

Influence of Internships on Engineering Students' Attitudes about Socially Responsible Engineering

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Abstract—This Research Full Paper presents an element of original research uncovering what how engineering students change their social responsibility attitudes. As engineering students transition into the workforce they gain significant responsibility for individuals and society through their decisions. Internships have been found to be an important site where students begin to develop their identity as an engineer and understand the engineering profession. This research explored how internships affected students' perceptions of engineers' social responsibilities. In this qualitative, longitudinal study, students were asked about their understandings of and influences on social responsibility in ~1 hour interviews each year throughout four years of college. Fifteen engineering students who participated in internship experiences outside of academia form the cases explored. These students were attending five universities and primarily majoring in civil and mechanical engineering, with four additional majors represented. The various internship experiences led four students to expand their understanding of socially responsible engineering (SRE), with three working at public sector jobs. In contrast, three other students narrowed their understanding of SRE and the majority experienced minimal change due to their internships. Faculty may want to consider internship experiences when developing curriculum related to ethics and societal impacts, setting expectations prior to the experiences to attune students to these issues and incorporating reflection and discussion elements for seniors to examine these issues.

Keywords—social responsibility; internships; professional development; professional ethics;

I. INTRODUCTION

Engineers in practice have a large impact on individuals and society. It is therefore important that engineers are trained to recognize and consider these implications of their work, and take responsibility for these broader impacts. This notion is encompassed within the new Accreditation Board for Engineering and Technology (ABET) Engineering Accreditation Commission criterion 3 outcome 4 related to “ethical and professional responsibilities... considering the impact of engineering solutions in... environmental and societal contexts” [1]. While the ABET criterion implies that formal, required coursework will lead to achieving these goals, broader environmental socialization factors may impact students' understanding of socially responsible engineering [2],

including professional experiences. The most impactful form of professional engagement is likely to be a co-op or internship experiences in engineering.

Internships offer rich learning opportunities for students, including growth in professional skills and professional socialization [3-7]. As related to socially responsible engineering, Boni et al. [8] noted that internships were impactful in students' understanding of the public good that can result from engineering. Koehn [9] studied the impact of summer, internship, and co-op work experiences among civil engineering students at Lamar University, and found “undergraduates perceive that their understanding of health and safety issues and ethical considerations has also increased.” Burt et al. [10] found that students discussed co-op mentors and internship experiences in the context of ethical development. These studies point to potential links between internship experiences in engineering and students' attitudes about socially responsible engineering.

However, large quantitative studies have found generally declining attitudes among engineering students regarding their social responsibilities [11,12]. This includes Cech's [11] “culture of disengagement” study where students' public welfare beliefs were found to decline. A large percentage of engineering students typically engage in internship and co-op experiences during college [13], raising the broad question as to whether these experiences generally contribute to or might detract from ideas of socially responsible engineering. Internships might expose students to business motivations of engineering that may place profit over public or environmental benefits [14]. Studies that explore the nuances of students' feelings of socially responsible engineering are needed to explore these issues.

II. RESEARCH QUESTION

This qualitative research seeks to identify relationships between engineering students' experiences with their internships and the ways they defined and discussed socially responsible engineering.

III. METHODS

The importance of internships emerged from a larger four-year longitudinal study of how engineering students' ideas

about social responsibility and engineering change over their time in college [15-17]. Students were initially contacted as incoming first-year students in Fall 2012 through the Engineering Professional Responsibility Assessment (EPRA) [18]. From among students who volunteered to be interviewed, criterion-based selection [19] was used to recruit students with diverse social responsibility attitudes, disciplines, and institutions, with an over-representation of women. Among the 34 students interviewed in the first year, the fifteen students who both persisted in engineering and had engineering-related internships outside of academia form the cases that are the basis of the current study (Table 1). These students represent six majors, five universities, and a range of initial (as incoming first-year student) social responsibility (SR) attitudes as measured by the average score on 50 Likert-type items (scale 1 to 7; Yr0 SR score). The universities attended by the students were a technically-focused medium-sized public university (TU, n=8), a medium-sized private research intensive university (PrU, n=3), a large public research-intensive university (LPU, n=2), a medium-sized public university (MPU, n=1), and another medium sized public university to which one student transferred (MPU2, n=1). Interviewees included 9 female and 6 male students, with a majority majoring in civil engineering (n=6) and mechanical engineering (n=5) in year 4.

