Engineering: Learn by Doing

Grand Challenge Scholars Program Portfolio

Engineering the Tools of Scientific Discovery

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Class of 2013

This portfolio is submitted in partial fulfillment of the Olin Grand Challenge Scholars Program requirements

Olin College has been an amazing experience. I remember my indecision and concern upon finishing high school. “Is this the right college? Will project based learning work for me? Can I keep up with everyone else?” It was a hard decision. I liked the idea of building intuition and learning the theory by jumping into a project head first, but did not know how that would feel or even if it would work.

My first year felt rough. I was jumping into subjects that I would never have considered. I was routinely out of my comfort area, doing circuitry work or learning how to machine parts that I designed myself. To deal with these challenges, I had to learn to realize that my classmates were there to help. I learned to reach out to the many brilliant people surrounding me so they could teach me a different way of thinking about a problem, or a new technique. I found myself in a supportive network that would lend me a helping hand when I fell. And to my surprise, I too found myself helping others with my new-found understanding. It was an amazing give and take that I did not expect coming to Olin, but upon looking back on it is the way that Olin works.

As I continued to fail in my second and third years, I realized that failure is a tool for learning. Not completing a task or having a project not work were the moments where I pushed myself to learn the most. To be routinely be uncomfortable with what I was working on became common place, and ‘failing’ no longer had a negative connotation. It was the challenging projects that would require me to look up the grain structure of copper, reference documentation pages of a function, or revisit my design decisions on a failed prototype. In doing so, I was not only expanding my knowledge on these topics but also teaching myself to find answers and teach myself new topics. This step in my education was huge, and is one of the more useful things that I have learned in my life. The exposure to constant problem solving helped to make me not afraid of failure and to give me confidence to jump into work that is initially over my head.

This brings me to senior year. By this point, I felt like an engineer. I had the technical background on a mechanical engineer, and the understanding of other areas of engineering, design, business, and leadership. My last year allowed me to polish what I have learned at Olin, and prepare to transition to the ‘real world’. In such a place, I learned that failing and learning from ones mistakes are lifelong tools to use not only in academics but in industry as well. My knowledge and background has helped me to mitigate drastic failures, allowing me to be comfortable with a tough project, learn from it, and find a solution. Learning through failure is still not something to be feared. It teaches you how to make your system better than if you were to succeed quickly and move on without reflection. I know that I can

jump into scary projects that I do not fully understand, and be okay with what I do not know. I know how to tackle the unknown, fail and then make it work. I am an Engineer.

Service Learning

Habitat for Humanity

Growing up as a Boy Scout, I always enjoyed working with my hands, working on a team, and helping others. When I started college, I found a way for me to continue my love of all of these things: Habitat for Humanity (http://www.habitat.org/). Whether it was simply taking a day off to drive to a local area to build, or traveling down to North Carolina to do an impressive amount of work on a house over spring break, I enjoyed the feeling of doing what I could to help others.

Figure 1: Our Collegiate Challenge group 2012 attaching siding to the house.

The more I participated in Habitat events, the more I realized that help is needed everywhere. Some areas, such as the cities we targeted in North Carolina over our spring break trip, are more apparent in their need, but just because an area or city is nice does not mean that everyone there has good housing. Help can be provided close to home, no matter where you live. We can all make a difference in other peoples' lives.

The more I helped, the more I learned about the process. I found myself helping my classmates instead of simply doing the work for myself. I am familiar with fun power tools like the sawsall, which, as the name implies, can saw all things. The machine can be terrifying to operate, but really fun when you realize the use you can be with such a tool. At first I simply enjoyed using the tool at Habitat projects. I soon found, however, that it was nice to hand the tool to someone unfamiliar with it, but interested. The steps starting at introduction to the tool often end at empowerment, where they understand and can work on their own, mastering their newly-earned technique. It is these moments that make me realize that I can help my community, my friends, and myself in so many ways in my daily life.

Figure 2: Sawsall, a reciprocating blade powertool that can cut through metal, wood, and plastic.

Entrepreneurship

Habitat for Humanity Collegiate Challenge Coordinator

My sophomore year, I led Olin College's Collegiate Challenge program. This program is designed for college students to volunteer their spring break to travel to a build location. The dedicated and focused work allows for houses to be built much faster and is very helpful to Habitat for Humanity.

