GRAND CHALLENGE SCHOLARS PROGRAM PORTFOLIO: **ENGINEERING FOR PEOPLE**

Grand Challenge: Health

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Abstract:
I tailored my college education to the areas of engineering, health, and medical anthropology. At Olin, I have achieved the greatest satisfaction, both academically and in my extracurricular activities, from understanding people's needs and helping them accordingly. Whether using interdisciplinary teams to build tools to help people live better lives, trying to understand what motivates them, or working to spread knowledge, I directed my efforts towards the needs of people who could be helped by my work, and focused on ways to help directly or indirectly through classes, research, and extracurricular endeavors. My learning and personal growth at Olin has been key in my decision to pursue a clinical research career as an MD/PhD.

Hello!
My name is Julianne Jorgensen. I am graduating from Olin College of Engineering with a Bachelor of Science degree in engineering with a concentration in bioengineering. My journey began with an interest in research, a focus on helping people, and while along the Olin path, the unveiling of my future.

My Background
Entering Olin, I knew that I was interested in bioengineering and research. As a high school senior, I conducted polymer research at the University of California in Los Angeles (UCLA) in Dr. Heather Maynard's lab. This experience sparked a passion for research in me. My aspiration became to attend Olin and move on to a PhD program at which point I would pursue an academic research career. With this mentality, I came to Olin.

I tailored my college education to the areas of engineering, health, and medical anthropology. At Olin, I have achieved the greatest satisfaction, both academically and in my extracurricular activities, from understanding people's needs and helping them accordingly. Whether building tools to help people live better lives, trying to understand what motivates them, or working to spread knowledge, I directed my efforts towards the needs of people who could be helped by my work, and focussed on ways to help directly or indirectly through classes, research, and extracurricular endeavors.

I have long contemplated the distinction between traditional bioengineering and biomedical engineering, and the question of which direction my studies should take. Thus far, my favorite explanation of the differences between bioengineering and biomedical engineering is that bioengineering is more oriented towards chemistry, materials science, and tissues, while biomedical engineering is more focused on devices – electronics, mechanics, software, and instrumentation. Before Olin, when I had the privilege of working for two summers in Dr. Maynard's lab on a drug delivery research project, I loved being in the lab and thinking about the impact I could make.This research was published in *Nature*, and I participated in it - this project, which has a huge potential to positively impact the lives of sick people all over the world. While I enjoyed the camaraderie of my fellow researchers, lab work can seem impersonal. Hence, at Olin I struggled with my desire to pursue research with its long-term opportunities for beneficial change and wanting to connect with people and develop a product with a more immediate impact - one that people can receive and respond to right away. This struggle propelled me more towards biomedical engineering opportunities. Through different classes, I was able to:

1. Develop an electroencephalogram (EEG) to read someone's brain waves and document their sleep cycles while they slept.[1] This device worked with a high degree of accuracy and could assist people to identify sleep disorders or disruptions;
2. Design a prosthetic arm for someone who had been interested in rock climbing, but had not attempted climbing past bouldering due to a missing limb.[2] This prosthetic was specifically designed to assist in rock climbing;
3. Produce a microfluidic device that would allow researchers to quickly identify antimicrobials. Such antimicrobials are critical in the effort to develop pharmaceuticals that can respond to drug-resistant bacteria; and
4. Quantify gait abnormalities in people with multiple sclerosis (MS) to measure the efficacy of different types of foot orthotics.[3] With this assessment, foot orthotics have a better chance of improving the gait and thus the ability of people with MS to walk.

Over the course of my four years at Olin, I also spent a significant amount of time working in the traditional bioengineering space measuring cell migration, developing artificial skin that mimicked human skin, analyzing arteries and their failure modes, as well as many other projects. These projects helped inform both the research I continued to conduct and my understanding of the human body and ways in which it can be helped. I have endeavored to develop a working knowledge of how and why people respond a particular way to certain circumstances or events.

Understanding How

Each new phase of my engineering education began with understanding how something works. Many of my classes have taught me about parts of the body and how those parts fit together. Other classes examined biological systems, including microbes, mammalian cells, and tissues and the integration of those systems throughout the body. Adding to this initial classroom education, I conducted research in motivation and took a medical anthropology class to better understand motivational forces that drive people. With this background, I was able to use a holistic approach to studying and identifying solutions for an individual's needs and the interaction with the needs and values of the community.