Semi-structured interviews were conducted in the Spring semester each year from March 2013 – April 2016. The phone interviews ranged in duration from 60-120 minutes. They were recorded and transcribed verbatim using Nuance Dragon software and Microsoft Word. Pseudonyms were assigned to the students before the first interview using typical conventions [20]. Students were compensated with a \$100 Amazon gift card for participation.

The students were asked questions about their college courses, significant events, thoughts on social responsibility generally, and how these are related to their ideas about SR within and outside of the engineering profession. As a longitudinal study, the researchers aimed to ask questions that were similar each year, but also tracked with typical student experiences of engineering students as they progress through college. Two main parts of the interviews elicited responses about internships: the first general question, “Tell me about the last year...” and “What are the responsibilities of an engineer? Why do you think so?” A particularly relevant question in the fourth year interview was, “What will be your responsibilities as an engineer in the future?”, which was followed-up with a question about what influenced this perception. The complete set of interview questions can be found in [16-17].

The first author (also the interviewer) categorized the student experiences related to internships, with the second author verifying the characterizations.

All of the research was conducted according to methods and protocols approved by the Large Public University Institutional Review Board for Human Subjects Research, Protocol 11-0414, and included informed consent before each interview and the online surveys.

IV. RESULTS AND ANALYSIS

Internships and other professional experiences were a major source of discussion at the beginning of many interviews. The question “Will you tell me about your experiences over the summer?” constantly led to an extended monologue about their jobs, what they liked, and what they did not. Thus, the source of much of the following results were not from a direct question about the impact of their internship on how they think about SRE, but rather were inferred based on the larger body of the conversation.

While many factors influenced students’ ideas about SRE [2] and their internships had an array of impacts, the following results discuss only the evidence that supports how students considered internships to be a source of their understanding of SRE. The students were categorized into three domains regarding the impact of their internship experience on their SRE attitudes: minimally impacted, narrowed, or expanded their understanding of SRE (Table I). The majority of the students had multiple internship experiences, where ‘C’ represents a semester-long co-op experience and ‘A’ represents an academic or research experience. Academic or research experiences are discussed in this paper. The following sections elaborate further on the three categories of internship effects on students’ ideas about SRE.

TABLE I. STUDENTS’ PROFESSIONAL EXPERIENCE AND INFLUENCE

Pseudonym	Yr0 SR score	Major	Institution	Internship Year(s) ^a	Internship Influence on SR
Katherine	6.3	Civil	MPU	3, 4	Expanded
Sarah	6.6	Civil	TU	2C, 3	
Wynne	5.9	Architectural	LPU	2A, 3, 4	
Rachael	6.1	Software	PrU	3A, 4, 4C	
Jolene	6.6	Civil	MPU2	2, 3, 4	Narrowed
Nathan	6.1	Civil	TU	3, 4	
Madison	4.9	Mechanical	TU	2, 3, 4	
Todd	5.1	Mechanical	TU	2, 3, 4	Minimal
Jamie	5.6	Mechanical	TU	4	
Jason	4.7	Mechanical	TU	3, 4	
Derek	6.3	Mechanical	PrU	3, 4A	
Ashley	5.6	Chemical	PrU	3A, 4	
Tucker	5.5	Civil	LPU	3, 4	
Brandon	5.8	Civil	TU	2, 3, 4	
Tanya	6.1	Environmental	TU	2A, 3A, 4	

^a. C = Co-op during semester; A = academic or research experience

A. Internship minimally impacted understanding of SRE

The majority of the students did not express a significant difference in their understanding of SRE due to their internship experiences. These internships were in a variety of settings including process engineering, lighting engineering, aerospace engineering, marketing, quality, manufacturing, land

surveying, engineering inspection, and construction. This included students from four different engineering disciplines and the majority of the mechanical engineering majors. As well, students with an array of initial ideas about SRE are included, including those with fairly narrow ideas of SRE (e.g. Jason) and those with more expansive views (e.g. Tanya). For example, Derek, a mechanical engineering major at PrU, had an internship following his first year testing the quality of packaging at a manufacturing facility. Throughout his following interviews, he did not once mention any experiences from his three months spent at the firm relating to how he came to his understanding of SRE. Some of these students did not experience significant SRE changes during college overall like Todd, a mechanical engineering major who had a narrow understanding of SRE and wanted to work in aerospace. Others were influenced to change their SRE understanding by their professional practice or humanities classes, political discussions with friends, and volunteer experiences [2].