I was in charge of the setting up the trip and making sure we had food, transportation, money for gas, a project to work on, and a place to sleep. This was a new project and I had the sole responsibility to make happen. I had to find and identify what resources were available to me, such as petitioning the college volunteering organization and the local Habitat counsel for funding support. Identifying a work site that had need and would be appealing for the Olin community was a challenge, since the further south we travel would provide better weather, but also a longer commute. I needed to market the trip so we had enough participants to meet the demand for volunteers at the site. Selecting a group of people diverse enough to cover the variety of tasks required to build a house was also important. We needed to have people who were tall enough to lift door frames into place, comfortable doing work on ladders, and able to operate the complex machinery. But the trip also had to be appealing for members to give their time and money to participate on the trip. Overall, I had to make sure that everything in North Carolina would fit what Olin students want to accomplish on a spring break trip, while ensuring that our group would provide useful work to Habitat for Humanity.

Figure 3: Collegiate Challenge 2011 group photo. Behind you can see the work we made framing the house and the piles of rafters that we added later in the build.

Overall, I found myself in a challenging position to connect all of the dots. I had to make compromises between individual members, between our college group and the Habitat build site. Things I had to ensure included making sure the group got enough sleep each night, waking them up earlier than they wanted to be at the work site by sunrise, and keeping the group entertained on their spring break trip (trips to southern food restaurants, games, local hikes, etc.). I found that being clear with the team about my expectations and explaining why I we were doing things a certain way was the easiest way to lead the group. Similarly, managing the expectations of the Habitat build site coordinator to our team's abilities and selecting work that would be relevant for us to work on was a productive conversation to help set expectations for both our group and for the build coordinator.

There was a lot more to consider from the last time I went on the trip simply as a participant. But through added responsibility, I found that I appreciated the rewards from my effort that much more. Organizing a group of my peers was different from working collaboratively on a group project. It required me to balance the views of what the group wanted with the schedule that we needed to keep for the project. I learned to make the right decisions for all of us. Not only was I happy to volunteer my time over my spring break weekend, I was overjoyed to see my group of friends successfully help Habitat for Humanity.

Interdisciplinary Experience

Learning at Olin College

On my first day on Olin's campus, I was surrounded by so many new faces. All of these new people were here, to learn to be an engineer! I soon learned after my first couple of classes that the starting point of all of us was very different. Some had written code for the past several years. Others, like me, had never seen a command prompt, much less been expected to use it effectively. Where I knew some rough design ideas from high school projects, others in my class had redesigned their car to use vegetable oil rather than diesel. I knew this would be a challenging, and rewarding, opportunity to learn to be an engineer.

As we continued through the years at Olin, I also realized that we also had different ideas in our heads about what it means to be an engineer. I initially saw the work to increase in technical ability, learning details about materials science and physics. I realized other areas are important as well to pulling off a great project: controls, robotics, electrical theory, communication, and team leading. It was a hard shift. Being a mechanical engineer on a team did not just mean doing mechanical work, it meant understanding the whole project and figuring out what I could do to help. When I first considered being an engineer, I did not think these topics would be particularly important, disregarding them to be things other people would worry about and allow me to focus purely on my part of the project. But this experience changed my view, leading me to understand that everyone should be able to understand and help on the whole project.

