

Learning Today – Building Tomorrow

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Grand Challenge Scholars Program

Engineering the Tools of Scientific Discovery

Portfolio Summary Reflection

When I started at Olin four years ago, I had a vague inkling that I wanted to become an engineer in order to help make the world a better place in some way. I was generally passionate about serving my community however I could, and solving problems had always been fun and engaging for me. My experiences in engineering, entrepreneurship, and global service over these four years have helped me direct my energy and learning towards making a real difference in the lives of others through mathematics research, Habitat for Humanity activities, and more.



Figure 1. I always try to look as official as possible when I am doing real engineering work.

At Olin I took courses that brought engineering thinking into other disciplines, and this opened my mind to the numerous opportunities I may find in the future. These are the opportunities which may allow me to apply my education to fields beyond just closed-ended math problems and software implementation. Olin's entrepreneurial focus and summer business incubator program gave me the chance to explore the small business start-up process by starting and running a bakery on campus, which offered me insight into the management of resources and people working towards a goal. My efforts in sharing my knowledge of engineering and design thinking with children have reinforced my interest in applying technical skills to solving the world's problems, from building a sustainable city on Mars to creating devices that will help people stop losing their possessions. Teaching kids the design process that I have learned at Olin helped to solidify my understanding of this process and how to apply it creatively in the real world.

Entrepreneurship - *The Midnight Bakery*

My most significant entrepreneurial experience was founding and running the Midnight Bakery, a small business that started in the Olin Foundry summer program and continued through one school year at a lower scale of production.



Figure 2. Our logo, designed by a fellow classmate and future bakery employee

The idea for this business evolved over my first year at Olin. Throughout that year, my future business partner and I gained quite a reputation for baking and wandering around the dorms late at night offering our baking creations to our studious and hungry classmates. After several suggestions that we go into the baking business, it occurred to us that this might not actually be out of the realm of possibility. When the Olin's summer business incubator program opened to applications, we decided to put together a proposal for a bakery business that would do 24-hour delivery in the Olin area. Thanks to this program, we were granted housing and resources for the summer to start and develop our own entrepreneurial venture.

Our original plan was to bake in one of the student kitchens available on campus, but during our preliminary conversations with the Needham Board of Health we eliminated the possibility even before the academic year ended due to the difficulty of certifying a kitchen for commercial use. Eventually it came down to a long-shot request to use space for the summer in the dining hall kitchens. Amazingly enough, the new dining services manager seemed thrilled with our idea and agreed to share the kitchens and equipment (see Figures 3 and 4). Once we had secured a place to cook, it just took several rounds of filling out paperwork, meeting with insurance people, and testing out recipes during downtime, and by the end of June we were ready to officially open for business.



Figure 3. My business partner and I in our official baking attire



Figure 4. Our storage and baking space in the dining hall kitchen, which of course stayed completely organized for the entire summer

Since our hours of operation were limited by the dining hall kitchen schedule, we adapted our business plan to accommodate specialized orders for delivery during the day, and certain items that would be available all night on each day of the week. While waiting for certification, we developed our website (<http://bit.ly/midnightbakery> in case you're interested), menus, and marketing; therefore, when we finally opened, we were all set to start filling orders as soon as we made the trip to the local Restaurant Depot to buy enormous quantities of our basic ingredients. The orders began to trickle in, a few per day, and as we got used to using the kitchen's convection ovens and trying to keep track of how many cups of flour had gone into each of three different cookie doughs, we gained customers through emails to Olin students and staff. We

quickly branched out to fill orders from the Babson community, and began to advertise mail orders to anywhere in the country.

At the end of the summer, we had made a respectable profit and decided we were having so much fun that we might as well hire a few of our friends and maintain the viable business into the next school year. We toned down from daily 24-hour delivery to just bake weekly for local farmers' markets and special events, and always made sure to do events for non-profit organizations whenever possible. We ended up donating some of our profit to the Greater Boston Food Bank to help out as much as possible with the problem of local hunger since we were a food-related business. We stayed profitable throughout that year until we all went our separate ways the next summer and decided to focus on other activities.



