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# Rethinking Technocentrism: Case Studies of Three Engineering Students' Social Sciences Approaches to the Sanitation Crisis

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I am an undergraduate majoring in mechanical engineering and minoring in education at Stanford University. Apart from design and engineering, I am particularly interested in education as well as the intersection between engineering and education. Over this past summer, these interests were fueled by working at the Kozmetsky Global Collaboratory with paper co-authors Dr. Hariharan, Devika Patel, and Sarah Salameh. In my spare time I enjoy watching sports and films as well as doing sleight of hand tricks.

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# Rethinking technocentrism: Case studies of three engineering students' social sciences approaches to the sanitation crisis

Abstract:

According to the WHO, 2.5 billion people lack access to proper sanitation resources.[1] Integral to this alarming statistic is the absence of sanitation technology. Current engineering initiatives have responded to this challenge with toilet fairs and competitions showcasing cutting-edge technologies in the sanitation sector. That is, engineers have often approached this sanitation crisis as well as other world problems from a technocentric perspective—the philosophy that considers technology as capable of solving human problems.[2] Technocentrism speaks to the current outlook of engineering education. We as engineering students are trained to design and build technical solutions for world problems. Furthermore, this focus within engineering education parallels our society, in which technology is increasingly important in mediating the way we interact with the world and its problems.

This paper is a synthesis of the authors' experiences as undergraduate engineering students working in an engineering internship to build a solution to end open defecation in rural Gujarat, India. The case studies will explore how the students entered the internship with the technocentric preconception, yet, after articulating their care statements—an understanding of what the students value in the context of this problem space—they broadened their focus to a greater consideration of the socio-cultural aspects of the community they were working with.

Our paper addresses the topic of liberal education in action through multidisciplinary projects and ethics from three students' perspectives. From these case studies we examine the way we, as student engineers, reconcile technocentrism with ways of thinking utilized in liberal education. Analysis of the case studies imply a role for reflection and care in addressing technocentrism and our paper ends with a call for further studies analyzing these relationships.

Introduction:

"My app will change the world, my product is a disruptive innovation"—these are the mantras of startup founders, engineers, and computer scientists throughout the Silicon Valley. Writer Joel Stein presents this profile of tech entrepreneurs in his Bloomsberg Businessweek article, *Arrogance is Good: In Defense of Silicon Valley*.[3] This stereotype may signify a core societal belief in the capability of technology to solve human problems. Indeed, the popularity of technological approaches to education as well as health and fitness may be indicative of this mindset.

Perhaps these inroads are reminiscent of what Seymour Papert cautions against in *A Critique of Technocentrism in Thinking About the School of the Future*, an essay on the unscrupulous incorporation of technology in the classroom. In the essay, Papert presents a poignant definition of technocentrism that may be salient for all engineers to be mindful of: the fallacy of referring all questions to technology.[4]

This paper explores the relationship between technocentrism and humanitarian work—specifically humanitarian engineering in the sanitation sector. Engineering students interested in this field, however, may be myopically biased towards designing and building an intervention without considering the nuances of multidisciplinary and multifaceted humanitarian problems. In *Educating the Humanitarian Engineer*, Kevin Passino lists numerous anticipatory questions for engineers engaging in humanitarian work: "Does the [affected] community really want the technology? What is the priority of deploying the new technology? Is a new technology needed, or is it more important and appropriate to educate the community on how to use existing technology (e.g., computer software)?"[5] Yet student engineers may not be answering these questions with due diligence, resulting in technocentrism.

Regarding humanitarian engineering in the sanitation sector, the Gates Foundation's Reinvent the Toilet Challenge may represent a gray area in terms of technocentrism. On one hand, it has spurred the creation of numerous impressive designs that are ostensibly inexpensive, sustainable, and aspirational.[6] Yet this engineering initiative also sparked some criticism by sanitation experts. For example, former World Bank senior water and sanitation specialist Pete Kolsky believes the Gates Foundation challenge needs to be put into perspective: "the developing world's sanitation problems are immediate, and are far more organizational, motivational, and social than they are technical."[7] Indeed, in examining the case studies of three student engineers working in a summer research internship in the sanitation sector, this paper seeks to explore means to facilitating these organizational, motivational, and social considerations that extend beyond technocentrism.