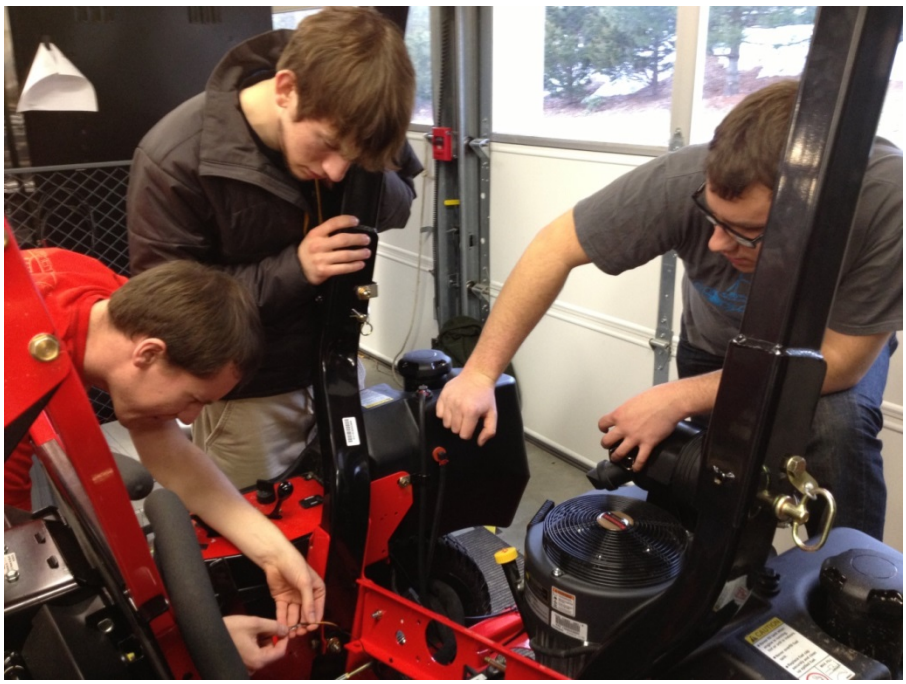

Figure 4: My Engineering Senior Capstone team working on our project of adding sensors to a riding lawn mower.

This is especially apparent in my Senior Engineering Capstone Course. Our team of five engineers is nominally made up of three mechanical engineers, one electrical and computing engineer, and one robotics engineer. Looking beyond that, our group has a graphic designer, a product designer, a controls and LabView expert, a big-picture project manager, and a mechanical engineer who can design and make anything you want to do. These are the motley groups that I have learned to work with to complete mathematical simulations, circuit diagrams, and robots. I know how to balance the variety of skill sets on a team, to realize when I can learn from someone else, and how to be a good team member. It pushed me beyond what I knew how to do, but helped me to see what needed to happen to get the job done.

Looking back on it all, I realize that the ability to work on an interdisciplinary team has taught me to listen to what others mean, understand multiple view points on a single topic, and the ability to work on projects that are beyond my level of understanding by trusting my teammates. This may not be the traditional view of engineering, working on a specific technical detail of a project. But I have learned that engineers have a wider role to synthesize the entire project, communicate those values with their team, and translate them to the technical details.

Grand Challenge Project – Engineering the Tools of Scientific Discovery

Force Amplification Mechanism Research

For two years I pursued research to develop a dynamically switch-able force amplifier. This work was based on the idea of creating a mechanism to mimic a biological leg. Similar to a human leg muscle, our capstan mechanism actuates by tightening a tendon and behaves well under dynamic loads. I was interested in this research because it was a truly novel idea that my friends and I came up with. We were not sure where our design would lead, but we had great hopes that we could take our research to lay the groundwork for bipedal walkers.

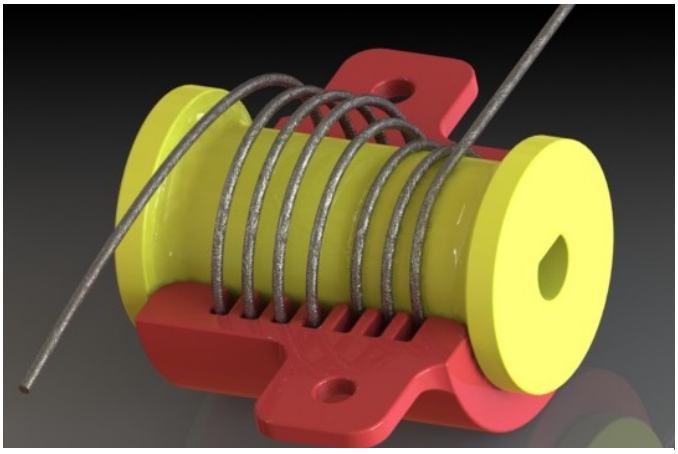

Figure 5: Our Dynamically Controllable Force Amplificaiton Mechanism. The central drum constantly spins, and by selectively tightening the metal cable around the drum, varying amplification ratios can be achieved. The red helix cover holds the cable in place to prevent tangling.

Current approaches for precise and controlled robotic leg systems require multiple high power electric motors which can hold any position statically. While this allows for an over-controlled leg, the power usage and distribution is exceedingly high and unrealistic for scaling to large systems. Our capstan based force amplifier allows the benefits of an under-actuated leg with the power and some of the controllability of an over-controlled system.