B. Internship narrowed student's understanding of SRE

Three students expressed a narrowed understanding of SRE when compared with their previous year's responses. Two of them had internships in each of the summers while they were students. Nathan and Jolene, both civil engineering majors, originally expressed a strong interest in putting their engineering skills to use in low-resource communities based on their pre-college familial influences. Madison, on the other hand, always wanted to be a manufacturing engineer, and her SRE ideas focused more and more with each internship as her professional career approached. Jolene and Madison are discussed in more detail below.

In Jolene's first year interview, while she was at TU, she expressed that she planned to help people in less privileged countries:

I mean as an engineer, I would have the knowledge to do so and go to other places where, like in Third World countries where they might not have the people who have that knowledge or more of that knowledge. So, using those skills that I acquired to benefit others in other countries and such.

She discussed how she planned to build a biogas digester in Ethiopia with her father. In the next year's interview, after transferring to MPU2 closer to her hometown, she said they did not travel for various reasons, and were planning to go the following summer. She still was very interested in a pathway that would allow her to "better other people's lives, in a way" with her engineering skills. Through her internship at her father's company, though, she began to see herself as a wastewater engineer in the future; thus, the ways she was seeing SR fit into her engineering career narrowed to the effects in terms of safety and the inherent impact of treating wastewater. Her work would be socially responsible, but she did not expand to the larger role that she could have as an engineer or for the profession more broadly.

In the following two interviews, Jolene localized and narrowed her understanding of SRE. While she still referenced a desire to work in developing communities such as Ethiopia and Trinidad and Tobago for a couple weeks per

year, she saw herself taking over the company business in the future, and SRE became exactly what she would be doing in the future as part of the civil engineering profession. An internship in the final summer with a local municipality didn't change her established ideas about SRE, and she planned to return to the private sector for her engineering career.

Madison, a TU mechanical engineering student, was the only student among 34 interviewed who had a detailed idea of what she wanted to do in her future engineering career during the first interview. She intended to work as a manufacturing engineer and worked as a manufacturing intern over each of the three summers. In her first year interview, she described a rather broad scope of SRE, and that engineers contribute to safety, bettering society and the environment through infrastructure and technologies. She also recognized that some engineers "need to help impoverished countries..." but that was not part of her plans.

Madison was consistent in each of the following years about her anticipated responsibilities as a manufacturing engineer: safety and health of the workers in the plant, safety of products in society, pleasing the clients, and faithfully serving her employer. Notably, these align quite well with the NSPE Code of Ethics. Her most significant narrowing, though, happened between the third and fourth years. In the third year, she mentioned towards the end of the interview a macroethical responsibility she would have, which indicates a deeper understanding of SRE:

if we eliminated a job of someone on the line rather than just firing them because they don't have a job available for them there, it would be a good idea to find something else for them to do that would help you in some way.

In the fourth year after her internship at a large car manufacturing company, Madison seemed to recognize and abdicate the responsibility for lost jobs through her engineering. She said:

So you are trying to get rid of the people that you have, so it's more cost-effective so you are essentially losing workers, but I hope that whoever it is that's making the decision can find other ways to use these people so they are more beneficial for the company so they might work on a continuous improvement project rather than letting them go.

This may seem like a small difference, but she saw herself and her engineering as separate from the issue of job displacement and not included within her realm of responsibility. Perhaps this was due to seeing the hierarchy at the large company, and recognizing that she would not be one of the decision makers as an engineer. Rather, she would do her job of saving the company money while still making a safe product. In this interview, she also mentioned that the design engineers in the company would have more responsibility than she would as a manufacturing engineer, which is an interesting distinction.