Methods:

This paper offers a unique perspective on student experiences in global engineering programs written by the students themselves. The research design is a multiple-case self-study of the phenomenon of technocentric thinking in engineering students in global engineering programs. It involves three students' (Devika, Jonathan, and Sarah, the authors of this paper) cases of working in a summer engineering internship of building a solution to end open defecation in rural Gujarat, India.

The research setting of the global engineering program for each of the three cases examined was the Kozmetsky Global Collaboratory (KGC) at Stanford University. Two of the students whose experiences are explored as individual cases are Mechanical Engineering majors and one is a Mechanical Engineering: Product Design major.

All three students were entering their third year at Stanford University, had previously taken Global Engineers' Education (GEE), a global engineering course within the mechanical engineering department that involved prototyping a solution to India's sanitation crisis. They were advised by Dr. Bhavna Hariharan, the course instructor, for their summer internships. For the three students, GEE was an introduction and immersion to a variety of non-technical topics relevant to global engineering: designing with care at the center, articulating and realizing individual and community aspirations, ethics of engaging with underserved communities, and working sustainably with (and not for) underserved communities. During the course, the students drew from readings and discussions on these topics during weekly interviews with collaborators from the Environmental Sanitation Institute (ESI), a sanitation and hygiene NGO based in Ahmedabad, Gujarat, as well as their final design prototypes addressing the sanitation problem. Furthermore, this instructional content informed the students' research during the summer internship.

The students initially intended to continue developing a prototype from the class during the summer internship, but in reality the most important takeaway from the class was the concept of articulating care statements. Indeed, building upon the prior research of Dr. Hariharan on global engineering pedagogy, a major component of both the GEE course as well as the summer internship involved, understanding the engineering students' values in order to drive design. Thus, beyond teaching content, throughout the duration of the course and the internship, Dr. Hariharan's main role included encouraging the students to develop and reflect upon their care statements.

The similarities in major, class year, and research setting provides literal replication for each of the research settings, providing more grounded evidence in patterns in common in all three cases.[10] Multiple cases enable replication logic that provides more deeply grounded evidence for a more robust theory.[14]

The students drew from three sources in writing the case studies: the primary source of the students' daily research journals throughout the summer internship whose contents can be verified by Dr. Hariharan, holistic reports written at the end of the internship period, as well as interviews conducted several months following the conclusion of the internship.  These data sources match David Boud's stages of reflection: the returning to the experience, attending to feeling, and reevaluating the experience. Writing daily journals allowed students to recount the experiences of each day as well as document any subsequent thoughts. The internship reports and interviews allowed the students to synthesize and reevaluate experiences.[15, 16]

The students had not anticipated a later retrospective analysis of their personal experiences. Thus, using journals that were written during the time of the internship in conjunction with the interviews eliminates much of the retrospective bias that can occur when solely using data from sources reliant on recall, such as interviews.[8] Using journals and reports written during the time

of the internship also provides insight into the thoughts and feelings of each of the students throughout the internship, as Bollough and Pinnegar recommend in *Guidelines for Quality in Autobiographical forms of Self-Study Research.*[11] Because the cases are the authors' own experiences, using journals from the time of the internship as data provides more access to thoughts and motives for any patterns found.

Rather than rely on autobiographical accounts of the summer internship, each of the authors wrote the case of another fellow author (i.e., Sarah wrote Devika's, Devika wrote Jonathan's, and Jonathan wrote Sarah's). This methodology allays some of the biases inherent in recounting personal experiences.

What follows are three case studies written by the subjects themselves. The three cases provide biographical perspectives of the learnings and transformations of the subjects' engineering education trajectories.

Case study of Sarah:

Entering the summer internship at the KGC, Sarah had taken GEE from which her main deliverable was a prototype for a bike-powered fan for latrines. At the outset of the internship, she was primarily concerned with iterating on her fan prototype: "I thought about ways of improving the prototype I made in class and also read about different sanitation technologies that had been built, like various composting toilets, trying to understand their mechanisms." Despite this engineering bent, Sarah and her fellow interns recognized the necessity of background research in the sanitation problem space. Although Sarah did not enter the internship with an interest in economics, she was assigned to research the economic facet of sanitation development.

Sarah conducted an extensive literature review focusing on various economic schemes that facilitate sanitation. For example, she looked into the interaction between public and private organizations as well as the failure of incomprehensive government programs in mitigating the prohibitive costs of toilet installation. Indeed, while she had no initial interest in the economics of sanitation entering the internship, her pursuit of this subject was in line with her care statement: "create a product or suggest a system that would empower users of the toilet to not fully need outside assistance in managing sanitation, thereby empowering them in other aspects of their lives as well."