Figure 5. The Greater Boston Food Bank serves as many as 545,000 people in need of food in our community each year (source: gbfb.org).

Throughout this project we learned a lot about the inner workings of the dining hall kitchens and the local government, not to mention honing both our baking prowess and our business skills. We even improved our engineering skills...doing mental math to make $\frac{3}{4}$ of a recipe counts, right? Between buying ingredients, confirming orders, estimating late-night numbers, and balancing finances, there can be a lot to do in the bakery business. But a lot of the real value from this project was also in the business and employee management experience and the higher level marketing strategy planning; these will all serve me in my future entrepreneurial endeavors, whether these will be starting another small business or just working in the tech world.

Grand Challenge Project

Engineering the Tools of Scientific Discovery – Graph Theory Research

One of the most interesting and exciting courses I took during my time at Olin was Discrete Mathematics, a class on combinatorics and graph theory with applications in computer science and many areas of problem-solving. I had a great experience in the course and especially enjoyed the plethora of examples we discussed that showed discrete math helping to solve real problems in the world. I have always relished the problem-solving aspect of mathematics, which really came through in this class in the flexibility of methods that can be applied to solve the problems involved. The space for creative thinking in approaching the homework sets let me explore many areas of math that I had not previously considered. This is what prompted me to join the research team of the course's professor the following semester, to delve deeper into the practical applications of what we had covered throughout the class.

During my semester of research, I worked on several projects in the general area of graph theory. However, I focused most closely on one very specific application graph theory, the committee assignment. Broadly defined, the research question I worked on is how to fairly assign committee responsibilities to a population of a given size k out of a larger group of size n . Here the term “fair” indicates that no one group member is in more committees than other members, and when $k > 2$ that no two group members serve in more committees together than any other pairs (to within a buffer of one). One approach to solving just the $k = 2$ increment of this problem is to look at the group as a graph, with each member as a node and edges representing members on committees together. As demonstrated in Figure 6 below, this representation then lends itself to the use of known graph factorization methods in order to assign any number of committees (pairs) in as fair a way as possible (see Roberts' *Graph Theory and Its Applications to Problems of Society* for more details).

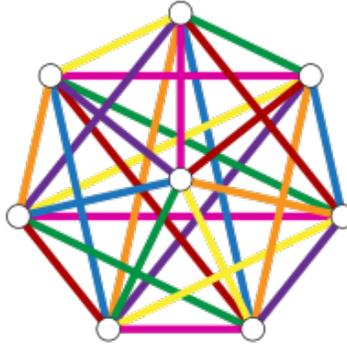


Figure 6. A set of 1-factorizations of the K_8 graph: each color represents one full pairing of nodes in the graph (for example, faculty members in committees of two) – *image source: Wikipedia*

The specific problem was the actual assignment of admissions application reading committees of professors in nearby Babson College's honors program. Historically, each year the program staff spent a great deal of time manually creating assignments of pairs of faculty to committees that would be fair (in the sense that no faculty members would end up with more applications to read than any others). The goal of my specific research was to provide Babson with an automated system for the assignment process. Thus my personal contribution for much of the semester was writing a Python script to take in CSV files of student applicants and faculty members and generate reading committee assignments.

This experience gave me the opportunity to see theoretical research in mathematics applied in a very practical situation, and to see my own academic engineering work be used to make people's lives easier in the real world, not to mention giving me an outlet to exercise my creative thinking in mathematical problem-solving. I learned not only about the mathematics relevant to the project, but also built my skills as a programmer through this work. I also gained knowledge of new software distribution methods in ensuring that my program would be easy to use for Babson's staff members who would not necessarily have the Python programming language installed to be able to run the program directly. Working on something that could be useful to others even much after my own involvement made me consider factors in my work that I had not previously paid enough attention to, such as clean commented code readable without my explanation, and robust error checking in case of problems. This experience in designing mathematically-based software for a specific function and set of users gave me expertise and process knowledge that will continue to serve me as I work to engineer the tools of scientific and mathematical discovery in the future.

