Socio-technical Engineering Education in Middle School Outreach Programs

Milestone 7: Complete Report

EGRS 451: Senior Capstone Seminar in Engineering & Society

Swetha Tadisina, Jahi Heath, and Grace Ouko

12.10.2024

Professor Sarah Appelhans

INTRODUCTION

Traditional engineering education gives overwhelming precedence to technical skills, leaving little room to explore the field holistically (Wisnioski 2012). This makes engineering seem distant and irrelevant to the experiences of middle school students, often discouraging them from pursuing it. As seniors in the Engineering Studies program, we want to introduce a more holistic understanding of engineering education—we argue that this will help contribute to broader understanding and representation in the field and help middle school students of varied backgrounds see themselves as engineers of the future.

To make the subject more engaging and relatable, we developed two lesson plans that prompt exploration of the question "What is Technology?" and connect engineering to practical contexts. The two lesson plans we designed for this were: "*What is Technological About a Toilet?*" and "*Who, What, and Where of Breakfast Cereal*". We chose to teach about toilets under the sociotechnical framework because toilets represent a technology that not only involves innovative design but also addresses critical societal challenges of public health, environmental sustainability, and infrastructure systems.

Through this project, we hope to find out what exactly might be absent (or beneficial) in the middle school curriculum in Easton, why there might be a need to address it, and what we expect it will achieve. As sociotechnical engineers, we also reflected on our own experiences in engineering and the educational experiences that best educated us on these concepts.

SOCIAL CONTEXT

Across the world, *technology* permeates the modern human experience throughout one's lifetime. Whether it is understood as a collection of objects for utility, as an activity, as a sociotechnical system or something else logically depends on individual perception, collective conversations, and formal education around it. These perceptions have changed immensely over time, creating a significant shift in how engineering is performed, taught, and considered in our contemporary society (Wisnioski 2012). This mindset has shaped the engineering disciplines to become solely fixated on technical effectiveness and execution, forcing society to be hindered by a field of study that serves to advance humankind.

This historical trend of engineering being a narrow, uni-dimensional practice that prioritizes technological advancement has created systemic barriers and limited representation from underrepresented groups. Through STEM outreach programs, we can address these inequities by reintroducing engineering as an interdisciplinary and sociotechnical field that values diverse perspectives and fosters equity in education and practice (Lucena 2024).

When we ask American students, "what is technology?", their typical responses are not surprising: devices, social media, and machines. Although these perspectives are from younger students, this idea reflects the contemporary beliefs in public discourse that often link "technology" primarily with "computers," similar to how previous views associated technology with machinery, tools, and industrial processes (Cohen et al. 2014, 6). Traditionally educated engineers also typically view technology as deterministic and object-oriented (Bijker 1992, 71-82). Critical theories of technology in the 1960s and 70s, and the consequent development of fields like Engineering Studies, History of Technology, and STS deconstructed and challenged the popular understanding of technology as value-free, apolitical, asocial, deterministic, and neutral (Wisnioski 2012, 10-13).

Within formal education, technology is understood as a sociotechnical system only in select spaces in certain educational environments such as Engineering Studies programs, Human Factors Engineering programs, and some humanities courses. At the primary and secondary school levels in Pennsylvania, this happens sporadically (Pennsylvania Department of Education 2023**)**, in ways that do not begin to reinforce any idea of technology beyond the physical artifact.

The ultimate case for teaching engineering as a sociotechnical process has been articulated within Engineering Studies class discussions and by Cohen et al.: the social and technical are not divorced within a "technology" (Cohen 2014). To align undergraduate education with this philosophy, the Introduction to Engineering course taught from this lens at Lafayette College has been tested and built on. This calls for the need to expand the image of technology within a younger generation by including nuanced and informed definitions such as 'sociotechnical systems', 'legislators of the future', 'congealed knowledge', and 'human activity' (Cohen, "Part 1: Introduction"). Similarly, we expect to see that introducing technology as sociotechnical systems at the middle-school level would provide a headstart in our goal of 'making socio-technologists'.

Across the globe and specifically in the US, the image of an engineer is characterized as male, technical, and physically labor-intensive. As shown in many forms of media like television and pictures in textbooks, younger generations view an ‘engineer as the hero’ as was popular in the industrial age or as a mere political tool in the age of science (Wisnioski 2012). This viewpoint inevitably creates a particular mould that students either embrace or reject during their journey of becoming engineers (Kney 2024). This is a decision that is rooted deeply in the perception of engineers within society, which can often be discouraging for individuals from disadvantaged backgrounds. Many of these students feel as though there is neither representation nor a mere presence within the field, leading to a lack of inspiration and motivation to pursue engineering careers (Slaton 2010). This is portrayed through the overwhelming trend of demographic dominance of white, heterosexual, middle-class men in engineering, reinforcing a specific form of masculinity as the cultural norm in the field (Secules 2019). In relation, engineering curricula retain a prevalent connection between masculinity and competition within both engineering education and broader U.S. culture (Secules 2019).

This dynamic spotlights how students who were more inclined toward competitive interactions were consistently white male students who held sociological dominance within these spaces, perpetuating the exclusion of minorities from them. Non-dominant students often recognize the presence of competition but choose not to engage, explicitly distancing themselves from the dynamics that reinforced a dominant in-group and marginalized others (Secules 2019). This exclusionary culture aligns with broader demographic hierarchies in engineering, where dominance and marginality are tied to race, gender, and sociocultural identity.

