully diversified education. Applying an ethical pedagogy to a technical curriculum can be challenging, but it can be done effectively with the right tools.

The Pedagogy

Why Is This Important?

College professors are responsible for shaping the minds of the future. Michael Harris, Professor of Higher Education at Southern Methodist University and author of

Understanding Institutional Diversity in American Higher Education acknowledges, "Observers of

higher education generally acknowledge the necessity of institutional diversity to support a system of colleges and universities that proves flexible, responsive, and adaptable for a range of purposes" (Harris 1). Diversity and inclusion are no longer expected to just be seen statistically, but also to be taught and intertwined throughout campus. In this, it is the educator's job to "give perspective to more fully understand society" (Bigelow, 1978). This teaching style has been discussed and slowly adopted over the past 50 years, but more educators must integrate this pedagogy into their curriculum. Bigelow continues, "It highlights the injustice of all kinds— racial, gender, class, linguistic, ethnic, national, environment— in order to make explanations and propose solutions. It recognizes our responsibility to fellow human beings and the earth [...] Aims to make the world a better place" (Bigelow, 1978). After all, is engineering not meant to better the world? Is it not meant to make society a better place? To make our lives better? Students must internalize this pedagogy to ensure a future more inclusive of all.

When students attend a Liberal Arts College, they expect to obtain a robust and holistic education, meaning they will be offered multiple perspectives and opportunities when learning about a historical event; however, there is a disconnect when applying this pedagogy to a STEM classroom. For example, when students learn about Christopher Columbus, they are not only taught about all the land he explored and how much money he made for Spain, but we also focus on the injustices that occurred and the oppression that came out of his explorations. Today, it would be unfathomable to discuss

Columbus's accomplishments without also discussing the heinous crimes he committed; yet, we discuss engineering innovations without mentioning the overlooked, marginalized, and exploited people it took to achieve the invention. For example, a multitude of engineering disciplines could discuss the invention of the traffic light. Whether it be mechanical, electrical, or computer engineering, the techniques used to create the traffic light could be applied to all; however, little is taught about its inventor Garrett Morgan, a Black inventor from Cleveland, Ohio who paved the path for many Black engineers to come (Biography, 2018).

Applying it in the Classroom

Professors start the anti-racist pedagogy journey at many different stages. It would be inherently wrong to practice an anti-racist pedagogy without being patient with its followers. Enid Lee, the director of a Canada-based consulting firm dedicated to implementing an anti-racist pedagogy into the curriculum, outlines some very simple yet effective steps professors can take toward adopting an anti-racist way of teaching.

Detailed steps are outlined below, but Lee notes that it is up to the individual to decide where they start their journey. Lee suggests starting with the basics. Just as one would do when learning anything else, consider what this means to you personally and in the context of your career (Lee, 2009). It is important for the professor to reflect on their practices and beliefs individually and how they may or may not follow an anti-racist way of teaching. Educating oneself on this method and reading what experts have published before them is crucial. Professors will need to take a step back and think hard about what

perspective they are teaching from and whom they are marginalizing or forgetting because of that. Lee encourages faculty to discuss socio-technical issues with their peers and students to grasp what it truly means to hear and appreciate multiple perspectives (Lee, 2009). Identifying the boundaries established by the engineering department and Lafayette College is essential to understanding where the department currently stands before progressing forward with pedagogy changes.

Next, Lee suggests that teachers incorporate anti-racist pedagogy into one unit on their syllabus. In doing so, professors are given the time and space needed to practice this way of teaching in small doses (Lee, 2009). They will also be able to receive feedback from students regarding the unit and will be able to make changes in the future. This pedagogy will not be mastered overnight; professors should not expect it to. A way to do this in a technical classroom would be creating a unit in which the students do a project on an invention and uncover all the unknown information about its inventors. In this, students will learn about the technical invention (how and why it was created, its triumphs and failures, etc.) and the people behind it.

Once the instructor feels comfortable teaching such a unit, they can start incorporating these methods into every lesson they teach (Lee, 2009). Professors can give context and background on all systems they teach. The professor must first be comfortable teaching with this methodology because it can be uncomfortable for students to learn this way. Self-reflection is a crucial part of this process on all ends. Students will be pushed to rethink the world around them, which can be challenging coming from a

background where this is not the norm. Another challenge professors may face while integrating anti-racist pedagogy into their teaching is the expectation many engineering students hold that STEM classes will be technical, with answers that can simply be judged as right or wrong (Rossmann, 2022). While integrating such topics into their courses, professors must be able to effectively teach students that the "optimal" solution to engineering problems is not always the most ethical or just approach and the context surrounding the problem, including how the "problem" itself is defined just as vital, if not more so than the technical aspects of engineering education.

