First-Year Engineering Service Learning Projects Can Play Large Role on Global Issues

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Full Paper: First-Year Engineering Service Learning Projects Can Play Large Role on Global Issues

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Abstract–Service learning projects associated with food availability, literacy, and habitat construction are just a few of the many service opportunities available to first-year students. Recent first-year engineering students have had the opportunity to participate in a project with greater potential for global reach. In response to the United Nations Development Programme Sustainable Development Goal for zero hunger, first-year engineering students were tasked with designing and building a solar-powered food dehydrator that could be built on location with minimal resources other than the primary building materials. The actual design here was implemented at one-third scale. The project was targeted for implementation in regions of emerging development including areas with chronic widespread hunger and, simultaneously, lacking in material resources and infrastructure –including access to electrical power. In practice, using a food dehydrator makes it possible to extend the period for which fresh food can be safely prepared and stored for later consumption when food sources are scarcer. The design is powered by solar energy, and by merging the energy collecting and dehydrating chambers into the same volume, a compact design is achieved. Sunlight enters the drying chamber via a roof that is covered with semi-transparent plastic sheeting. Incident radiation striking the walls of the dehydrator also contributes to the solar energy input. Air circulation through the unit occurs via natural convection as the relatively dry outside air can enter the drying chamber through an adjustable height door and/or via several mesh covered holes located on the floor of the drying chamber. Subsequently, the warmer moisture-laden air exits through a mesh-covered roof vent. Testing of the dehydrator in early summer in the Northeastern United States on sunny and/or partly sunny days with outside air temperatures in the 88-91 ^{o}F range revealed that the internal air temperature will approach 115 ^{o}F.

Keywords: zero hunger, solar-powered food dehydrator, freshman year experience, UNDP

1. Introduction

Access to a solar-powered food dehydrator makes it possible to extend the period for which fresh food (e.g., fruits and vegetables) can be safely prepared and stored for later consumption when food sources are scarcer. The design project was targeted for implementation in regions of emerging development including areas with chronic widespread hunger and, simultaneously, lacking in material resources and infrastructure –including access to electrical power. A design constraint was that the dehydrator should be able to be built on location and with minimal resources other than the primary building materials. Construction design techniques were also to be considered; that is, there was to be no over-reliance on, say, a fully equipped machine shop. In this way, student teams may be able to travel abroad to demonstrate construction and use of their design.

Freshman at GU take a mandatory First Year Seminar (FYS) course which includes a service learning project. Participation in service projects directly supports the fundamental mission of the university to prepare students to be global citizens through programs grounded in the liberal arts and sciences via a comprehensive, values-centered learning experience that emphasizes faith, leadership, inclusiveness, and social responsibility. For example, the St. Joseph House of Faith in Action is a new residential volunteer-supported construction which will eventually be a home base for volunteering and connecting in the community. A recent study found that a clear majority of students were willing to volunteer for weekend community service projects post-graduation [1]. A smaller majority were even willing to forgo some salary as a professional engineer working at a company known for its support of community activism.

Engineering FYS students lean on their background and/or inclination in engineering design and construction to help carry out their particular service project. In past years, engineering students have designed and built rooftop rainwater collection systems for garden use, vertical planters for efficient space utilization, and composters for community gardens. For AY2017-18, the engineering FYS faculty team included project ideas with greater potential for global reach. Thus, in response to a joint UN/IEEE Humanitarian Technology Challenge (HTC) Sustainable Development Goal (SDG) for food security, a service learning project was initiated in order to produce a working model of a solar-powered food dehydrator which could be used to address hunger in communities far removed from our local one [2]. In addition to zero hunger, other SDGs included no poverty, affordable and clean energy, and good health and well-being [3-4]. The United Nations Development Programme (UNDP) is a leader in this global challenge.

To carry out this project, students were randomly assigned to design teams composed of between 5-6 members each for a total of 5 teams. Team formation was such that –where possible– each team was composed of members representing the various engineering majors on campus (i.e., ME, BME, ENV, EE, or IE). Each team selected a leader and co-leader and once the teams were formed they spent the next 6 weeks developing their design. Along the way, interim progress reports were submitted and evaluated. At the end of the 6 week design phase, each team made a PowerPoint presentation in front of judges who were invited to class to score the competing designs. Selection of the team presenter was made –arbitrarily– just before the scheduled presentation. At the end of the competition design phase, the winning design was advanced to the construction phase. At this point, materials were acquired and the team leaders assigned construction tasks to the non-winning teams. In this way, critical aspects of project management including talent assignment and task scheduling were introduced. Finally, as a result of the project students were not only able to apply fundamental engineering concepts in the design of a product that addresses global hunger, but they also learned about teamwork and the responsibilities of being a global citizen.