Global Awareness - *Habitat for Humanity International*

Founded in 1976 in Georgia, Habitat for Humanity International has served over 3 million people worldwide by providing affordable housing through home construction and repairs (see habitat.org for more details). The vision of this global organization is “a world where everyone has a decent place to live”, which has been gradually coming into realization as thousands of volunteers come together each year to work with partner families to build the houses in which they will live, or to repair damage done by natural disasters.



Figure 7. Habitat for Humanity International reaches those living without sufficient housing worldwide to provide building supplies and volunteer hours in an effort to rectify this problem of global significance. *image credit: habitat.org*

During my time at Olin I got involved with our Habitat for Humanity collegiate chapter through local weekend builds and ended up holding a leadership role on campus during my sophomore year. My participation in this globally influential organization opened my eyes to the international problem of homelessness and insufficient housing, and I was proud to be able to take part in addressing it. Through local builds working on houses for families within the Needham community, I began to recognize the need within our immediate vicinity here at Olin. Through my three week-long spring break trips to North Carolina to build houses for community members there (see Figure 8 below), I learned about the national state of housing and the experiences of those outside my own community. There are families living all across the country in substandard housing, from crowded apartments holding too many people to dangerously run-down houses that pose a threat to the children residing in them. Through holding the position of president of the collegiate chapter for a year, I gained much more awareness of the global housing need that faces the world’s population by interacting directly with the larger Habitat organization. I attended meetings with the greater Boston area Habitat collegiate leadership, and through these meetings learned about the organization’s international opportunities to address

housing needs, and the efforts being made by other collegiate chapters to assist the organization's efforts through volunteering abroad, raising money, and holding awareness events.



Figure 8. One of the homes I helped to build in North Carolina on a spring break Habitat trip.

During my involvement in the Olin chapter and with the larger organization of Habitat for Humanity International, I had the opportunity to interface with the local and regional Habitat offices and interact with other related groups, and thus learned about some of the opportunities that Habitat provides for volunteers to help out abroad, and the work that is done to ensure safe housing for people globally. Although I did not personally work with Habitat internationally, through my involvement with the organization within the United States, I gained an appreciation for the global issue of substandard housing. Given the organization's globally-minded fundraising and volunteer work, I could see the effects of these efforts on five continents in building homes, raising awareness of insufficient housing, and fundraising to provide the supplies necessary to increase housing quality.

My interactions with other collegiate leaders and Habitat volunteers showed me examples of similar work done abroad to what I had done in my own community and the wider national community; through them I learned about the differences between working here in the United States and abroad. For example, another Habitat volunteer that I worked with building a home in North Carolina had also helped with building houses through Habitat in Cambodia, where rather than working on one family's house for the span of a week, the group of volunteers had been able to completely build three to four houses each day due to the simpler design and lighter

building restrictions on construction in this international setting. This example highlighted for me the huge disparity in housing quality between countries across the globe, and made me feel even more fortunate to have grown up in a nice home. I plan to continue my involvement with the efforts of the Habitat for Humanity International organization, and maybe sometime in the future to volunteer abroad to help address housing insufficiencies worse than those that exist within my own country.

Service Learning

Olin service board, Engineering Discovery, Society of Women Engineers outreach

Service to the community is not only one of my own personal values, but is also included in the core Olin values that drew me to come here four years ago. Throughout my time at Olin, I have made sure to take time out from academics and social engagements to serve my community and learn through this service. Much of my service has been focused on engineering education outreach, through which I have been sharing my knowledge and skills with younger students who are the next generation of engineers and scientists.

I have done so in a number of different ways. For example, as a member of the Society of Women Engineers, I helped with a weekly science afterschool program for local elementary school girls. These efforts during my first year at Olin were further expanded when I took over leadership of the SWE outreach effort during my sophomore and junior years. In this role, I orchestrated two weekend workshops exposing children to various branches of engineering. Additionally, I planned hands-on engineering demonstrations for several outside organizations' outreach fairs, such as the local Science Club for Girls group and the national SWE conference event. Working with children to help them explore the myriad of possibilities to change the world through engineering reinforced my own convictions about wanting to become an engineer. In addition, through these activities I learned about planning activities that are fun and engaging for fourth graders even if half of the materials for these activities weren't available and some crucial components did not work as expected.