By privileging competition as a core value, engineering education risks perpetuating narrow perspectives that overlook the diverse approaches and collaborative practices necessary for fostering innovation and inclusion in the field (Riley 2017). Therefore, enhancing accurate and diverse perceptions of engineering will require targeted educational interventions, specifically STEM outreach programs to younger students expanding this narrow perspective of how engineers look, think, and work within the discipline.

This intervention will challenge traditional STEM education that was aimed at increasing accessibility in response to strictly adhering to scientific and technological demands. However, access to high-quality STEM education has often been accompanied by disparities based on geography, socioeconomic status, and demographic factors (National Academies of Sciences, Engineering, and Medicine 2011). This was a result of flawed policy formulation, which led to legislation that systemically created barriers for minorities to have equal education within the early 20th century. For example, the "separate but equal" doctrine, established by *Plessy v. Ferguson* in 1896, lawfully established racial segregation and became the backbone of policies that systematically deprived minorities of access to essential resources, especially in education (Slaton 2010). Under this doctrine, schools for children from disadvantaged backgrounds were consistently underfunded, overcrowded, and lacked basic educational resources compared to predominantly White schools. This problem has led to a lack of diversity in the field of engineering, the creation of ineffective solutions, and the development of technologies that do not align with the values and needs of society.

To solve this issue, the school districts have prioritized the growth of engineering outreach initiatives, which aim to broaden access, inspire diverse talent, and engage underrepresented communities in pursuing engineering careers (Bakshi 2024). However, the initiatives typically favor the traditional engineering practices of the past, which re-establishes engineering as a purely technical field of study, creating fewer opportunities for sustainable growth and change within society (Riley 2017). Nonetheless, our implementation of a sociotechnical lesson, taught by a diverse group of people of color, challenges traditional engineering norms by exploring questions like "who decides the course of technology?" and "what values shape innovation?".

By integrating interdisciplinary concepts such as human factors of engineering, life-cycle assessment, waste management, energy systems, and environmental justice, the lesson encourages students to view technology holistically and consider its societal impacts. Connecting these concepts to everyday life will help students reflect on how technology affects communities and the planet, fostering critical thinking about ethical decision-making. Our approach aims to foster a more inclusive and thoughtful perspective on technology and empower all students to pursue engineering.

POLITICAL CONTEXT

Political frameworks and policies significantly impact access to quality STEM education, funding, and outreach opportunities. In the United States, initiatives often focus on reaching under-represented groups, including women, minorities, and low-income students, to bridge participation gaps and address structural barriers within education systems (Ochoa and McCrary 2022). This growing recognition of the importance of diversity and equity in education is particularly critical for marginalized communities. This focus not only aims to diversify the workforce but also seeks to foster a more just society by providing equal opportunities for all students to engage with STEM disciplines.

STEM outreach and education are often framed within the context of national competitiveness, as countries strive to cultivate a workforce capable of keeping pace with global technological advancements. This competitive framing emphasizes the significance of producing a skilled workforce that can drive economic growth and maintain a nation's position in the global market (Ochoa and McCrary 2022). However, such a perspective can sometimes overshadow broader educational goals, such as fostering creativity, critical thinking, and social responsibility among students.

Decisions regarding curriculum development, research funding, and educational priorities are often shaped by political agendas and the allocation of federal and state resources. For instance, national priorities in areas like technology, defense, healthcare, or infrastructure can direct funding toward specific fields, influencing what students learn and how outreach programs are structured (Miaoulis 2010, 37-39). Organizations such as the National Science Foundation (NSF) work to enhance STEM education, however, the effectiveness of such initiatives often relies on local implementation and the political climate.

The figure below shows the decline in the overall funding rate to 26% from 28% in 2020, marking a trend of reduced funding opportunities (NSF 2024). This tightening of funding opportunities reflects broader constraints in federal science budgets and highlights the growing competition for research grants. Programs like LafKid Connect, which emphasize inclusion and broader impacts, are critical in addressing these societal needs, even as funding opportunities become more selective.

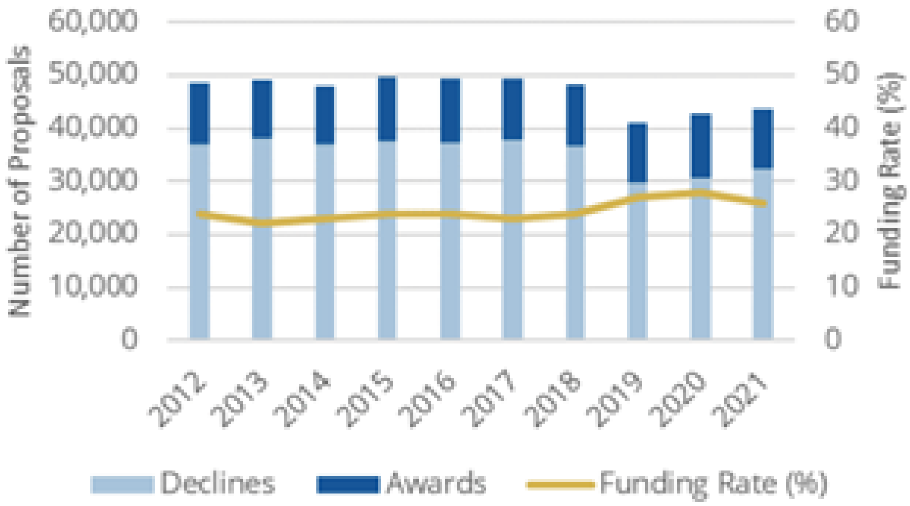


Figure 1: Overall award, decline and funding rate trends. Source: NSF

At the local level, the city of Easton illustrates these political dynamics on a smaller scale, where community demographics and socioeconomic status create specific educational needs. As of 2022, Easton's population demographics reveal a predominance of White residents, while Black and Hispanic residents represent notable minority groups (Data USA 2022). This diversity is mirrored in the Easton Area School District, where nearly half of the student population identifies as racial or ethnic minorities. Approximately 47.8% of students in this district are economically disadvantaged, and 8.2% are classified as English language learners, highlighting the significant need for tailored educational support (Data USA 2022).