Sarah's literature review of the collaboration between government, business, and nonprofit organizations in sanitation as well as her care for empowerment led her to research social impact bonds. As Sarah explains in her journal, "An external organization, like some sort of NGO or nonprofit, evaluates the impact of whatever intervention or measures are funded by the bonds. Once the desired "change" has been reached, investors, as individuals or companies, are paid

back principal payments, as well as any interest or profits." Even at the early stages of her research on social impact bonds, Sarah understood that "What would be difficult would be measuring the impact of whatever sanitation campaigns or measures have taken place."

Noting that a classmate in GEE had developed a prototype for a device that measures the frequency of latrine usage, Sarah began to consider technological solutions for social impact metrics. Weeks into the internship and despite her extensive readings in the economics of sanitation, she noted in a journal entry that she was "torn with how I want to spend the rest of the summer with the KGC— I definitely would like to develop an economic model similar to that of the social impact bond as a proposal to fund sanitation interventions, but I am unsure if I would prefer to work on...building something dealing with hand washing or adding to a bike powered system."

Sarah grappled with this conundrum as she investigated community-initiated demand for sanitation as a metric for impact investment. The process of reexamining her inquiry into social impact in the context of her care statement, however, clarified her research focus and objectives. As she explained in a journal entry, "What I care about with a sanitation/hygiene intervention is sustained behavior change, or hygiene/sanitation practices that continue for each individual's lifetime. I see this long term individual by individual behavior change not only important to see positive health outcomes, but indicative of community members starting a chain of catalytic positive changes in sanitation and hygiene." This care statement aligns with her research on sustainable and equitable funding schemes for sanitation campaigns. But rather than developing engineering solutions or economic models, her focus is now on how to measure the impact of sanitation interventions—an endeavor that could inform funding plans akin to social impact bonds.

While in India, Sarah focused on sanitation and hygiene metrics specifically for the collaborators at ESI. She hopes to continue working with Dr. Hariharan to research metrics for social impact—unencumbered by any sense of obligation to build anything.

Case study of Student B:

When Devika arrived at the KGC, she had taken the course two years prior and served as a teaching assistant for the course during the school year leading up to the summer. The student also had a personal connection to the problem area of ending open defecation in rural Gujarat, inspired by issues her mother and grandmother faced in India pertaining to issues of hygiene and sanitation.

On the first day of the internship, Devika was interested in taboos related to sanitation, specifically those related to women in the arena of sanitation and how language affected and comprised those taboos. Interested in researching gender in sanitation and critically questioning

the "...'seemingly obvious' relationship between women and sanitation," Devika still expressed interest in building something during her internship: "Still trying to synthesize all that I have learned...but I really want to see if we can build something this summer!" However, the student also entered the internship recognizing that the KGC is not only mechanical engineering laboratory, but encourages interdisciplinary work.

One topic that Devika explored was Community Led Total Sanitation (CLTS), a sanitation information campaign that paradoxically engages the community to trigger reform using social pressure tactics.[12] Further delving into taboos, Devika began "...exploring taboo perpetuation in CLTS as a critical response to the approach… particularly challenging taboos of toilet maintenance. I'm interested in seeing any retrofitted solutions for cleaning toilets in current toilet technologies in India." Reflecting on her experiences during the internship, Devika explained she always had a leaning towards building something, but "thought I couldn't relate taboos to engineering and that was why I leaned towards cleaning attachments." As research on taboos progressed, Devika became less attached to the idea of building something, stating "Unfortunately I have no idea of a tangible product idea."

Uncomfortable with the idea of breaking taboos, Devika reached the pivotal point in her internship when connecting Gandhian values of cooperation to dealing with taboos. Eventually, a conversation with the research advisor motivated Devika to completely surrender the idea of building something. In this conversation, it became apparent that it was necessary to critically think about why she cared about taboos. From this point, she realized the discomfort with breaking taboos and finding alternative approaches to addressing taboos related to sanitation, specifically those related to women and menstrual hygiene. In India, Devika gathered data on women and menstrual hygiene taboos through interviews, observation and conversations. Devika explained she would look at her research as an "...alternate way to reach the ends that the taboo is the means for. Basically, looking into why taboos exist, what are they trying to achieve, and how we can use a different mindset or perspective to thus work with the taboos."