Physical

Bioengineering focuses largely on physical systems. I have worked to understand the materials science aspects of these systems, as well as the cellular and tissue interactions within them. In structural bioengineering, using materials science analysis, we studied the structure and function of various tissues throughout the body.This study culminated in a project to understand arteries and their various failure modes, focusing specifically on aneurysm formation and arterial dissection.

The cellular bioengineering field principally focuses on the cellular response to various chemical inputs. By understanding such physical interaction, I was able to quantify the cellular response to mechanical stresses[4], an input that is commonly disregarded. This understanding proved useful in tissue engineering[5]; when developing tissue constructs, my team had to understand the natural tissue system and components needed to build a model tissue sample and then prove that these constructs mimicked native tissue both chemically and with mechanical analysis. By developing an understanding of how each system worked individually at the materials, cellular, and tissue level, I was able to develop a comprehensive understanding of the native body system. Ultimately, with this knowledge I aspire to develop tissues and organ systems that can be used for possible future tissue and organ replacement.

Psychological

With an understanding of the physical system, I also wanted to gain insight into individual psychological responses. To this end, I undertook education research analyzing the motivations of male and female students through the development of their goals in an introductory materials science class. Our analyses involved parsing students' goals to gain meaning that may be implicit within students' responses. Our results indicated that the women students' goals were more social in nature while their male counterparts had goals that were more competitive. Our findings were accepted for presentation at the Frontiers in Education Conference in Madrid, Spain[6], where we found quite a bit of interest and support for our work. This experience has been invaluable in understanding how I, as a woman, may be perceiving my course goals and how those may mesh with my peers.

In addition and to add a different perspective, I also wanted to explore medical anthropology and sociological and anthropological responses to global health crises. Thus, I focussed my humanities classes around two main elements: anthropological cultures of cancer, and global health and social epidemiology.

The epidemiological method has developed and expanded since early epidemiologists, such as Hippocrates, James Lind, and John Snow[8], laid the foundation for modern epidemiology not only by observing and analyzing the natural occurrence of diseases, but also by testing hypotheses of the causes of disease.This method has matured to include qualitative and quantitative tests that can be conducted on a study of disease. As studies evolved from ecological and cross-sectional studies to retrospective and prospective case control and cohort studies, epidemiologists were able to understand and recommend disease treatments. Nonetheless, observing any disease in isolation limits our ability to understand the people experiencing the disease as well as the cultural phenomena that can encourage spread of outbreaks.

In cultures of cancer, I sought to understand the cultural response to cancer as a deadly condition in cultures that have been exposed to AIDS and other deadly long-term infectious diseases, focusing specifically on South Africa. Understanding the cultural and sociological response both to diseases and medical treatment is key to the effective treatment of everything from outbreaks to pandemics. During the semester I took this epidemiology class, the Ebola outbreak occurred in West Africa. The cultures that were hit hardest by Ebola suffered in large measure from a lack of available medical care, but also due to cultural norms that placed a high priority on physical contact between people despite strong medical cautioning to avoid direct contact with infected individuals. Even in deadly outbreaks, the ability to understand local cultural values greatly affects the impact policy and aid workers can have. For those of us who want to develop responsive treatments and have a positive impact on disease management and control, this understanding is even more important.

This passive ignorance of the human experience can be found in engineering and, at times, in medicine. And yet, the psychological motivations that drive people can be used to develop devices and tools to assist them. The user-oriented collaborative design (UOCD) class taught me the importance of understanding people's needs as a best method of designing for those people. My project group worked with street performers and learned critical information not only through respectful conversation, but also by working to understand driving values: they wanted to do what they loved without concern for money or safety. This understanding enabled us to address their concerns and design a device that allowed these performers to actively do what they love and increase their potential to make money and stay safe.

User centered design can also be incorporated when creating medical devices and in medical care. The biotechnology field and medical treatments are regularly viewed as intimidating by the average consumer. Therefore, any device that is made must take the user perspective into account to increase user satisfaction. Similarly, the medical community should (1) consider the impact of medical care on the patients undergoing treatment, (2) seek regular feedback from those patients, and (3) listen and respond in a caring and meaningful way.

This design focus was furthered in Investigating Normal[2], a course centered around development of assistive technology. We learned how to hold a conversation around disability and accessibility, making the world a better place for all people, particularly those with accessibility limitations. Using a combination of biology, design, and mechanics, my group designed a prosthetic arm for a man born with one arm. He longed to expand his climbing experience beyond boulders to rocks but hesitated without an effective prosthetic. He represented our starting point, and we assessed positioning and loading conditions. Working with this individual, developing the design of the this arm, planning for its construction, and furthering research in this field, represents one of the most personally satisfying moment of my bioengineering experience at Olin.

