Engagement in Practice: Engineering Solutions for a Local Organic Egg Farm

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Abstract

This engagement in practice paper summarizes the development and implementation of a collaborative partnership between a local organic egg farm and Western Washington University's Engineering & Design program. The objective is to engage students in a project-based design experience while fostering meaningful community involvement. Over the past 18 months, this collaboration gave students the opportunity to apply technical and business management skills to improve the farm's economic success. Student teams, in direct collaboration with the farm owner and staff, worked on identifying, narrowing, and focusing on potential projects. Once the projects were identified, teams developed problem solutions using the engineering design process. One team explored alternative chicken bedding options and distribution to benefit the well-being of chickens and cut labor cost. A second team developed a system to monitor egg collection and improve delivery processes. This paper discusses the benefits and lessons learned from the student's perspective as they engaged in the open-ended projects. Discussion highlights the impact this experience has on encouraging independent work through open-ended tasks to achieve a goal. Although an increase in structure would have benefited the groups, working through problems independently aided growth of student research skills and their ability to apply the engineering design process. Overall, this project was a positive educational experience for students and helped them learn how to structure a research project and what role engineering can play in supporting their community. The opportunity to conduct research in developing a solution with real-world impact was a strong motivating factor for students over the project's duration and proved beneficial to their learning.

Introduction

Day Creek Organic Farms (DCOF), a local organic egg farm in Washington state, partnered with Western Washington University's (WWU) Engineering and Design department (ENGD) to provide open-ended project opportunities to students. In the spring of 2022, the DCOF farm owner visited the WWU engineering department and discussed his interest in offering projects to undergraduate students. Two faculty continued conversation with the farm owner, who then provided the department with a generous donation to support project materials and student internship opportunities. The faculty advertised the initial internship (summer 2022) to all ENGD students. Two students were interested in participating, both of whom were hired after being interviewed by faculty advisors. The two student interns (one undergraduate in ENGD and one graduate student in the business college) were given the opportunity to participate in business strategy and development as well as engineering problem definition through collaboration with the farm owner, the farm manager, and faculty advisors. The interns were tasked with identifying specific problems with the egg farm's operations, researching potential solutions, and identifying projects for future students. This effort led to the identification of projects for a first-year engineering design course, Innovation in Design (ENGR 115).

ENGR 115 is a course focused on teaching students about teamwork and the design process through a quarter-long design project and is a requirement for all first-year engineering students.

Student projects in this class are structured around researching, designing, and fabricating a prototype solution to a problem. There has been a recent effort by faculty to provide students with the opportunity to work on open-ended, community service-oriented projects in ENGR 115. The typical ENGR 115 project is a more traditional class-based design project that provides the students with clear objectives, constraints, testing parameters, materials, and supplies (the current project involves design of a prototype device that generates energy from falling rainwater). Community based projects, often more interesting to students, tend to be more challenging due to their open-ended nature. Students in ENGR 115 were provided with a choice of project options: an open-ended farm-related project or the standard course energy generation project. Students indicated which project they would prefer to work on, and teams were selected based on their project preference. Two teams of four students completed farm-based projects during the Winter 2023 and Spring 2023 course offering of ENGR 115. Regardless of the project option chosen, all student teams in the class completed the same project deliverables and were graded using the same rubrics.

In addition to the ENGR 115 projects, DCOF provided summer internships for students interested in working on farm related projects during summer 2023. There were two teams of undergraduate students (six total students) who worked on farm projects during the summer internship. Student teams were chosen based on schedule availability and project topic interest area. All ENGD students were notified of the internship opportunity and all students who applied for it were given the chance to participate. All interns were paid and worked between 10-20 hours/week for 10 weeks. The teams consisted of students from all major areas: manufacturing engineering, industrial design, and polymer materials engineering. All students who participated

Motivation

The faculty advisors working with DCOF were motivated to use this collaboration to generate enthusiasm and build engineering skills in students who are in the early stages of their studies. Similar community engagement projects [1] have identified that “service learning”, where students learn skills through projects based on community engagement, is attractive to students who are drawn to the prospect of engineering as a real-world practice and achieves a meaningful societal impact. Projects that incorporate service learning can meaningfully apply classroom knowledge in a real-world setting while fostering a deeper connection between the student and the larger community. This helps students cultivate new relationships, build awareness of local issues, and expand intercultural understanding. As stated in the International Service Journal for Engineering, “Community engagement pedagogies, often called ‘service learning’, are ones that combine learning goals and community service in ways that can enhance both student growth and the common good.” [2] This recognizes that there are more socially conscious paths that can be followed in engineering skill development than those that rely purely on solving a technical problem. “Engaging future engineers is a central topic in everyday conversations on engineering education... It is imperative that the community reflects on progress and sets a more effective path for the future.” [4]

A second motivation was to provide an opportunity for students to begin building self-starting skills earlier in their academic career. The owner of DCOF was highly supportive of

allowing the activities and engagements to be student-led. This gave students the independence to set their own activity structure and to make decisions in deciding their goals and needs in accomplishing tasks. There are clear benefits to students; “Without the presence of an organizing faculty member, students are forced to make decisions in a real-world environment, in which the scope of their responsibilities and the consequences of their decisions are greatly expanded.” [3]

The advisors were also keen on identifying projects that would fit well into a pre-major level class (ENGR 115) where students from different engineering discipline backgrounds must collaborate effectively in one project. Students with different engineering interests could work together to learn about problem solving, machine design, user design, business management, engineering research, and how to document and present their findings. This diversity of students promotes a richer discourse and exchange of ideas. This allows for a fuller appreciation of the importance of farms like DCOF to the local community, and the struggle that small-medium sized farms face with profit threatening challenges such as outdated machinery and operations.

