

Preparing Engineers for Careers in Social Innovation and Sustainable Development

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Abstract—Since its founding in 2002, Engineers Without Borders-USA has grown to have a chapter at almost every university across the nation. Alongside, academic programs in humanitarian engineering and social entrepreneurship are popping up globally. Administrators often think about such programs as vehicles for students to develop their soft skills and meet ABET requirements. There is ample evidence that such experiences develop students’ technical skills as well as non-technical skills like teamwork, communication, and ethical decision-making. However, many students get involved because they want to leverage their engineering education to pursue lifelong careers improving the human condition. An approach to helping these students is to identify potential career pathways to aid them in navigating their way. We spent three years interviewing hundreds of STEM innovators working on a range of societal challenges across diverse sectors and organizations in the US and globally. We learned about their work, professional preparation, and career trajectories, and asked them, “What advice do you have for professors and universities as they educate the next generation of social innovators?” This session fosters discussion on the recurrent themes and insights based on their decades of living on the bleeding edge of social innovation.

Keywords— *Engineers Without Borders, social innovation, sustainable development, humanitarian engineering; social entrepreneurship; career preparation*

I. INTRODUCTION

From solar panels to fertilizers to the microchip, engineering has always revolved around improving the human condition. Many professional organizations promote this charge in their mission statements: the Institute of Electrical and Electronics Engineers aims to “advance technology for humanity,” the American Society of Mechanical Engineers aims to help engineers “develop solutions to benefit lives and livelihoods”, and the National Society of Professional engineers is committed to “hold the public health, safety, and welfare above all other considerations” [1, 2, 3]. And yet, engineering is not viewed by the general public as a caregiving profession vital to advancing humanity. This may be because while engineers have always been motivated by the idea that their inventions would be useful to society, they are only recently getting more directly involved on the frontlines of building and improving society, talking about it, and taking credit for it. Engineers are designing products that empower people in less developed communities; they are educating the next generation of engineers with social impact as a driving

principle; and they are ensuring their company is sustainably and ethically sourcing their inputs.

Thanks to student clubs and professional organizations like Engineers Without Borders and Engineers for a Sustainable World, and academic programs like D-Lab at MIT and GlobalResolve at Arizona State, there is growing interest among engineering students to pursue careers where they can directly see the human impact of their work. Such careers develop in many different ways, through many kinds of organizations, but they call for a common set of professional competencies. Most students associate business with large corporations like Amazon, Google, and Apple, and there are careers in social innovation and sustainable development in such businesses which have a triple bottom line. At the same time, there is a rise in businesses that prioritize social returns while being self-sustaining, such as Kickstart which makes low-cost water pumps for smallholder farmers in developing countries and Fenix International which makes a smart battery system designed to withstand harsh conditions, is charged via solar panel, and allows customers to “lease to own” the systems via a mobile-enabled payment plan [4, 5]. The global shift toward a tech- and business-oriented world is placing a greater emphasis on using entrepreneurial approaches to solve issues in international development. Given these trends, how do we prepare engineering students for careers in social business and global sustainable development?

This question assumes more prominence with initiatives like the National Academy of Engineering’s Grand Challenge Scholars Program, which emerged from letters of commitment presented to President Obama from more than 120 engineering colleges to educate a new generation of engineers expressly equipped to tackle the most pressing issues facing society [6]. Educators interested in propelling their students into careers in social innovation and global sustainable development can take away clear action items from this session on how to advise their students on career paths, previously undefined. Specific actionable insights include the most important professional competencies to become a social innovator, the value of interdisciplinary and out-of-classroom academic experiences, how to help students find their niche, and approaches to prepare students for a competitive, complex world.

II. SITUATION AND MOTIVATION

Many millennials want to directly see the human impact of their work but never discover career paths to leverage their education and passion to improve the human condition. In a

rapidly globalizing world where societies and problems are increasingly interconnected, career paths are rapidly changing to meet the new demands of society. With improving technology, engineering professionals are working on problems facing their local communities and those on the other side of the globe. However, the exact jobs and career paths are not well defined. Therefore, students who pursue international service learning and similar opportunities in college are unsure how to continue pursuing their passion after graduation.

We have witnessed this problem first-hand over the past ten years with students in the Humanitarian Engineering and Social Entrepreneurship (HESE) Program at Penn State. HESE engages students and faculty across campus in the rigorous research, design, field-testing, and launch of technology-based social enterprises in several low- and middle-income countries. Through a series of courses, HESE teams advance ventures related to food security and global health over multiple years with aspirations for large-scale commercialization and dissemination. Alongside their enterprises, students work on original publishable research [7].