Session #	Group A	Group B	Group C
1	CS - 328	MechE - 326	MatSci - 318
2	Design - 128	CS - 328	MechE - 326
3	Electrical - 126	Design - 128	CS - 328
4	MatSci - 318	Electrical - 126	Design - 128
5	MechE - 326	MatSci - 318	Electrical - 126

Figure 9. The schedule of events for one of the engineering workshops, in which groups of younger students attended a rotation of sessions taught by Olin students on various branches of engineering

During those same two years, I also held two positions on Olin’s community service board (SERV, for the board’s mission to Support Encourage and Recognize Volunteerism at Olin). Serving on the SERV board (no pun intended) gave me the chance to get out into the wider Needham and Boston communities outside the “bubble” of Olin’s campus and give back in some way, from volunteering passing out water at a charity race to sorting clothing donations for underprivileged local children. Helping to organize events such as a Relay for Life in collaboration with Wellesley College (see Figure 10 below) enabled me to participate in service in a more active and wider-scoped way. Additionally, being a part of the college’s service leadership gave me an explicit outlet to encourage other students to get out and volunteer as well through advertising our events, and to solicit and enact their ideas for service opportunities. Thus we could engage a larger portion of the school population by gearing activities towards their specific interests, whether that meant helping middle school students build their artistic fountain designs or bringing a husky rescue organization to campus to do a puppy petting fundraiser.



Figure 10. Service can be fun too, especially at an all-night event to raise awareness and money for cancer research.

Another important component of my educational outreach efforts at Olin was my participation in the Engineering Discovery group. In this group, I helped with many one-day weekend workshops and activities, but primarily worked on the planning and implementation of three

semester-long school outreach programs: two math programs in scaling and approximation, and a fourth- and fifth-grade design class oriented towards ideating and prototyping products to help people who commonly lose things keep better track of their belongings (some of the students' initial prototypes and final designs are pictured below in Figures 11-12). Teaching engineering design principles to children to get them inspired about pursuing the field of engineering reignited my excitement about the possibilities opened by learning about engineering. I also learned from the kids about creative ways in which one can improve solutions through design iterations and thereby create interesting solutions to real world problems.