The ENGR 115 Experience

Once the ENGR 115 teams were determined and selected, the instructor provided them with the farm related project options that were identified by the summer interns. One student team chose to develop a ramped nesting box that would utilize gravity to help in the collection of eggs. As part of their work, they conducted research at the farm, including chicken behavior study, use of nesting boxes, suitable ramp grades, and potential bedding material usage. The team built a full-size functioning nesting box model during the lab time of the class using resources available in the department’s Makerspace and presented their design at the end of the quarter, as shown in Figure 1.

Figure 1. Nesting Box Design Developed by Student Team in ENGR 115 Class

A second team of students chose to research and develop a solution to the egg collection process on the floor of the hen houses. Their solution used the space below the floor and ramped sections to collect eggs from the ground. Both projects were focused on increasing productivity for the farm in a way that reduces manual labor in a challenging work environment. In addition to developing their skills in applying the engineering design process, the DCOF projects helped students recognize and exercise their duty of care to society by improving conditions for nesting hens and working conditions for farm employees.

The Summer Internship Experience

After being introduced to DCOF operations through their ENGR 115 projects, students interested in furthering their experience with community engagement projects were offered the chance to work in teams as paid interns on other projects over the summer of 2023. In total, six students participated in the summer internship, five of whom were pre-majors. Figure 2 shows students during visits to DCOF along with the inside of a hen house where the projects were located.

Figure 2. From Top Left (a) Visiting DCOF, (b) Inside a Hen House, (c) Working in Utility Spaces, (d) Engaging with the DCOF Owner

The owner of DCOF gave an open invitation to the summer interns to visit the farm as needed to assess and identify its operational challenges. During these visits the interns experienced first-hand the problems their project work in ENGR 115 had addressed, and learned about new ones, such as eggs getting stuck at different locations on conveyor belts leading to excessive breakages. DCOF's owner noted that these were preventing the farm from cutting labor costs and increasing product output. The faculty advisors gave the interns the freedom to use their observations to identify focus areas that interested them for their summer project. The group of six started with meetings to discuss the project options based on the problems they saw and ended up choosing two teams of three based on interests, diversity of skills, and scheduling availability. They used the structure of the quarter-long class projects experienced in ENGR 115 to base their planning, research, and design work on. This process helped promote "self-starting" skills in the students by giving them the responsibility of identifying an engineering problem on their own and leading their own task accomplishment such as team formation, work distribution, and work plan development.

One of the teams focused on automating bedding distribution to the rooms of the hen houses. They began by researching different types of bedding materials suitable to chickens in small to medium scale egg farms and created a summary of the pros and cons to each potential material based on purchasing cost, ease of distribution, functionality in collecting waste, ease of disposal,

and impact on the health of hens. Two materials that met the requirements were sawdust and hemp. Their extensive research resulted in the decision that the sawdust bedding DCOF sourced locally was the most cost-effective, met the functional requirements, while still being healthy for chickens. This research activity helped develop the interns' skills discovering and interpreting relevant information about a problem and expanded their capability to learn independently. It also helped build their ability to effectively communicate findings in reviews with faculty advisors and in final project documentation. A second part of this team's work was to explore solutions for spreading sawdust throughout over 30 rooms using automative strategies instead of relying on manual labor. Like the experiences in ENGR 115, this required the interns to practice using the engineering design process though given the scale of the problem, as physical prototyping was not possible. The team developed several concepts for consideration, examples of which can be seen in Figure 3.

