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Understanding Missions for Engineering Outreach and Service: How New Engineering Faculty Can Learn from Past Generations of Ph.D.-holding Engineers and Engineering Educators

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Abstract

Teaching, research, and service are the three "arms" of academic success, especially for new faculty. The roles of teaching and research are relatively concrete in disciplinary standards, but service is more ambiguous. This paper reflects on the service and outreach of prior generations of Ph.D.-holding engineers to more fully interrogate the idea of what service means in the context of being an expert in the field. This paper studies the role of service and outreach in the careers of engineering Ph.D.s in academia and industry through the lens of Golde and Walker's (2006) Stewardship framework. Although service and outreach are not tenets of the three arms of Stewardship as proposed originally by Golde and Walker, we find that they are integral parts of all three tenets of Stewardship. As part of a larger NSF-funded study on the preparation of engineering doctoral students, interview data from 40 Ph.D.-holding engineers in a variety of careers indicate that practicing engineers identify strong linkages between their engineering expertise and outreach, service, and the broader impacts of their work. This research will help to prepare new engineering faculty for the expectations of service based on the paths of prior generations of engineers and engineering educators.

Background and Literature Review

For new faculty members, colloquial knowledge of promotion and tenure criteria requires a shown commitment to the three "arms" of an academic career: research, teaching, and service. The service component is sometimes an afterthought to ideals of rigor related to publishing, building a research group, and teaching excellence. However, by studying the ways in which service is incorporated into the careers of engineering faculty and other Ph.D. holders, this research helps to provide a clearer vision of the role that service and outreach can have in the career of a new faculty member. Findings from this study can be used to help pre-tenured engineering faculty become more deliberate in the service and outreach opportunities that they pursue, optimizing their passions for different kinds of outreach and service as well as aligning mental faculties and resources during often-stressful pre-tenure years.

New faculty members are often exposed to the criteria for promotion or tenure that they must exhibit a commitment to the three "arms" of an academic career: research, teaching, and service[1]. Commitments to research, publication, and teaching excellence are expected, as Ph.D. students through their education are expected to demonstrate these commitments. However, for new faculty, the service commitment is often overshadowed by research and teaching obligations, and the undefined nature of this aspect of a faculty career leads to some uncertainty, especially since it is difficult to find literature on "service" in academia without the context of teaching and research activities.

Higher education scholars note discrepancies in the service habits of faculty at different career stages[2], departments [3], and tenure/non-tenure track classifications[4]. Differences have also been noted between male and female allocations of research, teaching, and service activities[5,6] as well

as differences between foreign-born and domestic faculty[7-8]. Whole books are written for graduate students and new faculty on finding the balance in the obligations of the academy in order to better prepare incoming generations for their multiple roles[9-11]. Successful faculty members often find ways to integrate their service opportunities into their research interests, disciplinary professional societies, or other areas, where one's time and mental resources can be spent efficiently. However, there are very few "best practices" for strategically selecting service and outreach opportunities that can be references for new faculty members. This research intends to bring the conversation into a more practical space, studying the service and outreach opportunities in which engineering faculty may invest their energy. We propose that by studying the service and outreach activities of current faculty and other Ph.D. holding engineers in academic and industry careers, we can better map out strategic ways for new faculty to fulfill their service commitments. Our data is analyzed through a theoretical framework called the Stewardship Framework, proposed by Golde and Walker[12]. Different facets of service and outreach surface in each of the three dimensions of the framework, and offer an interesting vehicle for thinking about the role of service and outreach in the activities of faculty members.

Stewardship Framework

Golde and Walker (2006) discuss the role of the Ph.D. through the lens of the Stewardship framework, which proposed that the three charges for Ph.D.s include the *conservation* of the knowledge and rigor of the discipline, the *generation* of new knowledge, and the *transformation* of their knowledge and expertise to be useful to diverse audiences. Although these elements are well defined, it is interesting to understand how the principles of stewardship are manifested in Ph.D.-holding engineers. Before our work, the Stewardship framework was only applied to six fields; engineering was not investigated. Past work by our group discusses this framework for engineering Ph.D.s in industry and academic careers[14-16].

Table 1: Overview of Three Stewardship Tenets as Identified by Golde and Walker[12]

Stewardship Tenet	Definition
Conservation	Working to conserve the nature of the academic field for the future
Generation	Creation of new academic knowledge
Transformation	Translation of expertise to diverse audiences and purposes

Methods

Data for this study was comprised of 40 semi-structured interviews with Ph.D.-holding engineers working in industry and academia and has been noted in previous publications by the research group[14-16]. Sampling for the interviews was conducted using purposeful and snowball sampling methods. Criteria for eligibility for the study included 1) having obtained a Ph.D. in engineering in the United States and 2) currently works in industry or academia. A recruitment email was sent to various American Society for Engineering Education (ASEE) Division Chairs in order for them to forward the research request to their members. Additionally, contacts and collaborators in engineering academia and industry were contacted for their participation, and asked to forward the request through their network. In total, 40 hour-long semi-structured interviews were conducted. The interview questions were phrased in order to better understand the

operationalization of Stewardship in the career activities of Ph.D. engineers and are described further in prior publications by the research group[14-16]. The interviewees were diverse: 25% were currently working in industry, 42% were currently working in academia, and the remainder transferred between industry and academic careers in their work history. In total they represented 7 engineering fields. Eleven of the 40 interviewees were female.