Case study of Jonathan:

Jonathan entered the internship having taken GEE during the spring quarter of his sophomore year. His major takeaways from the course include the "notion of "working with" rather than "working for" a community as well as the importance of articulating a care statement to frame and direct work and action." His initial care statement was guided by this question: "What happens to human waste and how does it get there?" From the onset of his internship at the KGC, he conducted a thorough literature review and iterated upon his care statement, ending with this: "Finally, I had tweaked my care statement to its current form: taking an educational approach to fostering sanitation and hygiene reform." Like his fellow interns, he came into the internship with an engineering perspective: "While my goals and expectations for the internship

were somewhat nebulous at the time, I was certainly eager to design and build...I was determined to work with the team to develop an engineering intervention for sanitation and hygiene."

His foray into the literature review was initially guided by this question: "What is persuasive technology and what is the process for designing a product that is persuasive? Unfortunately, most of the literature describing the process of designing persuasive technology seemed too unempirical to have much value." Realizing he had "pigeonholed" himself into only thinking about a design and engineering point of view through his research, he stepped back to re-evaluate his question and stopped looking only at persuasive technology: "My guiding question became 'how might we ethically persuade people to adopt improved sanitation?' I pared my focus from persuasive technology down to persuasion."

At around this point, Jonathan had also begun researching CLTS. After being shocked and questioning the purpose of the methods, Jonathan grappled with feeling uncomfortable about this approach. This led to the following realization, "The emphasis on pathos and ethos in persuasion worried me; it seemed unethical to compel behavior change through fear-tactics and shame. This ultimately led me to recalibrate my research yet again—this time concentrating on education." His sense of ethics began to truly drive his care statements, while any mention of technology or engineering approaches was generally left out of his reflections. His driving mentality was to ensure that information should be conveyed in a safe environment, where interventions were designed to "appeal to people's reason, not reaction—focus on facts (and understanding), not fear." During this time, he also articulated his first idea for his project, which was essentially a version of the course we were involved in before the summer internship administered to high school and college students in rural India. It would focus specifically on designing and building a latrine with the community and from initial concepts to installation of a physical product. When noting particular problems or issues with this idea, he notes in his journal, "Not much focus on engineering (for our part)—perhaps we can prototype the lessons on ourselves and build a latrine here?"

Thus began Jonathan's journey into education research. While conducting research on education and pedagogy, he read about the theory behind allowing students to take charge of their own education, but realized some potential issues with this approach in regards to small children: "However, to what extent can we leave the reigns to middle/high school students. [Paolo Freire's] work seems very applicable to teaching adults (which he did in numerous locations) but perhaps not for small children?" However, after reading about the Deweyan educational pedagogy, Jonathan realized that it was time to start experimenting with curriculum. As he noted to himself in his journal entry, "Courageously experiment with curriculum!" His claims to appeal to reason were challenged by faculty at the KGC and he was forced to "reexamine and compromise my already wavering commitment to rationality. That is, there must be a component of trust along with the appeal to rationality (combination of logos and ethos)." With these newly minted questions and directions, the rest of his time at the internship was spent developing a

research activity to work on with the children in the field. Rather than using a technological or persuasive approach to sanitation interventions Jonathan strived to appeal to the rationality and the logic of students receiving this information, and looking at education as a basis for "knowledge construction."

While in India, Jonathan focused on creating educational approaches to sanitation interventions that would be best suited to the collaborators at ESI they were working with, rather than designing curriculum from scratch. His project now involves drawing from his field experience in rural Gujarat to write and illustrate a pamphlet that motivates students to wash their hands. He hopes to continue working with Dr. Hariharan to develop these ideas and the accompanying materials for ESI to test and use in the villages in rural Gujarat.

Research findings:

Analysis of the cases above reveals similarities between the students' experiences. What is common between the cases is the disparity between the students' expectations and their internship experiences. They all describe situations in which they were challenged to critically think, synthesize, analyze, and reflect upon their research and care, each reaching a pivotal moment that changed their educational path.

The following appeared to be the most significant trends between the cases:

1) Initial focus on "building": All students pointed at some point or another in their journals of their desire to build a tangible project to use their engineering skills. As care statements evolved and in depth research was conducted regarding specific care statements, students would sometimes revisit the notion of building a product, but no engineering efforts came to fruition over the course of summer internship.