An Interdisciplinary Approach to Building Tools

This user-centered technique is employed to design tools for people. These devices and tools can then be developed and built by an interdisciplinary team.

User-centered design development

During SCOPE[7], our interdisciplinary team of mechanical, electrical, and biological engineers worked to improve long-term patient outcomes via destruction of premalignant pancreatic lesions. Premalignant cysts in the 1-3 cm range can be removed utilizing a variety of surgical methods. Treating them can prevent progression to malignancy and lower the anxiety of patients that comes with monitoring, as well as remove the stress on the patient, doctor, and hospital caused by the need for regular screening. While there is great interest in nonsurgical lesion removal within the pancreas, there are no clinically available solutions and only a small number of clinical trials to date. There is, therefore, increasing demand to create such devices to treat premalignant lesions. We designed and prototyped various iterations of a minimally invasive device to treat a premalignant state of pancreatic cancer and deploy a systematic targeted treatment to ensure that only the lesion is removed and preserving the surrounding normal pancreatic tissue. Through modeling, testing, and soliciting physician feedback, we have selected the most feasible device to recommend to Boston Scientific. This project required us to understand not only one subject matter, but multiple disciplines, bringing together an understanding of anatomy, user testing and feedback, and traditional engineering in order to create a device that has demonstrated promise in helping with lesion removal.

User-inspired design development

In another interdisciplinary project, I developed microfluidic chips by drawing together my understanding of fluid dynamics, materials, and microbiology. Antibiotic resistance is becoming increasingly prevalent, causing concern that traditional antibiotics will no longer be able to treat common infections. Treatment of antibiotic resistant bacteria requires the development of new antimicrobials. For children in developing countries, an estimated six million deaths are attributed to diarrhea, acute respiratory illness, malaria, and measles. These diseases have the potential to be treated by novel antimicrobials that can be more readily studied and identified using microfluidic devices. Microbes, both bacterial and fungal, naturally produce antimicrobial agents. The efficacy of such agents can be tested on a single bacteria and antimicrobial producing pair. My team's microfluidics experiment tested the antibacterial producing properties of the *Streptomycin* bacteria in killing *Bacillus* bacteria, by encapsulating the two bacteria together and observing growth over time. Similar to the UCLA research, this effort has the long-term potential to positively impact millions of people around the world.

Analysis of Users for Design Development

A cross-disciplinary approach also connected programming, biomechanics, and statistics in a data science class. I was able to bring together three engineering pillars of code, mechanical engineering, and bioengineering to study the walking patterns of individuals with Multiple Sclerosis (MS)[3]. MS is a progressive, disabling disease that causes damage to the nervous system and widespread dysfunction. The disease includes sensory, cognitive and motor impairments. The most common motor impairment is difficulty walking. By using statistics to analyze the gait of participants with MS, changes in gait and common walking patterns can be measured. Ankle foot orthotics (AFOs) can improve gait by increasing joint stability and joint alignment. In addition, the Human Dynamics and Controls (HDC) lab at University of Illinois at Urbana Champaign (UIUC) has designed a portable powered orthotic (PPAFO) that is powered at the ankle to help MS participants further achieve better gait while walking. My partner and I compared the efficacy of the PPAFO to AFO using walking trials for multiple study participants. This project was my first significant experience with coding at Olin. I was motivated not only by the problems the class endeavored to answer, of which walking support for patients with MS was one, but also wanted to develop myself as a well rounded engineer and contribute meaningfully to a project that was not in my “specialty” of bioengineering. This particular effort has the added appeal of aiding many individual people as they struggle to walk; something most of us take for granted. While we design and develop tools to help people, it is also extremely important to validate the benefit of the product. In this case, the data analysis allows the orthotic makers to validate the success and benefit of their product.