Local politics play a crucial role in shaping public funding and educational policies. In Easton, challenges related to funding disparities and educational inequities are prevalent, especially within the local school district (Kun 2024). Decisions made by city governance and the school district's board directly impact funding allocations and educational priorities. For instance, the LafKid Connect program, which aims to connect Easton Area Middle School students with college students and faculty recently lost funding (Fowler 2024). This highlights the fragility of outreach programs that rely on political support and funding stability.

Universities can act as hubs for research and innovation in STEM education. Through partnerships with local schools and community organizations, they can implement evidence-based practices that enhance the effectiveness of outreach initiatives (Fowler 2024). By focusing on sociotechnical approaches, institutions teach students how STEM fields manifest in the real world, such as in sustainability and the social impacts of technology. Lafayette College's LafKid Connect program plays a key role in addressing educational disparities in Easton. By engaging with local middle school students, the program provides hands-on experiences in STEM disciplines, enriching the educational landscape for both K-12 participants and college students.

For college students, volunteering in outreach programs helps Lafayette students develop essential skills such as communication, leadership, and mentorship. Furthermore, these experiences cultivate a sense of social responsibility and a deeper understanding of the challenges faced by diverse communities. STEM outreach and engineering education programs are situated within a complex political landscape where national, state, and local policies intersect to influence who has access to quality STEM education. While national and state policies provide frameworks and funding, local implementation and partnerships, particularly with universities, determine the success of these initiatives. By understanding and leveraging political support and addressing structural barriers, STEM outreach projects can work to create a more inclusive and diverse STEM workforce, meeting both educational and economic objectives in the process.

As seniors in the Engineering Studies Program at Lafayette College, while we are taught concepts in sociotechnical systems, we are also equipped to understand how technology and engineering have been taught throughout history, including in political contexts. Over four years we learn to see technologies with greater nuance and communicate it to broader audiences. We also learned about the family of STS fields – Engineering Studies, History of Technology, Humanitarian Engineering, Holistic Engineering, etc. For these reasons, we are in a position to explore new ways of engineering education at the K-12 level.

Engineering Outreach Programs and LafKid Connect Program

We focus on outreach programs in our project. While a curricular reform may be recommended, we believe there is unparalleled agency and potential within outreach programs. The effectiveness of outreach programs has been studied by Appel, who has shown that outreach programs have been and will be an ongoing effort to bring more underrepresented communities to STEM fields in general (Appel et al 2020, 2).

The Lafkid Connect program is a collaboration between Lafayette College and the Easton Area Middle School, facilitated by the Landis Center for Community Engagement. Adam Finkelstein ’20 developed LafKid Connect during a social entrepreneurship course at Lafayette to address a gap in mentorship and exploration opportunities for local students. LafKid Connect provides middle school students from underrepresented backgrounds with the opportunity to experience a college campus and receive mentorship from college students.

The program is designed to create a welcoming and engaging environment that not only facilitates exposure to higher education but also actively promotes inclusivity. By immersing these middle school students in a collegiate setting, LafKid Connect helps to demystify the college experience and instills a sense of belonging that is often missing in traditional educational pathways. The mentorship component is particularly significant since mentors undergo comprehensive training aimed at promoting cultural competence. This training equips them with the skills necessary to engage with the students in a way that is both respectful and understanding of their unique backgrounds (Fowler 2024).

ECONOMIC CONTEXT

Easton Area Middle School, like many public schools, relies heavily on state funding, which is often constrained by budgetary pressures. These limitations can lead to challenges in providing extracurricular activities and opportunities that foster career readiness and college aspirations. Lafayette College alumni Thomas R. and Sharon Smith's financial gift supports operational costs including transportation, field trips, and supplies essential to ensuring that students can participate in activities (Wilson 2021).

Beyond financial contributions, LafKid Connect thrives on the volunteer efforts of Lafayette students, whose time and expertise are critical to the program's operation. As mentors, these college students provide personal connections and relatable role models for middle schoolers, embodying the program's mission to inspire and empower. The economic context of their volunteerism is significant, as it represents an intangible yet critical resource. While volunteerism is invaluable, it raises the important question: what if the mentors were compensated for their contributions? Compensating mentors could not only acknowledge their efforts but also ensure the sustainability of such programs.

Table 1 illustrates the potential costs associated with compensating mentors based on the Lafayette College base hourly wage rate of $ 8.25 for a 13-week semester. When considering all 15 students, the weekly total cost for the program is calculated to be $123.75 (15 students multiplied by $8.25). Over the course of 13 weeks in the semester, the total cost for the program amounts to $1,608.75, which is the minimum value of the program for one semester. This analysis shows the economic implications of volunteer-based programs and the importance of exploring sustainable funding models that balance community engagement with fair compensation.