HESE provides engineering and non-engineering students a transformative experience and develops the competencies and mindsets necessary to launch entrepreneurial ventures and pursue careers in international development. After pursuing such an immersive experience, students want to go out and solve global sustainable development challenges—they want to decide what problems to invest their time, money, energy in. However, few students, faculty, advisors, and parents are familiar with what impact-focused career options they have.

III. METHODS

We spent three years interviewing hundreds of innovators working on a wide range of societal challenges across diverse sectors and organizations in the United States and around the world. Over two-thirds of them were scientists and engineers, almost half were women, and they all believed in the power of STEM to solve societal grand challenges. We turned these conversations into a book, *Solving Problems That Matter (and Getting Paid for It)*, which includes 54 expert briefs penned by leaders from USAID, Peace Corps, MIT, Engineers Without Borders, AAAS, and other organizations. In addition, 100 STEM innovators from the World Bank, UNICEF, Village Capital, Gates Foundation, Google, and dozens of social ventures, government agencies, nonprofits, academia, and corporations share their enlightening and inspiring profiles, including their current roles and responsibilities, career trajectories and lessons learned along the way. The goal of this book is to educate students, parents, faculty and career counselors about career pathways in social innovation and global sustainable development.

There are several relevant insights from this project that are worth sharing at the Frontiers in Education Conference. The bottom line is that engineers can pursue careers in the social impact arena—and they are more likely to be successful if they understand the nature of these careers and the professional competencies that they need to excel. How do engineering colleges rise up to this challenge to prepare the next cadre of globally engaged social problem solvers? We asked each of the innovators “What advice do you have for professors and

universities as they educate the next generation of social innovators?” This project was not a scientific study and neither is it possible to synthesize a 400-page book in four pages. This article is a reflective essay on the most relevant take-aways for engineering educators and this session will synthesize the recurrent themes from innovator insights gained over decades of living on the bleeding edge of social innovation.

IV. MYTHS OF ENGINEERING EDUCATION AND CAREERS

A. *Engineers Engineer*

There is a myth perpetuated that engineers all work in engineering – i.e. they are taking measurements to build a bridge or creating a new plastic in a lab. While many engineering professionals do fit these traditional roles, there are many more applying their analytical abilities and transferable skills to work in other fields such as finance and medicine. Fewer than half the undergraduate STEM majors in the US end up in STEM occupations—the rest go on to apply their skillsets, competencies, and mindsets in the world of finance, education, healthcare, and every other part of the economy [8].

B. *Engineers are Most Valuable for Math & Science Skills*

The competencies commonly associated with the engineering profession, like designing circuits, writing programs, and analyzing structures, are essential. But so is the mindset: the way of seeing, thinking and doing unique to the praxis of engineering! Currently, the engineering education system is focused on teaching large amounts of math, physics, chemistry, and programming to prepare students for careers in solving specific kinds of problems. Complex real-world challenges often cannot be solved with just this skillset. Students also need to develop a mindset that allows them to ask the right set of questions to unpack challenges with problem-solving, systems thinking, quantitative, data-driven, and evidence-based approaches. Knowing the mechanics of materials is important, but it does not always help students in the complex job market because an effective mindset works in tandem with a skill set. Consider a civil engineer tasked with designing a new levee for a river. She has the skill set of building the levee—but she must combine this with a problem solving mindset to ensure the levee keeps her city from flooding, a systems thinking mindset to factor in costs for taxpayers and how the levee will affect groups such as restaurant owners who will no longer have river views, a data-driven mindset to build it in the most effective place to keep people safe, and an evidence-based mindset to learn from other engineers who have built levees efficiently and safely. Ultimately, her ability to design the best levee is a result of her combined mindset and skill set.

C. *Educators are not Responsible for Career Preparation*

The engineering education system needs to become more proactive to the needs of tomorrow’s job market, preparing students for the new, complex challenges they will face. We are doing our students a disservice if we emphasize that the solitary goal of their undergraduate education is to prepare for industry jobs! While the majority of the students will pursue jobs in for-profit corporations after graduation (and that’s perfectly healthy), they must be aware of the umpteen other career pathways available to them. Engineering educators, and

the entire ecosystem including career advisors, internship and coop coordinators, and career fair organizers need to adopt a student-centered approach that helps students identify traditional and non-traditional career pathways and make informed decisions. The insights presented in the next section provide some of the guiding principles of how career preparation and workforce development can be radically reframed to prepare problem solvers and social innovators for a rapidly changing world.