Last summer, I worked at a hospital conducting research into the efficacy of using endovascular stents to treat thoracic aortic aneurysms and dissections. As the use of stents expands to serve this purpose, by publishing the statistical analysis, more physicians can learn about this method of treatment and potentially use, or avoid, this treatment option for someone who might otherwise die from an aneurysm or a dissection. For me, the potential for great beneficial impact inspires me to continue to conduct meaningful research. This experience also helped me to clarify my career goals. I found the hospital environment extremely compelling with patient interaction, and the concomitant challenge to understand the issues with each patient and how to develop a treatment for their specific disease state. With the juxtaposition of this clinical exposure to the depth and breadth of my Olin experiences, I realized then that I could bring together my passion for research, my desire to help people by making a difference in their lives, and my fascination with clinical medicine, by pursuing a dual MD/PhD degree with the ultimate goal of being a physician researcher. As an MD/PhD, my research efforts will leverage my bioengineering education and my clinical background to focus on developing innovative new treatments for various conditions.

Spreading Knowledge

I believe that dissemination of knowledge is a critical piece of performing research, especially when information needs to be shared quickly and efficiently with audiences at large. Hence, over the last four years, I have invested extensive amounts of time developing, implementing, and presenting my work at conferences and writing manuscripts for publication (please see my resume).

Helping People through Service Learning

While at Olin I have been inspired to help people not only through my engineering efforts, but also directly, with my available extracurricular time. When I started at Olin, there was a notable decrease in enthusiasm among students over service. I endeavored to help correct this gap by trying to understand both what opportunities interested students and why people did not wish to participate. I found that a large portion of the Olin population was, in fact, interested in service of various types, but did not define the work they did for fun as service, or had some barrier to entry. With different leadership positions, I was able to gather information to understand why people initially did not seem to want to participate in service but also about the nuances that would increase participation and community support. This endeavor gave me the opportunity to reflect on service in my life. I realized that I could not ask other people to participate in service without understanding the value I found in it. I realized that service is a way to positively impact other people's lives and through activities that take minimal effort on my part, I am able to make someone's day better. By making a blanket with SERV to donate to Children's hospital, I might make a child's hospital stay feel slightly more hospitable. And, if I have the opportunity to help even one person, I find the activity worthwhile.

This effect increases when I am leading a service club or organization. If I make the opportunity for many other people to participate in service, then my impact can be increased significantly. My direct efforts have included performing as the Vice President of SERV, the service organization at Olin, leading the GCSP steering committee, serving as President of SWE, the Society of Women Engineers, and working as an architect for Build Day. Through SERV we were able to make not just one blanket, but more than 50. Seeing this amplification of my efforts was gratifying. As the President of SWE, I organized community events that enabled Olin students and faculty to reach out to elementary and middle school girls who are interested in math and science. This activity was particularly meaningful to me personally because I never had exposure to engineering disciplines at that age and would have avoided math had I been able. Once I saw the fantastic opportunities afforded by engineering, I knew I wanted to pursue those opportunities. It is very important to me to offer that exposure to other girls who may really need it to find their passion.

Helping the Greater Community

Throughout my time at Olin, I have also come to realize that I can make an impact not only working on medicine and devices, but also working to help people beyond general bioengineering. Creating positive results can take many forms, and I took advantage of as many as possible while at Olin.

Beginning my first year at Olin and continuing today, I have worked on biological research to study a exopolysaccharide produced by a bacterial culture. This polymer can bind to heavy metals and remove them from polluted water. This bacteria and the polymer it produces have the potential to aid in water purification, which can help increase the amount of clean drinking water, which in turn has both implications for use in water treatment plants and globally to possibly increase access to potable water.

At the collegiate level, I worked on a project to help design a conference and connect people from different college campuses in the area. In this effort I worked in a class to redesign entrepreneurship at Olin. While in the class, I planned a conference to draw together and connect students from Olin, Wellesley, and Babson and provide a network that had not existed previously. This conference would provide a catalyst to conversations between engineering, entrepreneurship, and liberal arts students about upcycling, the process of converting old or discarded materials into something useful and often beautiful. By ensuring that students were aware of waste production and potential for re-use of materials, the students would hopefully be increasingly careful about their use of trash. This consciousness could serve to increase quality of life because not only would less trash be produced but also, this process would create art that could give personality to these campuses.

FUTURE

While I still struggle to choose between biomedical engineering/device research or bioengineering/lab science research, I have decided to pursue a clinical research career as an MD/PhD.

My time at Olin has been key in developing this long term career goal. My academic and extracurricular experiences have allowed me to develop and grow as an individual and not only actively explore my interests, but also spend time helping people. I have been able to learn about materials and tissue behavior, psychology and anthropology and how these two relate to user design. All of these components of my education will ultimately be used to develop medical solutions for people. Olin has helped me weave together the threads of my interests into the tapestry of my future.

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