The interview transcripts were coded by emergent themes in order to create a "codebook" for engineering stewardship through open-coding and constant comparative methods[13]. Further information on the coding schema can be found in prior published work[14-16]. Divided by overarching category (Conservation, Generation, and Transformation), the codes were sorted and defined in order to operationalize Stewardship for engineering Ph.D.s. Within the codes, however, we note that the emphasis on outreach and service were mentioned and defined within each of the three major areas. Most emphasis on service and outreach are found in the Transformation codes, but other significant emphases on broader impacts of technical work can be found in Conservation and Generation codes as well.

Results

Service and Outreach within Conservation

Generally, conservation codes relate to the maintenance and upholding of the rigor and quality of engineering fields. Technical leadership is the overarching code from which most of the examples of service and commitment to justice were found. Many of the participants in this study refer to their informal professional service as the way in which they use their technical expertise and position in order to work to conserve the direction of the field, especially though their teaching responsibilities: In one participant's words, by being "able to bring an understanding or knowledge about the field to the classroom [and…] come up with relevant examples for [students] to discuss, or interesting cases studies for them to consider." Other participants noted involvement in informal mentorship opportunities and outreach experience, such as advising the FIRST robotics competition at local high schools.

Additionally, some of the participants mentioned a personal commitment to using their expertise to inform political policy, which will define the future of the field. Formal service commitments for the university, department, or for the national or international engineering fields are also important to these engineering Ph.Ds. Examples mentioned by interviewees included serving in editor and reviewer positions for journals, which help to preserve the rigor of the field and judge the quality of research that is published. Serving on Ph.D. qualifying examination committees also show that the commitment of time and energies to the professional community as a whole are important.

Service and Outreach within Generation

The tenet of Generation refers to the creation of knowledge, one of the most unique features of a Ph.D. Within generation, our interview data shows an underlying theme of service and broader impact in the application of technical knowledge to new problems. The Ph.D. engineers interviewed demonstrated a thoughtfulness regarding what problems were worth working on and

worth publishing. Generally, it was important for these engineers to "work on something that is honestly important," according to one participant, and to another, to work on the "very big, hard problems." Advances in these fields were attributed to the development of value systems and very high ethical standards, teaching others to generate knowledge, and the use of creativity and diverse backgrounds to bring "unique perspective[s]" to research problems. One engineer described the need for diversity in engineering in order to innovate: "The advances come when you're sort of looking at—you're applying something new to a different area and you're bringing in people who haven't looked at it before." Others refer to the importance of collaborations and collaborative work in generating advances in technology, especially between different fields (ex. mechanical engineering and psychology to advance mental health technologies), collaborations between university research facilities and industry to overcome resource limitations, and collaborations across different countries.

The impact described by the interview participants regarding their technical advances shows their commitment to the betterment of society and to the affordability of solutions for all people. One engineer commented that "thousands of laboratories use some of the technology that we've developed," indicating a sort of second-order impact, where the advances by these laboratories happen as a result of the engineers' research. Some engineers indicate that they work on projects with personal significance, for example, one was discussing his/her work with devices to monitor heart health, that "what we're working on is something that'll keep people from that—from not being diagnosed." Others talk about the motivation of their work for other people: One engineer works to make devices for disability and autism behaviors "more reliable, more robust, more affordable," and that they're working toward developing a "*best* engineering solution instead of an engineering solution." Others work on solutions for Parkinson's disease, or sensors for toxins in water and food. The commitment of using technical expertise to better serve the population is evident in these research activities.

Service and Outreach within Transformation

Transformation as a tenet of Stewardship describes the work of experts in a field to translate their expertise to other audiences and the broader community. Often, this is linked with the importance of communication skills for Ph.D.s in engineering, but by looking at the data through a service and justice lens, Transformation indicates the application of knowledge to a broader or global environment. One participant urged Ph.D.s in engineering to be "flexible, open-minded, open to new cultures, [and] new understanding of the global environment." Other participants noted use of their expertise and position to establish global engineering exchange programs with institutions around the world so students (future stewards of the disciplines) could gain global engineering experience or work to support undergraduate research initiatives and other outreach programs. Specifically, some participants noted the importance of transformation in their efforts to introduce students to social responsibility in engineering through service components of organizations such as Engineers without Borders or service-learning engineering projects in their communities.