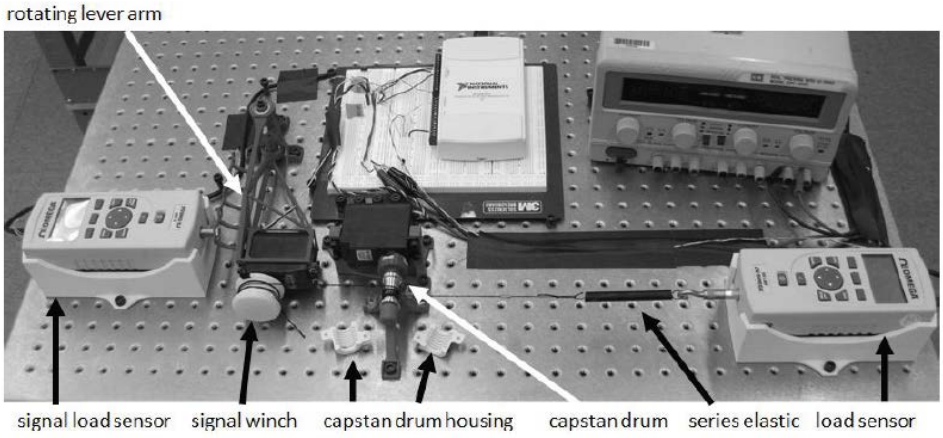

Figure 6: Our experimental setup to test and record the behavior of our mechanism.

Our research developed the highest recorded force amplification from a dynamically controlled capstan, and we predict that this force ratio can become even higher with further optimization. Through working

on this project, I learned how to do experimental work on a team, and approach a topic in a new way. Our team used many approaches to make our ideas a reality. Learning to approach our development in a controlled, logical manner took time. We had to create our own testing procedures, think through what would be the most useful for optimizing our design. While pulling together our findings to be published, we had to think about what would be most useful to share to the scientific community. It was a different way of thinking about a fun project that I had not done before. We had an idea that could impact future science and design, and did all that we could to develop our idea into useful work and communicate it to others.

I found myself realizing that while there are many things that we have developed in the world, asking the question “Can we make this better?” can lead to amazing answers. When it comes to developing systems that can change the world, each of us can have an impact to either make that change or provide the infrastructure to help it happen.

Global Awareness

New Zealand

I really wanted to study abroad. I spent most of my life within the United States, and I felt that the time immersed in a new culture and understanding a different way of life would be amazing. It was something that I had never done before, and my friends who had traveled had only good things to say of their experience. I was planning to go the fall semester of my junior year. Unfortunately, I could not financially support being away for a full three months. Instead, two of my friends and myself decided to go abroad for the more frugal time frame of one month. This was financially doable, and had the added benefit allowing us to simply immerse ourselves in the culture, without being distracted by the details of going to class or completing assignments. It was just the three of us and New Zealand.

One of the surprises was simply how I felt. This was my first lengthy trip outside of the US, and yet I found myself comforted by the community. Hostels were multicultural melting pots, where I made friends with Kiwis, Germans, French, and Australians, just to name a few. It seems mundane, but this was an eye opening moment for me to see that the world is really smaller than we think. We all were there on vacation, to travel the world, to see something different, and even to do something different from going home. Though communicating could be hard, we implicitly understood that we were there to connect with others, which is a powerful feeling.

Figure 7: Hannah Sarver, myself, and Eric Jones (left to right) after a multiday backpacking trip on the mountain and ridge shown in the background.

In addition to learning about traveling abroad, I learned about New Zealand as a country. I learned that as an island nation, New Zealand was worried about a completely different set of issues than a larger continental country like the United States. The entire island made great efforts to be self-sufficient. From farming to manufacturing and design, so much of the country was focused on being able to carry

itself forward without (too much) help from the outside. Of course trade occurred for specialty electronics and resources such as oil, but in meeting the Kiwi farmers and shopkeepers there was a savage pride in their eyes when they talked about what their country has produced. It was a sense of accomplishment beyond putting a “Made in” sticker on an object. It was the goal of being a part of a country that is sustainable and useful to itself and others. It made me rethink how I consider how my future work will interact on the global scale. Does a partnership with another country actually benefit both of us? If engineers were to take the mindset that the planet is our island, then through cooperation and dedication we could create a useful and sustainable future. It will take both work and willingness to communicate, to understand one another, to get there.

After undertaking the Olin College experience of project based, do/learn engineering, I have been training to be a scholar since I arrived on campus. And as a soon-to-be graduate, I know that I will take what I have learned to help work on the real world problems we face today.