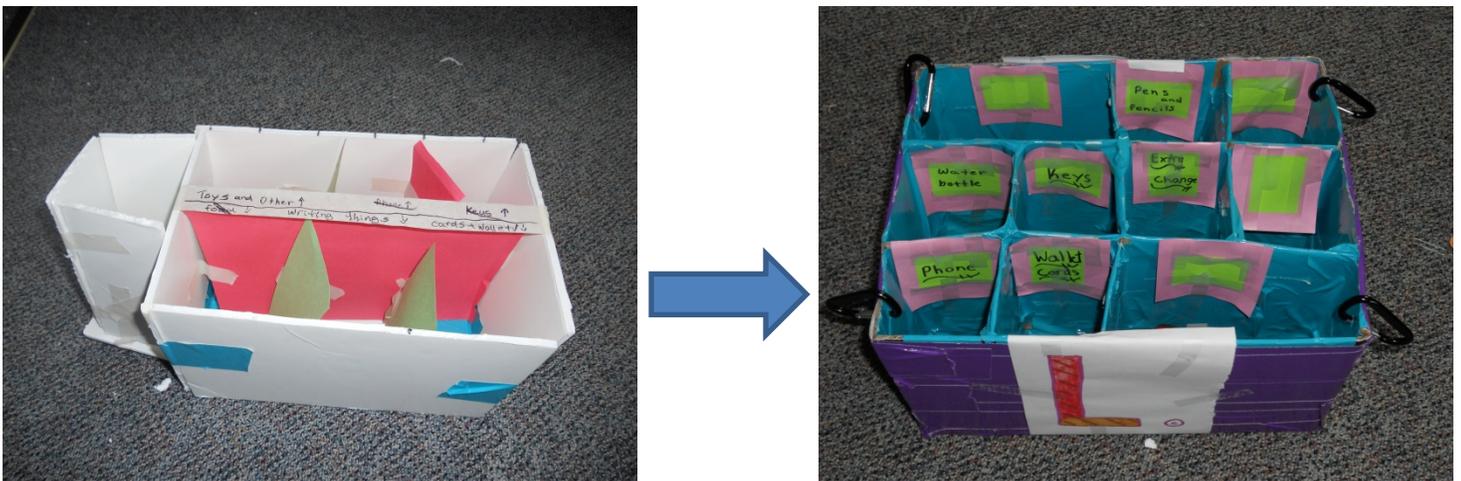


Figure 11. One team's idea started off as just a sectioned purse organizer, and ended up fully labeled and waterproof, with convenient hooks for easy attachment and removal.

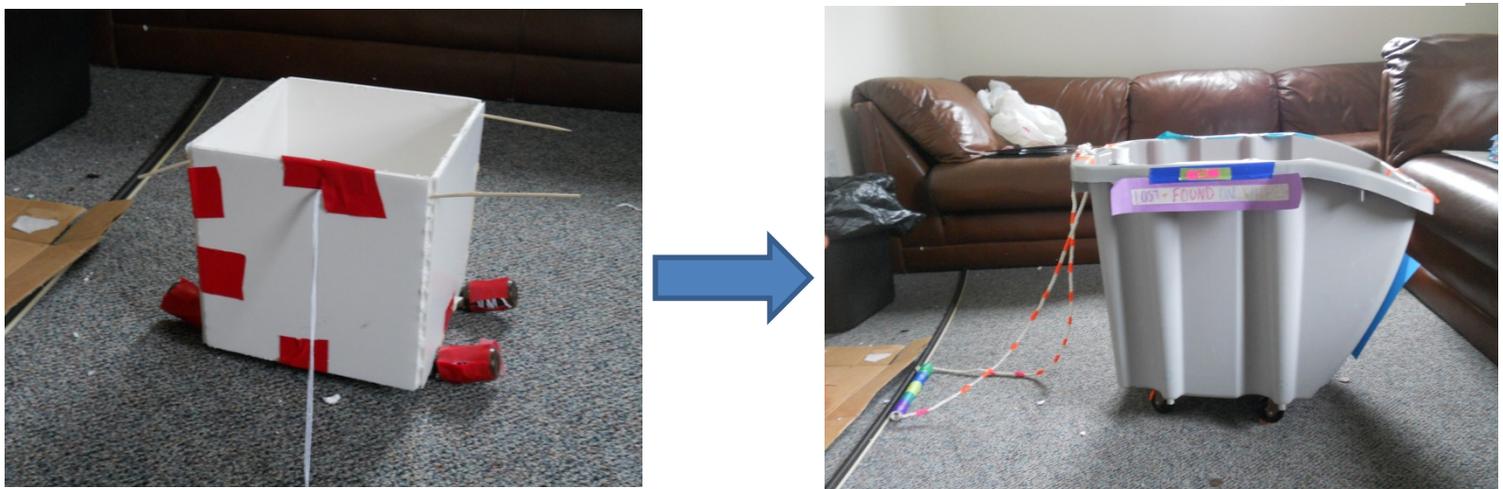


Figure 12. Another team's concept for a school-wide 'Lost and Found on Wheels' evolved more in terms of design than in purpose, ending up with an elevated coat-rack and pulling string attached at two corners to avoid tipping over.

Summary Reflection on Service Learning

Through this diversity of service experiences that I had during my time at Olin, I developed a greater appreciation for the many ways in which engineering and other community outreach efforts can impact people's lives in a positive way. I got to see the smiles on children's faces as they too discovered how to turn their creative energies towards solving real problems for others, and I am grateful that I had the chance to help them in this discovery process. Even through service activities that were not as strongly oriented towards engineering, I learned to value interacting with and finding out about the needs of my wider community, and I think that this appreciation of what is outside my own personal life will help me to be a better engineer and a better person in the future.