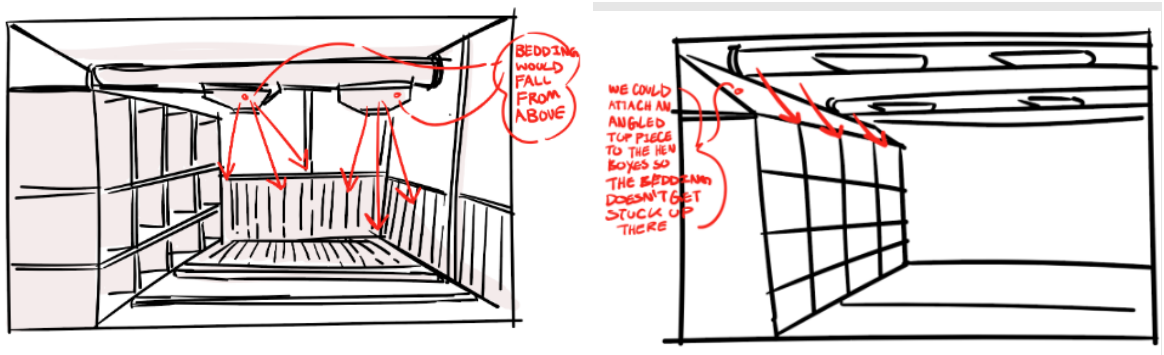

Figure 3. Bedding Materials Distribution Ideation Sketches

The second summer internship team worked on solutions for improving conveyor belt transitions and transportation of eggs to their crating point from the hen houses. They started by surveying and measuring the conveyor belt system currently in place at DCOF and created a to scale map of the belts. The students installed field cameras at junctions on the belts to pinpoint areas where eggs bunched up, got stuck, or fell off. They were able to associate certain belt cross-sections with decreased production output and started developing concepts of mechanical components to ensure the eggs moved past bottlenecks and reduce breakage loss. In addition to applying the design process, studying the conveyor belt system helped develop problem-solving skills such as their ability to troubleshoot and investigate cause and effect.

Discussion

The DCOF internship experience was designed to be flexible and to promote independence so that the student interns could set their own goals and expectations for their projects. The advisors had a smaller role than they would have in a structured classroom setting like in ENGR 115, where research projects are pre-defined. This unconventional structure caused some students to struggle with defining their project goals and objectives. The conveyor belt group noted in their final report: "Advisors were available through email and occasionally through online / in person meetings but were not heavily involved in the process. We struggled for a while to find a direction and figure out exactly how and what we wanted to work on. Though the

flexibility was very helpful, there might have been too much, and a little bit more structure and direction would have been supportive for us." While the freedom given to the student interns allowed them to fully explore their preferred mode of learning, how they worked with others, and topics of their choosing, it led to a slower start to the project than if its scope been predefined by their advisors. Since it was the project advisors' intention to allow the teams to work as independently as possible to encourage self-starting abilities, these difficulties were to be expected. The students also noted the impact on their progress due to most of them being pre-majors. The students noted that there was an advantage in that, "We were all on the same experience level, so it made working together easy". On the other hand, this inexperience faced students with difficulties such as a lack of detailed experience on their project topic and a limited amount of engineering knowledge, due to their introductory-level engineering experience. As one student intern noted, "We did not have a lot of knowledge of the subjects we were working on, nor did we have much formal instruction in the field, which caused us to feel unprepared for the work that we were doing." This feeling of a lack of preparedness could have been a contributing factor to the students' difficulties and confidence making decisions independent of the advisors, and additionally creating obstacles in navigating the initial stages of the project.

However, the students agreed that working without constant support and supervision helped them recognize how learning in a classroom setting is different from real-world projects. They also commented in their final reports that the summer internship provided them with important skills they will use in their majors and careers. It gave them new perspectives on how engineers can practice solving problems that impact the community around them. As one student put it, "I'm happy to be learning how engineers might operate within a company to solve problems. I think it's especially cool that we're working with a local farm, since it's shining light on the support they need to profit and how engineers can give back to communities." The students expressed that it was fulfilling to work with a small farm with organic operations focused on benefiting the community. The project had other positive impacts on the students, including confidence moving forward with independent research. Community engagement projects like this one provide students with experiential learning opportunities that prepare them for open-ended problem solving before entering an industry career. Service learning helps students learn key non-technical skills they can use later in their careers, and helps develop awareness, teamwork, and a desire to use engineering to promote development. [5] It also gives them a broader perspective on the potential impact of engineering.

The presence of a philanthropist type sponsor willing to provide access to an environment where opened ended type problems are found is a requirement for reproducing this work at other schools. The sponsor in question also highly valued providing this type of experience for students. They strongly believed that this type of community-oriented problem solving needed to be an opportunity provided for those students drawn to this type of work.

Conclusion

The DCOF project has been beneficial in offering a community-oriented project alternative for engineering pre-majors learning to apply the engineering design process both in their coursework and through summer internship opportunities. The students were able to apply their

technical and business management problem solving skills to study and propose solutions to improve a small, organic egg farm's economic viability and success. It also offered students a different perspective on engineering. Student interns were encouraged to develop self-starting skills, even though this meant they struggled with setting timely goals for their work. Though an increase in structure would have benefitted the teams, working through the challenges promoted growth in their research and design abilities. As one team wrote in their final report, "We have had a very positive experience with this internship... the internship was a very beneficial experience because it offered a lot of flexibility which gave us a lot of room to learn and grow." The project connected students in engineering to different perspectives by giving them exposure to a real-world application and connections to a local community-oriented industry. The hands-on experience broadened their understanding of practical applications of engineering, creating a valuable learning experience that went beyond the classroom.

This project was initiated by the sponsor who was keen on engaging students in open-ended community-oriented problem solving. The sponsor entered a partnership with the university to support the project for up to four years. The partnership also explored expansion to sponsorship of capstone senior projects. Plans to expand and add automation to the farm operations would provide a richer set of problems that would be more appropriate for seniors to take on and is a goal for our future work together.

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