C. Internship expanded student's understanding of SRE

Four students' internship experiences seemed to expand their understanding of SRE, and their personal role within the

engineering profession. As Wynne gained more responsibility at her internships, she learned how her company did not act as responsibly as she believed they could. The other three had jobs working with the public sector. Sarah's work for her own hometown showed the direct impact of engineering work on people's day to day lives. Katherine and Rachael each had very different, yet powerful internships between their third and fourth years, and these influences are presented below in detail.

Katherine was a civil engineering student at MPU who had broad and ambitious goals (vertical farms) for her engineering career before she learned more about typical engineering practice and took more civil engineering classes. She was still "wide open" at the end of her second year applying to many types of civil engineering internships, and believed that engineering firms "should care about their work and...they should all have meaning and purpose." The internship she described in her third year was with a wind analysis firm, which she appreciated, but did learned that structural engineering was not for her.

Conversely, Katherine's internship following her third year was for the city government in which the university resides, particularly the public works department. She learned about the context and approval process of infrastructure development. When asked what she is looking for in an ideal career, she responded, "I would like to be in a position where I feel like I am making a difference...that helps the larger population...like a public works engineer." She described responsibilities she will have in the future as an engineer such as safety of users, convenience for the public and client demands. When asked about her influences, she stated that both her classes and internship were important, but "primarily my internship because that process was out of the classroom and was actually designing something and getting feedback." Thus, Katherine may not have had a well-defined idea of SRE before her internship, but her experience exposed the broad public for which she will be somewhat responsible through her designs.

Rachael was a software engineering student at PrU excited about robotics. In the summer following her first and second years, she taught programming to middle and high school students. She was also quite advanced in her studies as evidenced by her undergraduate teaching assistant positions throughout her time at PrU and she completed her degree requirements in just three years. During her third year, she worked on a research project developing software for unmanned aerial vehicles for disaster response in high toxicity zones. In the summer between her third and fourth years, she worked at a national-security focused research lab in the U.S., then had a co-op at NASA in the fall semester of her fourth year, where she planned to work after graduation.

Before her fourth interview, Rachael discussed socially responsible engineering as "creat[ing] for progress." She described some details about functional and easy to use products, and that engineers should know the impact of their industry broadly, but did not go much beyond. It seemed as though the combination of the national lab and NASA professional experiences expanded her definition to realize how she could potentially affect people. She was asked about how she plans to be helping people or serving society in some

way in her future career. After describing that she planned to be part of the team to get humans to live on Mars following her experience at NASA, she was asked a follow up question with the following response:

I: To what extent is this component really important in a job to you?

R: I feel like it never used to be that important to me, like I said I always wanted to do science for science, so if a project was cool, then I wanted to work on it, but I feel like now it is actually pretty important in terms of the importance that I learned last semester because it's one of those things, like I work for NASA, and I think that kind of sticks now that it's very important that I do something that is progressing humanity.

Being able to see her future career more vividly and being exposed to engineering work that really could impact humanity pushed her to consider and value this aspect of the profession.

V. DISCUSSION

While only seven of the fifteen students expressed a significant change in their ideas about SRE due to their engineering work experience, internships are clearly important sites of development, especially for those who had little previous exposure to the engineering profession. Some students hardly discussed their internships at all except very briefly to explain what they did over the previous year. As most had internships over three months, this is surprising, and perhaps a missed opportunity to have an impact on students' understanding of the profession. It seemed there were two phenomena happening: (i) as their future profession became more of a reality, it did or did not include some of their previously held pro-social ambitions, and/or (ii) they experienced their future profession in a relatively limited manner that did or did not encourage learning about the social effects some of their coworkers considered and their industry impacted.

Jolene started with a strong desire to use engineering to alleviate poverty, which is not a commonly held goal among engineering students, but is an important minority. She was confronted with the reality and opportunity of a job in wastewater treatment, she found value in that, and could see a clear pathway, which was not the case with international development work. For Madison, she started with a relatively narrow view of her social responsibilities as an engineer, and as her employment became imminent, she focused on the limited view that her internship allowed her to see. Automobile manufacturing has massive impacts throughout the world, and she never was exposed to these elements during her three internships in the industry.