Category	**Calculation**	**Cost**
Hourly rate per student	Fixed-rate	$ 8.25
Weekly rate for all 15 students	15 * $8.25	$ 123.75
Total pay for 13 weeks in a semester (i.e. minimum value of program per semester)	13 * $123.75	$ 1608.75

Table 1: The estimated compensation costs for Lafkid Connect mentors over a semester

TECHNICAL CONTEXT

In developing lesson plans for middle school students for outreach programs, we have focused on the overarching question of "What is Technology?". We have been able to test our 'solution' with students in Easton Area Middle School at their weekly LafKid Connect session. Criteria for technologies or sociotechnical systems were 1) easy for students to understand, 2) demonstrates underlying social, political, or economic contexts, 3) Fun.

Solution 1 - Who, What, and Where of Breakfast Cereal

One sociotechnical system that met our criteria was children's food, especially packaged and processed food. We chose breakfast cereals because of their widespread presence in American homes. National surveys in the United States confirm that most frequently consumed foods at breakfast are cereals (Hoy et al 2024).

Time Duration	Activity
2 min	- Introduce mentors - Explain the Engineering Studies program
3 min	- Where is food made? Who or what makes it?
3 min	- Introduce James Caleb Jackson, John Harvey Kellogg, and important figures in industrial food revolutions
5 min	- Exploring popular terms: how do you define "organic"? "Artificial?" "Sustainable?" "Healthy?" "Technology?" - Why is it important to know (and decide) their meanings? Who decides them? - What is a sociotechnical system?
15 min	- Divide into farmer group, truck driver group, scientists group, packagers, and retail group – start from the top and demonstrate real-life considerations of the supply chain of the cereal
5 min	- Genetically Modified Foods, fertilizers, high-yielding varieties
10 min	- Introduce Professor Benjamin Cohen's work in Food Studies. Discuss experience as students of a sociotechnical engineering program and as a College in general. - Reflection and reiteration of concepts

Table 2: LafKid Connect Lesson Plan, as created by authors

The lesson plan on cereal has several strengths. The relevance of food as a topic is accessible and relatable to middle school students. The lesson plan provides a holistic and interdisciplinary understanding of the historical, cultural, and technical aspects of food production. The introduction of food studies by Professor Benjamin Cohen offers a unique opportunity for students to gain insights into the study of sociotechnical systems through academia. It might also inspire students who are interested in food studies to come work with Professor Cohen at Lafayette College.

However, the lesson plan also presented several drawbacks. The complexity of the topic risked being too advanced for middle school students to fully grasp within the limited timeframe of a one-hour lesson. While the supply chain activity role play could be interactive, much of the lesson relied on lecture-style discussions for example the industrial food revolution and definition of terms. This could potentially lead to disengagement among the middle school students as they do not like being talked at. Ultimately, this lesson plan was not chosen because of its complexity and the limited hands-on engagement needed to capture their attention.

Solution 2 - What is Technological About a Toilet?

We found the sociotechnical systems around sanitation and waste management to be particularly extensive, of great depth, and relevant. This is based on the longstanding global challenge of sanitation and sanitation-related diseases as well as daily life which involves the usage of some form of toilet. We hoped to initiate conversations that expand the idea of technology. Through the discussion of sanitation and wastewater management systems, we can introduce well-established concepts in STS as well as nuances, such as “what is a norm?”, “what is a design decision?” and “who are the participants in a technology?”.

Time Duration	Activity
2 min	- Introduce mentors - Explain the Engineering Studies program
4 min	- Defining technology by providing examples - Is the toilet a technology? Why or why not?
3 min	- Discuss basic human needs for hygiene and relate them to rights like sanitation and building codes.
5 min	- History of toilets. Present pictures of toilets from ancient to modern designs, discussing the historical context.
15 min	- Break students into small groups to brainstorm and design a toilet. Consider 1. Cost and materials 2. Norms and culture 3. Sewer systems 4. Wastewater management and clean water 5. Health concerns
5 min	- Sociotechnical definition - Use toilets as an example to explain how they reflect societal norms, values, and needs
10 min	- Reiteration of concepts and reflection - Groups present their designs and provide constructive feedback to each other - Reinforce sociotechnical framework

Table 3: LafKid Connect Lesson Plan, as created by authors

As a team, we discussed several benefits of implementing a lesson about how toilets are considered a technology. Furthermore, the design process of the lesson plan started with a brainstorming of different topics we could discuss in our lesson plan that connected to various aspects of the socio-technical system. For instance, as shown in Figure 7, the contributing factors of toilet systems range from materials to norms and customs, each holding a significant role in the system's design, production, and usage. Additionally, we assigned each of the following topics to a specific category; social (S), political (P), technical (T), and economical (E). This revealed to us how much of a benefit it would be to utilize this lesson plan, as many topics created an opportunity to connect and explain technology as a complex and interdisciplinary system.