Students retain information better when they know they will be tested on it, so like any other systems exam, ethics questions can also be included. For example, solve the system, explain who the inventors were, and how they created it. Students could be tested on their understanding of the political and social contexts surrounding engineering topics they are learning about in class.

Teaching Example: The Traffic Light

Overview

Below, is a simplified outline of a lesson plan for three fifty-minute Electrical Engineering classes (1 week). In this example, the professor will teach the necessary technical equations and give relevant historical background to amplify the students' social awareness. The lesson plan outline is depicted below, with a detailed description of each step following.

Mock Lesson Plan

Figure 2, Day 1, Lesson Plan Day 1, As created by Authors

Step	Time Duration	Activity
1	10 min.	Who Invented the Traffic Light? Garrett Morgan overview with emphasis on being a Black inventor in mid-1900s Cleveland
2	10 min.	Class discussion about the importance of city planning. Give the example of Robert Moses.
3	20 min.	Traffic light mapping and detection tools
4	10 min	Ending discussion: what is the societal importance of traffic lights and general traffic planning?

Figure 3, Day 2, Lesson Plan Day 2, As created by Authors

Step	Time Duration	Activity
5	10 min.	Recap the importance of mapping
6	30 min.	Control Panel overview and analysis
7	10 min	Ending discussion: how might different cities implement control panels to adhere to city limitations?

Figure 4, Day 3, Lesson Plan Day 3, As created by Authors

Step	Time Duration	Activity
8	10 min.	Reflective writing assignment on known Black inventors
9	30 min.	Discussion: 1900s implementation strategies of the traffic light and what might change today
10	10 min	Systems and Circut Practice Set

The Lesson Plan Explained

1. To start the lesson, we expect professors to give adequate background context on the invention's social, political, and overall general context. Providing students with the background of the problem and proposed solution allows them to think critically about the greater issue trying to be solved (Gurin, Dey, Hurtado, Gurin 2002). In this example, the background context also sheds light on a Black inventor that may have been overlooked otherwise due to his stature in the early 1900s.
2. Further context on what is happening in the city planning field around the nation and the issues and injustices arising. It is important to learn about Robert Moses, a notoriously racist city architect for New York City in the 1900s (Britannica), while learning about the invention of the traffic light because the traffic light enabled Moses to enforce his racist agenda. This information allows the student to think about other inventions that lead to the further marginalization of groups and how to avoid this issue in the future.
3. While the background and social context of the traffic light are largely important, the student must also learn the technical aspects of inventing and constructing an automated light system. This will be split across the entire week as it is a long and intense circuit

and system process (Utrecht University Institute of Information and Computing Sciences).

4. Connect the full lesson circle by ending with another class discussion. In this discussion, students should be asked to think beyond the scope of the day's lesson and apply the information to a greater social context. This is important for students to practice in the classroom so that when they enter the labor force, they can apply the lessons learned in the light traffic example to modern problems and propose dynamic solutions.
5. Reinforce what was learned at the beginning of the week to ensure the students and the professor start on the same foot. Recap the technical skills learned in the last class and the social issues discussed and their importance. It is important to continuously reinforce the ideas the professor wishes the students to remember. The brain must be trained to re-learn and re-think in this anti-racist manner, just like any other muscle would have to relearn a sports skill after an injury.
6. Like on the first day, staying on top of the technical and mathematical skills needed to create an efficient traffic light system is important. Professors should note what "efficiency" means in this case and how the definition might change from community to community.
7. Follow up the before point with an ending class discussion of how students would change the traffic system in their town. Ask them to think about the current issues, why the infrastructure is currently set up that way, possible solutions, and the implications of those solutions.
8. Ask students to think of other Black inventors that may have been overlooked in history. Why did this happen? Is this trend changing? As students about to work in the industry,

how do you avoid this happening in the future? Asking students how they might make a change is an effective way of bridging the social context presented earlier in the week and encouraging them to think about all the pieces more dynamically.

9. Open the discussion further to the social and political context in 1900s Cleveland and how that affected the nationwide traffic light implementation. Push students to think about if they were to invent and implement the traffic light today, other than technical advancements, what policies and practices are in place that changes the creation, distribution, and implementation of the traffic light.
10. Finish the week with a circuit and systems problem set that focuses on the technical aspects of creating and installing a traffic light system.