In contrast, the students who expanded their understanding of SRE through their internships connected their work with social responsibility. Katherine originally had a vague desire to impact and interact with communities in positive ways, and her internship with the city government showed concrete ways she could do this through a civil engineering job. She was invited to participate in town hall meetings with various stakeholders and was brought into the decision-making process at the

municipal level. Rachael seemed to have a rather dramatic change of prioritization by learning about the possibilities with NASA to push society forward and provide improvements to life on Earth and perhaps on Mars. She did not seem very impacted by her classes at PrU, which were not very challenging, and finally she was confronted with a real possibility of making a difference, and that was motivating towards her future career choices.

Notably, one student, not discussed here, left engineering altogether after her summer internship following her second year. There were other important factors that contributed to her decision to leave engineering, but the internship was the final straw (see more details in [21]).

Note that Katherine, Rachael, and Sarah were impacted by ‘public’ jobs, including working with city government and NASA. All of the students that had a minimal change or narrowed understanding of SRE worked for private companies.

Interestingly, the two students who participated in formal co-op programs both expanded their understanding of SRE via their experiences. Co-op programs are likely designed with more intentionality than summer internships that students individually arrange. The industrial co-op partners likely have a greater appreciation for their role in educating students, versus summer internships where some companies may be more focused on the work that they can get out of a student for fairly low pay. Universities typically monitor co-op experiences to ensure that students have quality learning experiences, keeping as co-op partners those companies that prove to provide strong outcomes.

Internships can become more meaningful overall with better integration with the university and the course curriculum. Educators at the University of Washington used e-portfolios to help students reflect on their internship experiences throughout their employment [22]. Further engagement with and discussion particularly about the responsibilities of engineers at their internships could help internalize their impacts on society. Additionally, if the engineering programs have close connections to the companies that are providing internships, some materials could be provided to employers to help guide students to understand their job’s responsibilities through intentional education.

In engineering courses, faculty can attempt to connect course content, especially content about ethics and societal impacts, to students’ future and past internships. This could potentially be a great way to gain student buy-in for course content as well, since it will tap into their lived experiences. In particular, capstone courses provide a potentially rich site for illuminating how engineers can be more socially responsible. Most engineering programs have a capstone course, and a captive audience of students who see their often year-long projects as ‘real’ engineering. Thus, if capstone courses require a deeper consideration of the social and environmental impacts of engineering designs, students may see engineering problems more as sociotechnical and contextualized rather than calculations to solve.

VI. LIMITATIONS AND FUTURE WORK

Limitations in time or the students’ tangents that took the interview in a different direction are some of the hazards of semi-structured interviews with students of varying personalities. It is entirely possible that the students held beliefs that they did not share or the interviewer did not ask the right questions to elicit a response about their views on internships impacting their ideas of SRE. Additionally, the interviews took place in March or April each year, which was typically a long time after their summer internships; thus, the impact of these experiences may have faded from their memory. Experiencing an array of curricular and co-curricular environments during college, students may not be aware of specific activities that changed their views of socially responsible engineering. In fact, the interaction of curricular and internship experiences may be necessary for growth in student perceptions of SRE. For example, the scaffolding of SRE in courses prior to an internship experience and/or post-internship reflections or discussions in courses may lead students to recognize SRE links in their internships. Future studies should explore environments that intentionally scaffold internship experiences in the curriculum. Programs with mandatory co-ops might be an ideal site for these studies. Longitudinal qualitative studies are likely to be the most appropriate, perhaps coupled with quantitative methods to also explore attitudes toward SRE.

VII. CONCLUSIONS

The majority of the students did not discuss that internship experiences had a significant impact on their views of socially responsible engineering (SRE). This included the majority of mechanical engineering students. For a few students, views of SRE appeared to contract as a result of internships in industry. Four students expanded their views of SRE as a result of internships, including three students with internships in the public sector. This indicates that the internship experience is meaningful for many students but could be improved to enhance and expand how engineering students think about their future social responsibilities.

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