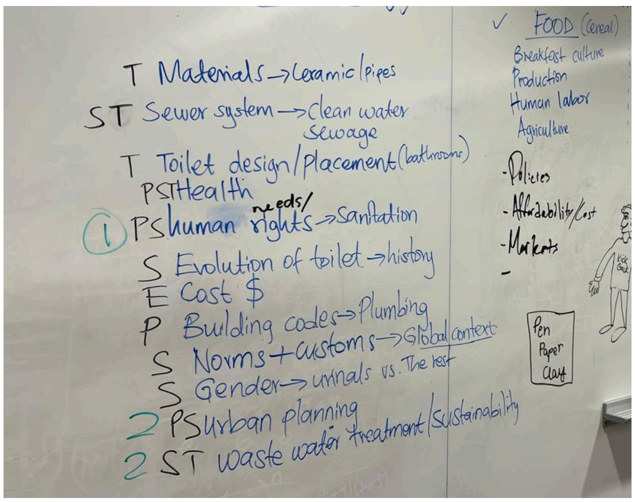


Figure 7: Decision-making process

Another strength of teaching this lesson plan was being able to incorporate an activity that not only engaged the students but also showcased the students' understanding of the technical content that we taught. In the realm of engagement, the topic of toilets was heavily relatable to middle school students. We chose a type of technology that is commonly used but also unconventional and interesting enough to grab students' attention. This was a major strength of the plan because the students entered the lesson with little prior knowledge about toilets being a form of technology, and began recognizing its presence in society as a sociotechnical system.

LafKid Connect Lesson on November 12, 2024

We volunteered to teach in an exploration class which took place on November 12, 2024 with the Easton Area Middle School students during their after-school program with LafKid Connect. The lesson aimed to teach the students about sociotechnical systems through the lens of toilets. Students were engaged and curious as we (facilitators) introduced ourselves and explained the Engineering Studies programs and their relevance to society.

Students were asked to define technology – they did so using examples like light bulbs, chairs, TikTok, phones, and chairs. This is an example of closure, which restricts 'interpretative flexibility' (Norton 2008, 5-6). The students' examples reflect a limited view of technology as "things" rather than including abstract aspects like techniques, systems, or the interplay between humans and technology The phenomenon of closure also calls for diverse perspectives in Engineering, which would open up new possibilities for solutions to broader sociotechnical challenges. A lively discussion followed the question, with students debating whether toilets qualify as technology. Some students connected toilets to engineering while others argued it as just another basic item. Facilitators guided students to connect their ideas to societal needs.

One of the facilitators asked the question, "Who has used a toilet before?" and students shared personal experiences and the facilitators transitioned to discussing hygiene and sanitation as basic human needs and rights. Afterward, historical photographs of toilets were shared, showing their evolution from ancient times to modern systems and from different parts of the world. Students were fascinated by the older designs and played a game to try and place the geographical background of the toilets.

Facilitators then asked students, “What features does a toilet need?”. Students worked in groups of four to brainstorm and design toilets with essential features such as seating options, flushing mechanisms, and comfort. They began sculpting the basic features with Play-Doh. Facilitators explained the importance of cost and materials, highlighting that sometimes the different types of materials need to be outsourced. Students integrated sewer connections and waste management features. Many models included mock pipes and compost bins made of Play-Doh, demonstrating a focus on hygiene and environmental considerations. Students were then guided to think about how their designs made sure to prevent diseases such as cholera and typhoid.

Through the activity, we aimed to expand design constraints (Lucena 2024). As the activity progressed, students were prompted to reflect on how designing a toilet goes beyond technical aspects. They highlighted the importance of human involvement in the process and most models included humans made out of play doh. The following page contain some of the creations.