V. INSIGHTS FOR EDUCATORS

A. Types of Organizations

Engineers in the social innovation and global sustainable development space work for a wide array of organizations in the public, private, and social sectors as well as at the intersection of these sectors, the “fourth sector”. In the public sector, they work for government agencies including the National Science Foundation and the Environmental Protection Agency, and multilaterals including UNICEF and the World Bank. In the private sector, they work for small companies like TechShop Pittsburgh, consulting firms like Brendle Group, and large corporations like GE. In the social sector, they work for nonprofits including NGOs, foundations, universities, K-12 school districts, think tanks, professional organizations like IEEE, catalyst organizations like Dasra in India, and certifying organizations like LEED. In the fourth sector, their organizations include social enterprises, blended value organizations, public benefit corporations, and community development corporations; organizations in this emergent sector prioritize social value while being independent of charitable donations. Organizations across these four sectors have different kinds of resources, pursue different approaches to effect social change, and comply with different legal, operational, and tax regimes across different countries.

B. Build Important Professional Competencies

Bachelor’s degrees are taken for granted as the most basic education for careers in social innovation and sustainable development. However, the majority of professionals interviewed had a graduate education, including MEng, MS, MPH, MPP, MPA, and MBA degrees, and doctorates such as PhD, MD, and JD degrees. While their degrees vary, the innovators recommend ten professional competencies as essential to thrive (Figure 1). Providing students with opportunities for growth in these areas will enhance their ability to solve societal problems. The innovators encourage students to develop these competencies alongside building a strong portfolio and network. Educators can support their students by giving them compelling rigorous projects and urging them to go to conferences, workshops, open houses, and other events where they can meet professionals in their area of interest. Educators can also stress the importance of networking because most nontraditional jobs cannot be found on traditional job search websites or may not be advertised at all—most are found through extended networks.

C. Encourage Creative Inquiry Across Disciplines

Many of the innovators hope universities will offer more programs focused on interdisciplinary, collaborative team experiences in which students identify real problems and

develop real solutions. Although there are disciplinary silos at most institutions, social innovators from a wide variety of disciplines work together to solve complex problems. By creating interdisciplinary projects and programs, educators can get students to think beyond traditional career paths and reflect on what they want from their career. The extra time students spend on endeavors outside of their major degree requirements such as pursuing interdisciplinary and out-of-classroom academic experiences is often worth it because of the career opportunities and ideas that might emerge from them. Educators and parents often discourage students from pursuing additional activities because they do not want students to decrease their productivity. Taking a longer-term view, an international experience, an internship, or service learning course could open up a new world to a student. Students will still spend most of their time in classes and studying during college, but their unconventional classroom and out-of-classroom experiences are often an important part of preparing them to develop solutions to sustainable development challenges. Educators who value interdisciplinary and out-of-classroom academic experiences can help students make logical connections between their in-class and out-of-class activities, further enhancing their learning.



Fig 1. Ten Most Important Professional Competencies for Social Innovators

D. Toughen Up Students for a Competitive World

Students pursuing careers in social innovation and global sustainable development need to be ready for a difficult, uncertain, and competitive path. Educators can prepare them to be creative yet realistic, hardworking yet balanced, thoughtful yet detail oriented, and great team members yet proactive by pushing them to pursue challenging academic real-world experiences and holding students to high standards. Along the way, they should learn that failing is often a detour on the pathway to success and to not fear the potential of loss so much that they will not take risks.

E. Teach Students Ethical, Evidence-Based Approaches

Ensure students understand that before designing and implementing a sustainable development project, they need to do their due diligence to assess the validity of the project and appropriateness of their strategy. Before designing and building a new latrine for a village in South America, students should survey villagers about whether they need it, would pay

for it, etc. Students should have an understanding of current approaches and use these insights to inform their implementation strategy, conduct impact evaluations, and use the results to improve and scale up their efforts.

F. Prepare Students to be Systems Thinkers (And Actors)

Sustainable development involves complex challenges that need a multiplicity of approaches, stakeholders, and organizations. Increasingly, we need young professionals to be able to work effectively in an interconnected world. By presenting more intangible, large, complex problems to students, educators can encourage them to think creatively about challenges that cannot be solved by reading a textbook or attending a lecture. Facilitating broader thinking across cultures and disciplines is critical in developing STEM students who are prepared to enter a field where there are no easy well-defined answers or no answers at all!