Example exam question: The below circuit represents a traffic light system that is being considered for the town center of Easton. Explain, mathematically, why or why not this would be a good alternative. Also, explain in words some possible implications of this proposed infrastructure, how we might have seen something similar in the past, and the changes *you* suggest to improve the traffic system.

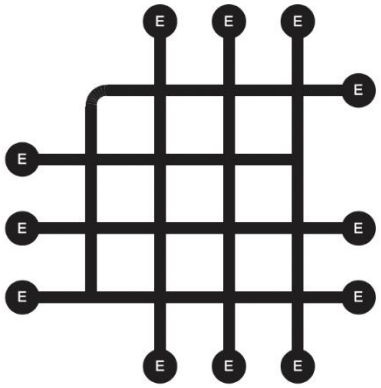

Figure 5, Traffic Grid, Sample Traffic Grid for an Exam Question, Utrecht University Institute of Information and Computing Sciences

General Lesson Plan Trends

Like many technical-based classes, the outline above focuses on reinforcing the concepts learned at the beginning of the week throughout the week. This approach was also taken with the social concepts as the plan sets aside time each class period to think about the social and ethical implications of the technology. Asking students to consider historical and possible future solutions allows them to think critically and analyze all aspects of the problem at hand. Breaking up the ethical conversation into smaller, more pointed discussions helps the professor and students understand the social context and how to better the process going forward.

Economic Context

Abstract

This section will focus on the economic factors that go into integrating an anti-racist pedagogy into STEM education at a liberal arts college. This section will highlight many aspects of the resources already available to professors at Lafayette college while suggesting additional programs. This project's economic scope spans from student and professor retention to investing in a greater tomorrow. Lafayette College will pay for the facility to attend off-site training programs that will further enrich their professional career. Professors like Jenn Rossmann have used this opportunity to participate in a class entitled *Race and Technology* at New York University (Rossmann, 2022). Furthermore, the Center for the Integration of Teaching, Learning, and Scholarship at Lafayette is an excellent resource for faculty and teachers to discover research programs, faculty services, and training. As previously mentioned, we implore the CITLS to implement a syllabus review program to help professors incorporate an anti-racist pedagogy in their pre-existing curriculum. By incorporating this way of teaching into Lafayette's engineering curriculum, the school is increasing the value of its students, professors, and overall programs.

Investing in Lafayette Students and Professors

Professors

Many of the expenses spent on training professors might be considered a sunk

cost by any Introduction to Economics student; however, this is different because the overall value of the professor will have increased. Anti-racist trainings and seminars provide the individual professor with more dynamic teaching skills and techniques. The college is also increasing its prestige by enhancing the professor's career. To have well-rounded STEM professors means the overall value of the engineering programs is increased. This will attract more students and professors to the college and, in turn, increase the college's revenue.

In order to reduce the cost of professor training, the college needs to look at hiring faculty with diverse skills and interests. By this, we are encouraging the College to focus their new hire search on candidates who have previous training in DEI and can offer suggestions on how to implement diverse curricula into the engineering curricula further. The college will increase its overall status by hiring cutting-edge thinkers and encouraging students from all over to learn at our DEI-focused, liberal arts-based engineering college. Drawing positive attention to Lafayette's engineering program will encourage students and faculty alike to study in the foreground of a new STEM pedagogy. A diverse way of teaching includes encouraging students to use active thinking skills, form perspective, and enhance racial understanding (Gurin, Dey, Hurtado, Gurin, 2002). By hiring professors with predisposed knowledge and practice with an anti-racist pedagogy, the college saves money and will be more attractive to potential students. While the college trains all new hires and includes seminars on anti-racism, the more practice one has with this pedagogy, the better. This will also foster more robust inter-departmental dialogue regarding strengths and weaknesses found while adopting an anti-racist way of teaching. Many disciplines at the college already practice an anti-racist

pedagogy, so including it in the STEM curriculum will further harness the Lafayette sense of community. As students at a liberal arts college such as Lafayette, we have noticed that much of the curriculum across departments is connected to diversity and inclusion; however, there is an apparent lack of DEI discussions in the engineering curriculum. It is virtual to the survival of Lafayette College that all departments start implementing a DEI curriculum to ensure students and faculty feel safe, heard, and welcomed all across campus. There is an evident inequality in engineering education verse humanities-based courses in that engineering students are deprived of the opportunity to deepen their connection to their peers, themselves, and their studies.