2) None of the students chose to build more sanitation technology: All of the students had taken a course before the summer internship whose focus was prototyping a solution to some problem related to toilets and sanitation and repeatedly throughout the internship they all expressed interest in further developing a prototype or building some sort of product. However, none of the students in the aforementioned cases ended up building or prototyping a product. Furthermore, the students all ended the internship doing research that was not directly related to engineering (one student focused on menstrual hygiene taboos, one interested in education tools and programs, and one interested in metrics related to sanitation).

3) Critical thinking about care statements drove the direction of the students' research: Each student came with a preconceived notion of their care statement from the class. In the context of the course, students were responsible for making sure their care statements were represented in the design, along with the care statements of their fellow team members. In the summer internship, students were free to re-evaluate and continue to

articulate their own care statements in light of their own perspectives and experiences on a more individual basis. This led to care statements that truly reflected the students' motivations and desires, which in turn, propelled their research forward.

Implication of findings:

As observed in these three cases, students stepped back from primarily technocentric and engineering perspectives to engage with the problem space through the lens of their care statements. Articulating care statements allows students to focus on one specific component of the vast sanitation crisis in rural India and allows them to stay motivated during their projects and research.

Because of the complexity of issues that humanitarian engineering revolve around, undergraduate engineering students often find themselves overwhelmed in designing solutions.[13] Frequent reflection, as demonstrated by the students in these cases, plays an important role in transforming problematic frames of reference and critically evaluating one's own assumptions.[19] Articulating care statements not only allows students to find direction in tackling complex problems, but in the context of the aforementioned studies, directed the students away from engineering, at least for the time being.

The literature on engineering and social justice express the importance of bringing an ethic of care to engineering design in order to better address complex problems.[20] According to Donna Riley, care permeates the design process: "caring about" during the initial problem definition phases, "taking care" in generating solutions, as well as "caregiving" in design selection.[9] Indeed, the curriculum for GEE that the three students had taken prior to the internship drew from research on the ethic of care to guide student projects. Yet the three cases in this paper highlight the power of care to not only guide engineering design, but also lead projects away from engineering.

The findings from the case studies imply that care can facilitate reimagining the role of the engineer in the context of "wicked problems" that have social, economic and technical effects. To relate this to the broader scope of engineering education, these case studies and their respective findings can serve as a template or an example for how to engage engineering students with complex issues. That is, a classroom or research center centered on care can provide students with an environment to be more comfortable venturing into seemingly unrelated subjects and think beyond the physicality of engineering design projects. Even if student engineers stop short of switching to non-engineering research as the students in the cases did, the perspectives gleaned from venturing into different fields should be invaluable in their humanitarian engineering endeavors. This implication echoes the recommendations for students involved in humanitarian engineering programs made in *Engineering To Help*, which encourage

humanitarian engineers to understand the "larger historical and political contexts...into which they are entering."[17]

In looking at the study holistically, there are several limitations that are important to examine. The first major limitation relates to the sample size of the study, namely the fact that the authors of this paper are the students the case studies are written from, limiting the sample size to three cases. In the writing of the case studies themselves, the second limitation was the fact that there was no set methodology in analyzing the case studies that was reproduced across the case studies. The students did not employ a universal coding system to methodically comb through the journals and reports in writing from the case study; instead, they employed their own personal analytical methods to do so. In addition, the study was limited by the use of the non-quantitative research and the complexity of technocentrism. According to Hodkinson and Hodkinson, "because the sample is small and idiosyncratic, and because data is predominantly non-numerical, there is no way to establish the probability that data is representative of some larger population."[18] This limits the authors' ability to generalize the trends to the greater engineering student population.

Conclusion and future work:

This paper shows the experiences of three engineering students and their transition from a purely technocentric point of view, to a more nuanced and sociocentric perspective. This paper highlights the tool of the care statements used by the engineering students to drive their research forward during their summer internship at the KGC. The students conducted research regarding their care statements on the current problem space around sanitation and hygiene in rural India. The findings imply care as a strong facilitator in redefining the role of the engineering students in solving humanitarian issues globally. Further research should be conducted in collecting case studies from more undergraduate engineering students. In addition, a rigorous empirical study on the relationship between articulating care and technocentric tendencies would add to this study's findings and implications and allow the humanitarian engineering community to move closer towards involving undergraduate students in effectively tackling these global issues.

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