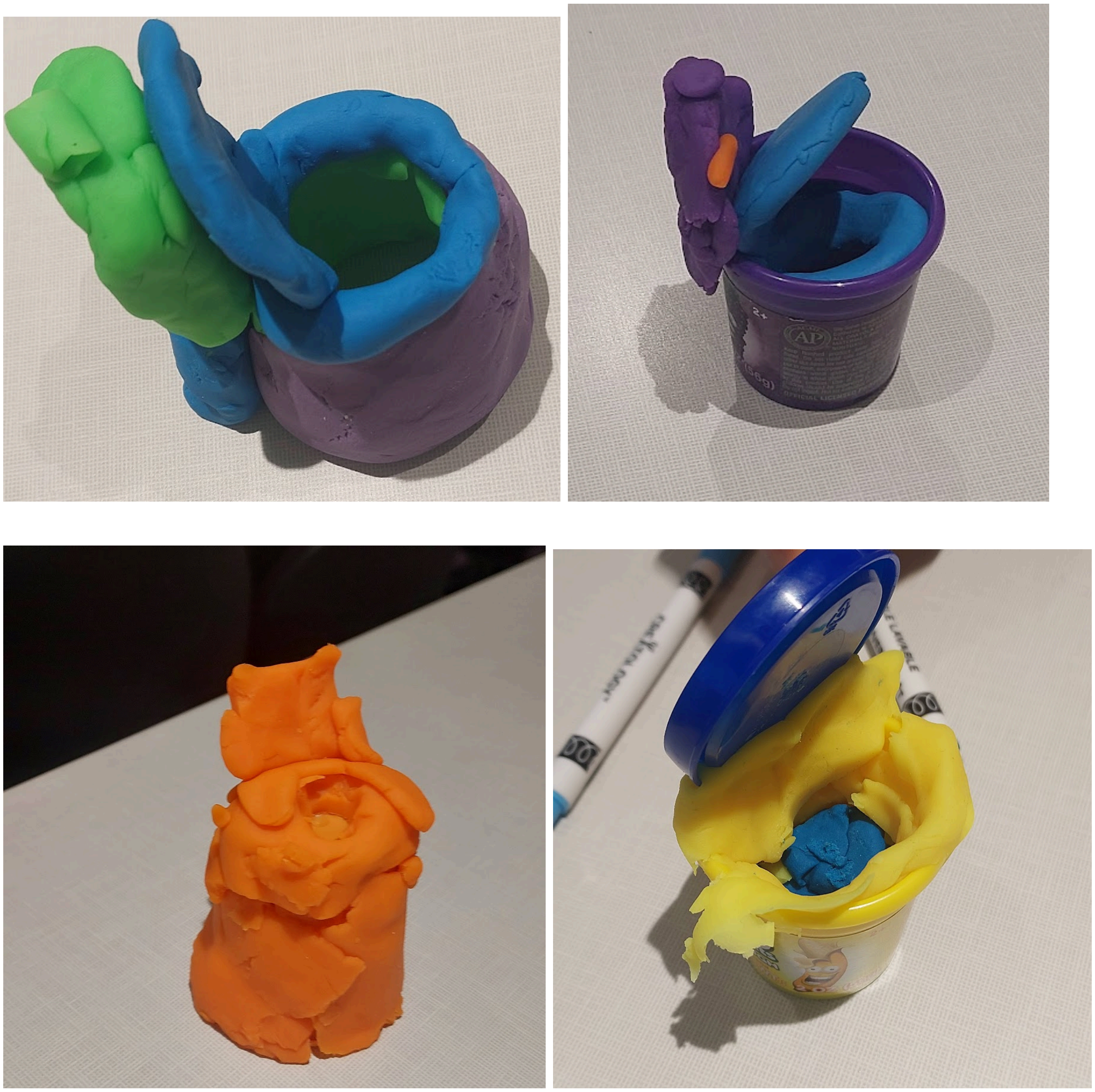
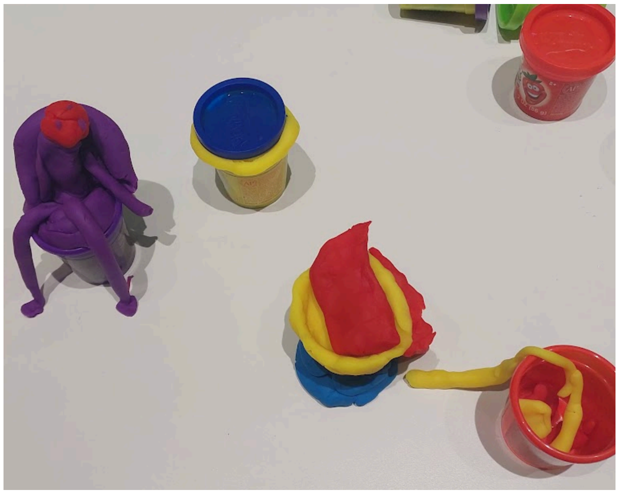
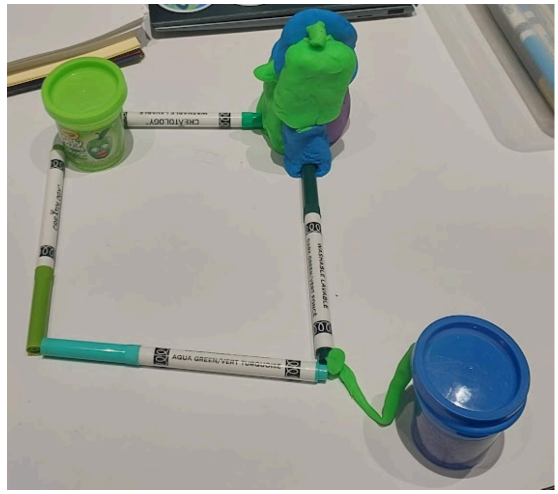


Figure 2: The images of the initial designs of the toilets





Figures 3, 4, and 5 (clockwise): The images of the final designs of the toilets

After the students finished designing and were satisfied with the outcome, facilitators introduced the concept of sociotechnical systems and explained how toilets integrate societal needs and values. Students were given a chance to relate this concept to their designs and define the term “sociotechnical” to the rest of the class. Groups presented their toilet designs, receiving feedback on creativity, practicality, and alignment with human needs.

Reflection on the Lesson with Easton Area Middle School Students

The following are key lessons from our initial lesson with LafKid Connect mentees:

1) Popular culture and mainstream dialogue of technology do instill a defined and narrow perception, even at a young age. When we asked students what technology is, their responses were often oriented toward end-products and modern computing apparatuses: phone, TikTok, YouTube, Snapchat. However, students are almost immediately receptive to concepts in sociotechnical engineering, likely because the interconnectedness between technology and society is encountered constantly even if it is little acknowledged in discourse.
2) Outreach programs led by college students are a unique opportunity to make engineering topics inviting and relatable. Our lively conversations with the students about sociotechnical systems demonstrated this to us. This also intersects with student demographic and relatability in terms of culture and lived experiences.
3) As members of non-dominant groups in engineering, our interactions with students were tailored to also encourage them to pursue higher education. We explained to them what capstone projects are, what research at Lafayette looks like, what the Engineering Studies program envisions, and more. Since LafKid Connect focuses on students from racially and ethnically diverse minority communities, this interaction proved to be a powerful and beneficial outcome, further strengthening the outreach program.