Just as in the Generation tenet, the impact of the research toward the improvement of life for people in society was interpreted as the transformation of expertise into societal impact. These include glaucoma research and impact on clinical care, biotechnology collaborations with

industry, increasing the efficiency of mercury removal from coal combustion, development of hygiene products, development of safer ultrasound techniques for the medical field, efficiency increase for solar power, and advances in optical telecommunications for high-speed communications. The engineer who works with autism, special needs, and disability assistive technology noted that her/his research motivates students to do better work because of the impact of the research.

Lastly, the role of transformation in service, outreach, and justice was identified by the participants though their informal or formal teaching roles; mentorship roles, or outreach activities. Some describe translating their knowledge for mentoring graduate students, junior faculty, women and underrepresented minority (URM) groups in engineering, helping with "Introduce a Girl to Engineering Day," working with the Black Graduate Association, and advising minority-serving national organizations such as the National Society of Black Engineers (NSBE). Formal teaching roles inspire the engineers to show students the most important parts of being an engineer, presenting at conferences in their field but also to fields that their research directly impacts, and helping to design high school teacher workshops on science and engineering topics. One participant noted using her/his knowledge to hold a seminar for bureaucrats and industry leaders in Washington.

Discussion

Table 2 outlines the summary of our findings above. Through the interviews with the 40 Ph.D.-level engineers in industry and academia, we coded for ideas complying with conservation, generation, and transformation, in order to operationalize Golde and Walker's (2006) Stewardship framework for engineering disciplines. In this work, we identify the elements of service and outreach that were found in the interviews for each of the three elements.

Table 2: Summary of Findings for Stewardship Tenets

Stewardship Tenet	Definition	Overarching Primary and Secondary Codes	Service and Justice Examples from Ph.D. Engineering Participants
Conservation	Working to conserve the nature of the academic field for the future	▪ Technical Leadership	▪ Informal mentorship of junior faculty ▪ Outreach activities as a way to attract talent into the field ▪ Inform political policy ▪ Professional ethics standards ▪ Professional service (i.e., reviewer/editor for journals, sit on qualifying exam committees)
Generation	Creation of new academic knowledge	▪ Contributions to the Field ▪ Teaching others to Generate Knowledge ▪ Impact	▪ Harnessing creativity and diversity of thought to solve important problems ▪ Collaborations and collaborative work (multidisciplinary, between academia and industry, and internationally) ▪ Broader impact of the technical advances to the greater good of society
Transformation	Translation of expertise to diverse audiences and purposes	▪ Application of Knowledge and Broader Impact ▪ Teaching ▪ Outreach and	▪ Translate expertise by teaching students about the importance of service learning and volunteer engineering opportunities (Engineers without Borders, Community-based service learning) ▪ Expertise translated to the public through the

		Mentoring ▪ Global Perspective	affordability and availability of new, helpful technologies (especially for health applications) ▪ Volunteer mentorship and outreach activities ▪ Volunteer for opportunities to help women and underrepresented minorities succeed in engineering and science

These findings are important in truly understanding how current expert engineers perceive elements of stewardship. It further demonstrates linkages between service, outreach, and engineering practices at the doctoral level. By further analyzing the data, we understand the elements of the role of the engineering Ph.D. in their commitment to service and bettering the world through new technologies and discoveries.

Recommendations for New Faculty

These results can be used to guide faculty members to strategically select their service opportunities to align with the activities in which they most actively participate. For example, most junior faculty members at research intensive universities are overwhelmed with the generation tenet of Stewardship: developing research programs, publishing, and creating new knowledge. If most of a new faculty's activities are situated in this area, then it is most strategic to align service activities with this area. From our findings, opportunities for service might include reaching out to interested interdisciplinary collaborations to produce novel insights in the discipline that are important for multiple stakeholders. This faculty member might volunteer their disciplinary skills in leading small research projects for undergraduates, finding ways to volunteer in disciplinary professional research societies, and translating their disciplinary knowledge in new venues to promote collaborative research activities. Similarly, this faculty member may find joy sharing their passion for research in seminars either in academia or for a general community audience, (especially if she or he is in a "hot" area like genetic modification of food or crops, energy or power technology (wind, hydroelectric, etc.)), or sharing at a "career day" at a local school to expose young children to research careers at an early age. In the same way, junior engineering faculty at teaching-focused institutions may best align their service with teaching-focused outreach: Leading science and engineering visit days on campus, helping with community service-based engineering projects, and helping students lead outreach efforts in the community at local schools or after-school organizations/programs.

Conclusion

This study reports on findings from part of a larger studying analyzing the knowledge, skills, and attributes of engineering Ph.D.s in industry and academia. By analyzing the service and outreach components of interview data from practicing engineers in academic and industry careers through the Stewardship Framework, we find different facets of service and outreach in each of the three Stewardship tenets. These findings are useful when strategically aligning one's multiple roles as a new faculty member: By choosing service activities that enhance other major activities, time and resources can be used more efficiently. Service is often overshadowed by the research and teaching aspects of an academic career, but by strategically aligning activities, service and outreach to the university and community can be a healthy and thriving part of a new faculty's professional career.

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