Students

Lafayette College professors are shaping tomorrow's minds, and it is essential to provide students with all the tools possible to help society. Investing in the student's future will turn around to financially benefit Lafayette through alum donations and increased word of mouth. The more successful a student is after college, paired with their college experience, directly impacts their donations to the school (Lafayette College 2021). Lafayette is investing in its future by investing in the student's education and well-being.

One of President Hurd's goals when arriving at Lafayette college was to enhance the student's sense of belonging, strengthen our sense of community, and prepare students to be the leaders of tomorrow (Get to Know Nicole Hurd, 2021). One way to do this is to create a more accepting campus environment. For it to be expected that all students can think dynamically and emotionally intelligently, professors must take the

first step and enforce these learning standards in the classroom. Lafayette hopes to produce the student that will shape a better tomorrow, but this is an impossible task without first teaching them about the hardships and misconducts of yesterday. Students take what they learn in the classroom and apply it to real life. Lafayette Students are fortunate enough to have a safe and nurturing environment to explore their personality and who they want to become. To grow and learn as an individual, you must apply empathy and intentional decision-making inside and outside the classroom. To help the students transform their community, they look to their professors for examples. It is up to the professors to teach their students to accept and have empathy for all. By providing students with a happy and well-rounded college experience, Lafayette is increasing the value of one of its post-graduates.

After dissecting alum donation trends, we have discovered that alums further from the time of graduation and with family members attending the college after they increase their chances of donating (Lafayette Gift Performance 2020-2021). Many of Lafayette's alum donations come from students and athletes who feel they were seen, heard, and listened to while attending Lafayette College (Summary of Giving 2020-2021). With so many donations from our alums, the heightened importance of cultivating an accepting community is glaring. Suppose Lafayette College wants to continue receiving donations from alumni who felt accepted and welcomed inside and outside the classroom. In that case, the STEM pedagogy must change to one that is much more robust, diverse, and inclusive. According to Lafayette College's Common Data Set for the 2022-2023 school year, the graduating class of 2022 consisted of 19.74% engineers, and the diverse makeup of the College was 22% non-white (Common Data Set 2022). While not every student

was accounted for in the data set, about 28 non-white students graduated from Lafayette College with some engineering degree in May of 2022. Twenty-eight more students were sent into the workforce without the proper DEI background and training to solve contemporary and pressing world issues. Lafayette College does right by its students in many facets, but neglecting the engineering student's right and responsibility to learn, dissect, and problem-solve from a diverse and inclusive perspective grossly misrepresents what it means to create a better tomorrow.

Training

While Lafayette offers several programs and trainings for both new and existing faculty, there is always more than could be done. Heather Bambam, the Curriculum Director at the Great Lakes Science Center, shares some initiatives that have helped her and her team focus on diversity and inclusion in STEM education. Bambam discusses the 1968 Brown Eye/Blue Eye experiment (Smithsonian, 2005). Before suggesting ways we could adapt this experiment into faculty training, she notes that many of the ethical questions of the experiment regarding the participants' age would not be an issue in this case as all participants would be consenting, informed adults. She suggests that seminar leaders divide the participating group into categories based on arbitrary attributes such as hair color, and then randomly decide which group is "better." Like in the case of the children, it will become abundantly apparent that the "dominant" group takes on attributes consistent with those that align with a racist pedagogy. This small experiment will illustrate firsthand to professors just how important this way of teaching is and how

personally impactful marginalizing language and practices can be to minority groups. This experiment is just one of many examples of free training that Lafayette could adopt.

The Center for the Integration of Teaching, Learning, and Scholarship at Lafayette College aims to "further the institutional mission of Lafayette College by providing research-based programming, services, and other resources to support faculty as teacher-scholars. Working in partnership with faculty, administration, staff, and students are integral to our success" (CITLS). This center aims to help professors create and foster a diverse and holistic learning experience for students. The CITLS often pairs with the College's Hanson Center for Inclusive STEM Education to create programs and lessons encouraging professors to include DEI in their curriculum. The Center currently has a board-approved monetary budget for professor trainings and seminars, but time and resources also play a factor when budgeting (CITLS). Asking professors and faculty to set aside extra time to participate in DEI training may be time intensive at first; however, in the long run, these trainings will add a non-quantifiable amount of value to Lafayette as a business and Lafayette as a community.