RECOMMENDATIONS

Through our interview with school teachers and a survey of programs that introduce non-traditional concepts to school students, we found the need for a comprehensive, accessible, and engaging system. One recommendation is a web page that is co-developed by Lafayette's students and Professors and Easton Area Middle School teachers. The following points describe the structure and usage of the website:

1) As mentioned above, Lafayette College Professors and students will work with middle school teachers to create a collection of packets containing: a) the lesson plan, b) resources for the teacher, and c) materials needed (such as Play-Doh, markers, electrical components, etc.)
2) Through time cushions and optional discussion questions, the lesson plans ideally will account for organic engagement with students in their specific context (interests, demographics, and experiences). Some topics (as mentioned in the figure) would be "Who, What, and Where of Breakfast Cereal", "Algorithms and Automation Beyond TikTok and ChatGPT", and "What is Technological About a Toilet".
3) Middle school teachers and college students organizing outreach programs will download the packets and conduct the lessons.
4) An additional recommendation is that the website can also be available on mobile devices and in non-English languages.
5) The lessons will be advertised through LafKid Connect and Engineering Studies websites, as well as a direct invitation to middle school engineering and science teachers to contribute to, or utilize, the resource.

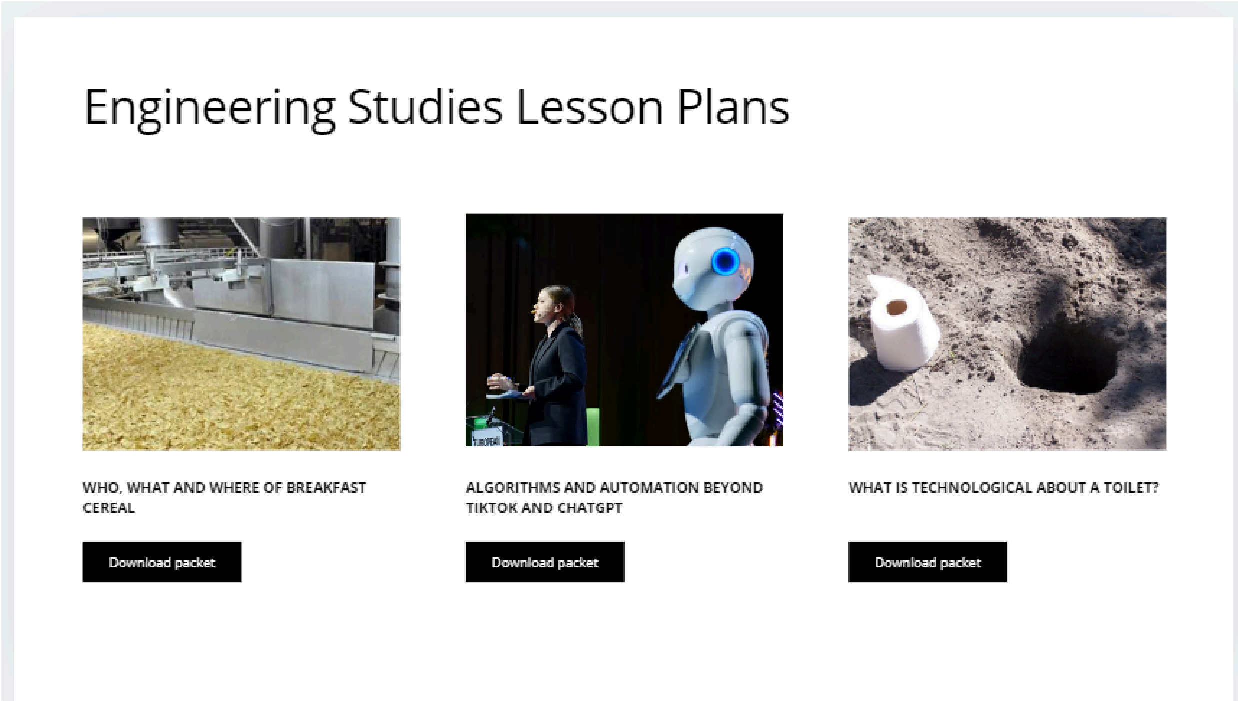


Figure 6: Initial outline of the website structure.

CHALLENGES

In executing our lesson plan, we encountered challenges that have become considerations for our recommendations and future lesson plan designs. These included managing the attention and participation of the students, working with our level of teaching experience, and gauging levels of comfort with topics such as toilets. In the recommendation and lesson plan creation, we also found it challenging to create space for spontaneity, which is a prized aspect of learning. We hope to limit excess structure for this reason.

CONCLUSION

In conclusion, by introducing middle school students to the sociotechnical framework through relatable and practical examples, we aimed to bridge the technical concepts and social implications. The lesson on “What is Technological About a Toilet?” was an effective prototype to explore how engineering within the sociotechnical framework made the topic accessible and relevant. This holistic approach helped reimagine how engineering is taught in outreach programs and inspired curiosity. It encouraged middle school students to realize that engineering is a tool to solve pressing 21st-century challenges, but only when seen as a sociotechnical system.

REFERENCES

Appel, Daniel C., Ralph C. Tillinghast, Carla Winsor, and Mo Mansouri. 2020. "STEM outreach: A stakeholder analysis." *In 2020 IEEE Integrated STEM Education Conference (ISEC)* pp. 1-20.

Bakshi McLean, Leena. 2025. *Stem for all: How to connect, create, and cultivate stem education for all learners*. Hoboken, NJ: Jossey-Bass.

Bijker, Wiebe E. 1992. "Social Construction of Technology." *Technology and Culture*, vol. 32, no. 3, pp. 71-82.

Cohen, Rossmann, and Sanford. 2014. "Introducing Engineering as a Socio-technical Process." *American Society for Engineering Education* 2014.

Cohen, Benjamin. 2024. "Sociotechnical Education in Middle School". Interview by Jahi Heath and Swetha Tadisina. October 20.