G. Educate Students about Nontraditional Career Pathways

College career fairs typically draw large corporations because they have the resources to travel there, pay the fees, set up recruitment booth and interviews, and hire several students at once. Small to mid-sized companies, nonprofits, foundations, startups, governmental agencies, and multilateral organizations cannot afford to participate in career fairs. While many engineering students will find their niche at a large company, many can benefit from at least being exposed to other options. By providing opportunities for students to interact with professionals in a wider range of jobs than advertised at a career fair, educators can expose many students to career paths that better suit their passions.

H. Actively Help Students Find Their Niche

The innovators we interviewed encouraged students to start their job search by identifying the problems they care the most about—that they are willing to make sacrifices for and devote a lifetime to. Once students have identified the problem they want to solve, they can determine what organizations will provide them the best platforms with the right tools, resources, and networks. Educators can help students identify a platform by encouraging them to consider their preferred engagement approach, if they want to work with people or systems, what type of organization excites them, what work culture they are most comfortable with, and what role they want to play. Undergraduate education is the best time to test drive as many different platforms through internships, coops, research collaborations, and other face-to-face encounters and identify which kinds of organizations align best with their values, world views, and ways of working.

I. Engage Women and Underrepresented Groups

Supporting the underrepresented population in engineering fields is essential for solving global challenges and for the greater economic success and equality of women and minorities. Scholarly literature and popular press communicate that women participate in engineering when the connection to societal impact is clear [9, 10]. Millennials, including women

and minorities, can be drawn to engineering if they can see that their degree can be a gateway to an impact-focused career. Real world projects with positive human impact provide a meaningful and impactful experience that can build confidence for women and minorities in engineering [11].

J. Keep it Real

By grounding your students in reality, you can help them understand what is actually practical and what methods could be used to address a specific challenge in a developing country. While students should be trying to solve large complex problems, they should understand that one idea, thought up in a classroom is extremely unlikely to change the world. A significant amount of work, creativity, people, and resources are needed beyond their idea before they can have a large impact. Grasping this reality of the competitive world and the complex challenges it faces can help students be more practical when they enter the workforce.

VI. CONCLUSION

“Engineering education should never put the abstractions of calculus and physics ahead of the reality of the world around us, desperately in need of creative and compassionate thinkers, prepared to hear and amplify the hopes and aspirations of the most vulnerable members of our society.”

—Frank Bergh (Project Manager, SoCore Energy)

A growing number of students want to leverage their engineering education to pursue impact-focused careers where they can directly, tangibly see the human impact of their work. This three-year project clearly validated that there is indeed a wide array of career paths for engineers that prioritize social impact. Hence, engineering educators should not consider cocurricular service activities related to Engineering Without Borders or academic activities in humanitarian engineering as just a way for students to develop their leadership and teamwork skills. Community-engaged activities that are not real and reciprocal seldom empower communities in the longer term and lead to self-determined and sustainable development. It is essential that we move beyond academic exercises where we consider partnering communities as sandboxes in which to develop our students' technical and soft skills. Throughout the social innovation and international development spheres, we need professionals who are not just literate but also engaged and passionate about using their engineering education and mindset to help others. As members of these fields, we must commit to sharing the stories of game-changing scientists and engineers who achieve radical collaboration with business entrepreneurs and international relations leaders. Future world changers need real examples of engineering professionals who use the principles, methods, and mindsets of engineering for improving the human condition around the world. We hope this session will spark the building of a network of faculty that are interested in and can cross-pollinate observations and lessons learned in advising students in this exciting and emergent space.

VII. SESSION AGENDA

- **Introductions and Agenda Review** (5 minutes)
- **Setting the Stage** (10 minutes): Participants discuss activities their institutions have for engineers to make social impact, the career pathways their students take, how they have advised them, and what challenges they have faced in doing so.
- **Initial Exercises** (20 minutes): Participants brainstorm nontraditional STEM career pathways in social innovation / global sustainable development in groups.
- **Regroup and Review Career Pathways** (10 minutes): Groups report out on their generated ideas and group discusses myths of engineering education and careers based on content of this article.
- **Follow-on Activities** (20 minutes): Participants discuss in groups how to prepare students for these pathways.
- **Regroup and Review Top 10 Insights from Social Innovators Interviewed** (10 minutes): Groups report out on their generated ideas and presenters share insights from the social innovators from this article.
- **Concluding Questions and Discussions** (5 minutes)

AUTHOR INFORMATION

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