Conclusion

The Lafayette Community gives the highest regard to its engineering programs and the ways in which it produces high-achieving, competent graduates and attracts further prospective students. The Bachelors of Science (B.S.) Programs in Mechanical, Civil & Environmental, Electrical, and Chemical engineering all prepare students to enter the workforce and provide the tools for numerous technical challenges they might encounter throughout their careers. While Lafayette as a school values a multidisciplinary education by requiring engineering students to also fulfill humanities requirements–as we have discussed throughout this project–the lack of integration between engineering classes and topics of racism and technology leaves Lafayette engineering students unprepared to combat systemic racism within technical fields. Even within the Engineering Studies Major, a program that by its own definition is intended to prepare students to address complex social issues in relation to their intersections with engineering, the nature and history of engineering in the context of race and white supremacy ingrained in engineering development is not discussed until this programs capstone course. Students are already preconceived about this lack of bias awareness by the time they have entered their senior year. This is reflected on an even greater scale across the engineering department as many students have no understanding of how their work and future careers shape the societies and communities they live in. With the recent rise in the cultural consciousness on systemic racism and white supremacy from the Black Lives Matter movement, it seems odd that a school that prides itself on its

programs for diversity and inclusion has not made efforts to be at the forefront of socio-technical education. The tools for self-reflection earned from the integration of racial justice lessons into daily classes could offer students invaluable skills to combat racial injustices within their field as well as previous notions of technological determinism within their communities.

Building a Framework

Throughout our process, our goal was to work with already existing resources at Lafayette in order to minimize the cost to the school and make our suggestions more appealing to the administration. Fortunately, Lafayette has programs and professors eager to integrate anti-racist lessons into their courses and many preexisting resources to draw from. For incoming professors, there are seminars and training programs available to prepare them for their work on topics of racism. The Center for the Integration of Teaching, Learning, and Scholarship (CITLS), as well as the Hanson Center, are both involved in efforts to increase the accessibility of such resources to both students and professors, however, as we have discussed, there is a lack of cohesion between the various programs on campus directed towards these efforts. Throughout our project, in our research and interviews, we found that approaching this issue at the level of the professor would be most effective within the constraints that we had. While future efforts from the students and the administration are also vital, through our interview with Professor Rossman, we determined that professors are the most well-equipped currently to make a change in this way. Previous capstone projects have worked on similar issues

such as the Justice in Acopian project which had previously determined as well that there were gaps in the engineering (studies) curriculum. While their project more generally suggested the broader and earlier integration of racial and environmental justice courses into the engineering studies curriculum, we made the determination that a more comprehensive approach that strives to integrate these ideals across the engineering division as a whole was necessary for addition to their suggestions. Looking beyond our project timeline, we hope that both the Hanson Center and CITLS consider our proposals to create a syllabus review program for the engineering program, continue to build their existing resources, and work to communicate closely with professors around these topics.

Future Capstones

Future iterations of this capstone project should build effective communication between engineering professors and the Hanson center as well as Engineering professors and those in the humanities. (Anthropology & Sociology, Africana Studies, International Affairs, etc.). Many professors in non-engineering departments have already developed courses on environmental justice through the lens of critical race theory that incorporates engineering issues, such as Professor Gallemore's International Affairs/Environmental Studies course "Mapping Environmental Justice" and Professor Fernandes' English course "Nature Writing". These professors' experience and knowledge in racial education and the impacts of the engineered world are valuable resources that should not be ignored in helping to integrate anti-racist pedagogy into Lafayette engineering. Additionally, developing measures of accountability and assessing students' understanding of this topic

is a vital tool that needs to be developed in order to measure the impacts of these efforts going forward. We suggest that developing a yearly survey for engineering students that records the classes they took as well as how these courses impacted their understanding of the intersection of race and technology could be a valuable step in efforts to expand this type of education to the greater engineering department.

Overall, these efforts to integrate an understanding of the racial and societal contexts of engineering into the curriculums of the Lafayette Engineering department will require ongoing concerted efforts from students, faculty, and administration in the ongoing years in order to accomplish the goals and reflect the images Lafayette holds for itself as an institution that values diversity and inclusion. Lafayette, however, is uniquely positioned as a liberal arts school with strong humanities programs to work towards integrating a cohesive understanding of the societal and racial impacts of engineering by bringing in the perspectives and experiences of other departments. Regardless of the difficulty of such a transition, we believe that such efforts are vital for the continued success of Lafayette as an institution dedicated to providing a well-rounded education to its students.

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