Cohen, Benjamin. 2024. "Part I: Introduction: the very idea of technology and history". EGRS 281: Historical Studies in Engineering and Society. Class lecture at Lafayette College, Easton, PA, January 23.

Conlin, Michael, and Meg Jalilevand. 2015. "Systemic Inequities in Special Education Financing." *Journal of Education Finance* 41, no. 1: 83–100. http://www.jstor.org/stable/24459301.

Data USA. 2022. “Easton, PA”. Accessed November 3, 2024. https://datausa.io/profile/geo/easton-pa#education

Dym, Clive L., Alice M. Agogino, Ozgur Eris, Daniel D. Frey, Larry J. Leifer. 2005. “Engineering Design Thinking, Teaching, and Learning.” *Journal of Engineering Education.* vol. 94, no. 1, pp. 103-120.

Fowler, Jodi. 2024. “LafKid Connect Program for Middle School Students”. Interview by Grace Ouko, Jahi Heath, and Swetha Tadisina. September 23.

Gomez-Velez, Natalie. 2013. “Urban Public Education Reform: Governance, Accountability, Outsourcing.” *The Urban Lawyer* 45, no. 1: 51–104. http://www.jstor.org/stable/24392340.

Hoy MK, Sebastian RS, Murayi T, Goldman JD, Moshfegh AJ. 2024. Breakfast Consumption by U.S. Children and Adolescents: What We Eat in America, NHANES 2017-March 2020. Food Surveys Research Group Dietary Data Brief No. 58.

Kun Chelsea . 2024. “Easton students faced challenges in recent years. The school district plans to combat them.” *Lehigh Valley Live*, August 25. Easton students faced challenges in recent years. The school district plans to combat them. - lehighvalleylive.com

Lucena, Juan. 2024. "Sociotechnical Education in Middle School using ECSD Concepts". Interview by Jahi Heath, Grace Ouko, and Swetha Tadisina. November 5.

Miaoulis, Ioannis. 2010. "K-12 Engineering – the Missing Core Discipline." In Holistic Engineering Education", edited by Grasso, Domenico and Burkins, Melody. Springer.

Norton, Peter D. 2008. "Introduction: What Are Streets For?" In Fighting Traffic: The Dawn of the Motor Age in the American City, 1–18. The MIT Press. http://www.jstor.org/stable/j.ctt5hhckp.4.

Kowalczewski, Peter S. 1982. "Race and Education: Racism, Diversity and Inequality, Implications for Multicultural Education." *Oxford Review of Education* 8, no. 2: 145–61. http://www.jstor.org/stable/1050352.

Liu, M., and F. Chiang. 2020. "Middle School Students' Perceptions of Engineers: A Case Study of Beijing Students." International Journal of Technology and Design Education 30, no. 3: 479-506.

McCauley, Pamela, and Conor Buckley. 2021. Engineering for teens: A beginner's book for aspiring engineers. Emeryville, CA: Rockridge Press.

Noguera, Pedro A. 2015. "*Cities, Schools, and Social Progress: The Impact of School Reform Policies on Low-Income Communities of Color*." In *The Return of the Neighborhood as an*

Urban Strategy, edited by Michael A. Pagano, 107–32. University of Illinois Press. http://www.jstor.org/stable/10.5406/j.ctt174d27j.9.

Ochoa, Ellen, and Victor R. McCrary. 2022. "Cultivating America's STEM Talent Must Begin at Home." *Issues in Science and Technology*. Cultivating America's STEM Talent Must Begin at Home.

Odis Johnson, Jr. 2014. "Still Separate, Still Unequal: The Relation of Segregation in Neighborhoods and Schools to Education Inequality." *The Journal of Negro Education* 83, no. 3: 199–215. https://doi.org/10.7709/jnegroeducation.83.3.0199.

Passow, A. Harry. 1977. "Urban Education: The New Challenge." *Educational Researcher* 6, no. 9: 5–10. https://doi.org/10.2307/1175156.

Pennsylvania Department of Education. 2023. Science, Technology & Engineering, and Environmental Literacy & Sustainability Standards (STEELS): K-12 Standards. Pennsylvania: Pennsylvania Department of Education.

Riley, Donna. 2017. " Rigor/Us: Building Boundaries and Disciplining Diversity with Standards of Merit." *Engineering Studies* 9, no. 3 249-265. https://doi.org/10.1080/19378629.2017.1408631.

Secules, S. 2019. *Making the Familiar Strange: An Ethnographic Scholarship of Integration*

Contextualizing Engineering Educational Culture as Masculine and Competitive. Engineering Studies, 11(3), 196–216

Slaton, Amy. 2010. "The Disunity of Technical Knowledge." In the Book *Race, Rigor, and Selectivity in U.S. Engineering.* Harvard University Press.

Squarcia, John. 2024. "Pedagogy and Engagement in Middle School". Interview by Swetha Tadisina. October 28.

Wilson, Stephen. 2021. "LafKid Connect Receives Alumnus Gift." Lafayette College News, July 26. https://news.lafayette.edu/2021/07/26/lafkid-connect-receives-alumnus-gift/.. 2021

Wisnioski, Matthew. 2012. *Engineers for Change: Competing Visions of Technology in 1960s America*. Cambridge, MA: The MIT Press. https://doi.org/10.7551/mitpress/7978.001.0001.

Urban, Michael J., and David A. Falvo. 2016. Improving K-12 STEM Education Outcomes through Technological Integration. Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-4666-9616-7