Interdisciplinary Experience

Literature from an Engineering Perspective

Olin's curriculum focuses on the cross-pollination of concepts and thought processes between areas of study, through collaboration between professors as well as students in different disciplines in creating course content and project concepts. One area in particular where I have felt that this building of interdisciplinary thinking has both been beneficial to and been developed significantly is in my arts and humanities concentration in literature. Learning how to read with an engineering perspective has changed the way that I approach both literature and technical work.

Within Olin, I took a course entitled *Science Fiction in Historical Context*, in which we read short stories from classic science fiction throughout history and contextualized them in the historical periods during which they were written. While this course is in itself already interdisciplinary in nature due to its literary and historical components, it also allowed me to use my technical knowledge and scientific perspective that I have acquired as an engineer to my understanding of the literature. Considering the socioeconomic, global, and political factors that that influenced creation of the stories we read, as well as understanding the technological advances at the times of their writing, I was able to explore in depth the ways that the stories represented their authors' culture and predictions about the future.

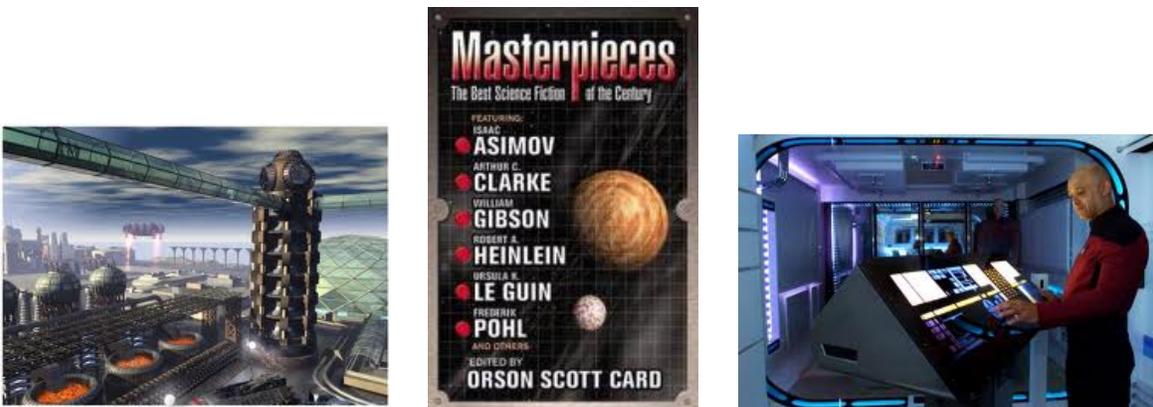


Figure 13. Science fiction authors often speculate about transportation, communications, and social systems in the future. Considering their predictions with the science and technology of their times in mind helps us understand how they might have come up with some of their ideas. *image credits: <http://student.plattsburgh.edu> and <http://blogs.reuters.com>*

Outside of my academic experience at Olin, I also took two literature courses at Wellesley College: *The Modern British Novel* and *World Literature - War and Peace*. In both of these courses I very much valued my unique viewpoint coming into the class readings, discussions, and writing assignments as an engineer rather than as a humanities student. While there may have not been much in a way of engineering content in the literature I read in these classes, the analytical skills that I have gained in my engineering coursework allowed me to approach assignments with a design perspective that offered more possible interpretations than might have otherwise been obvious. This perspective was particularly apparent in a discussion with one of my Wellesley English professors regarding the process of writing an analytical essay. In engineering, we often take many possible paths towards the solution of a problem or need, whereas in literary analysis we most commonly start with a given section of text and expand from that into many possible interpretations. Although these two processes seem in some ways opposite, my experience in problem-solving with methods used in technical fields, has helped my literary analytical writing. While it seems unlikely that I will be doing much literary analysis in my future as an engineer, what I have learned through this interdisciplinary experience about applying an engineering thought process to analysis of situations outside the field of engineering will certainly be useful in other contexts as well. Whether I end up applying technical thinking to pitching a business plan to executives, discussing politics with friends, or even organizing who will bring what to a family potluck, I expect that knowing how to think like an engineer will always serve me well.