All competing designs were compact in the sense that the energy collecting and dehydrating chambers were merged into the same volume. In the winning design, sunlight enters the drying chamber via a roof that is covered with semi-transparent plastic sheeting. Incident radiation striking the walls of the dehydrator also contributes to the solar energy input. Both the exterior and interior surfaces were painted black in order to help retain heat. Air circulation through the unit occurs via natural convection as the relatively dry outside air can enter the drying chamber through an adjustable height door and/or via several mesh covered holes located on the floor of the drying chamber. Subsequently, the warmer moisture-laden air exits through a mesh-covered roof vent.

In order to test the effectiveness of the design in achieving safe drying temperatures, the project team had to wait for the arrival of warmer seasonal temperatures. Testing in early summer 2019 in the Northeastern United States on sunny and/or partly sunny days with outside air temperatures in the 88-91 ^{o}F (31.1-32.8 ^{o}C) range revealed that the internal air temperature will approach 115 ^{o}F (46.1 ^{o}C). This is below the recommended 120-140 ^{o}F (49-60 ^{o}C) range for dehydration of fruits and vegetables [5-8]. A simple modification to the current design (i.e., thinner walls) is already being planned in order to determine if this concept design can generate the required air temperatures for safe drying for similar outside air temperatures. The dehydration of raw meat is a separate issue since safe dehydration requires even higher internal temperatures [9]. However, the current design is not necessarily excluded from the dehydration of meat since summer temperatures in the anticipated countries of implementation can exceed 100 ^{o}F, with corresponding increases to the internal air temperature.

2. Service Learning as Part of FYS

Early in the fall semester, the freshman engineering cohort is assembled together in order to introduce and discuss the need and opportunity for engagement in the community. This is not simply a hypothetical exercise. In Erie, the need is particularly acute. For example, in 2016 the estimated poverty rate in the city of Erie was 27.3%, compared to the national rate of 14.0% [10]. As a result, approximately 75% of children in the Erie City School District qualify for the National School Lunch program [11].

At GU, the freshman engineering cohort is typically divided across three sections. Within each section, students are assigned to multidisciplinary teams comprising typically between 5-6 members. Once the teams are formed, they will spend the next 6 weeks developing their proposal. Along the way, multiple interim progress reports are submitted and evaluated. At the end of 6 weeks, the stakeholders are invited to class to score the competing designs as each team makes a presentation. At the end of the competition design phase, the winning design from each section advances to the construction phase. At this point, materials are acquired and the team leader blends in students from non-winning teams. In this way, they learn valuable aspects of project management: scheduling tasks and assigning talent to those tasks. The GU Office of Service Learning plays a direct role by providing project funding. It should be noted, however, that previous teams have successfully engaged corporate or private sponsors to donate both materials and expertise in support of these projects. Thus in addition to developing some useful networking skills, this process also serves to advertise the service learning project to the community which, in turn, provides one small way for the company to engage in support of community service.

All course section faculty are involved in the process to ensure that timely progress is made and to provide guidance, as necessary. By the end of fall semester the project is completed and the design is typically delivered to the stakeholder. However, in the current iteration a local stakeholder has not been identified since, as previously mentioned, this service project was specifically initiated and constrained with the hope of being implemented in regions of emerging development.

3. Solar-Powered Food Dehydrator

The solar-powered food dehydrator (SFD) was designed and developed using this model. As envisioned, use of a SFD can extend the shelf life of fresh foods indirectly by using solar energy to decrease moisture content. That is, by circulating relatively dry air over and around food, its moisture content can be substantially reduced. This helps to preserve food by slowing down bacterial growth. Concept proof-of-principle (POP) SFD designs were initiated in AY2017-18. The competing designs were largely unconstrained –except for budget– and thus many of the designs closely resembled commercially available models and were constructed using parts and materials available from local home goods stores. Figure 1 shows one of the completed POP SFD designs from AY2017-18. This particular design included two completely removable food trays for easy loading/unloading. Also indicated is the use of a Plexiglas roof which allows sunlight to enter the enclosed space. As can be seen, the interior surface was painted black to enhance heat retention. A second completed POP SFD design is shown in Fig. 2. This design incorporated a collector to funnel warm air into a drying chamber which included four fixed trays. While demonstrating concept proof-of-principle, these two designs were never intended to serve as deployable designs due to an over-reliance on materials, hardware, and shop skills. It was felt that a SFD design that could truly impact global hunger would be one that could be mass produced on location with minimal resources other than the primary building materials, and with minimal-to-no reliance on access to a machine shop. Nevertheless, these initial concept POP SFD designs helped to establish the framework whereby the current Phase 2 designs might actually be suitable for introduction to the targeted region.

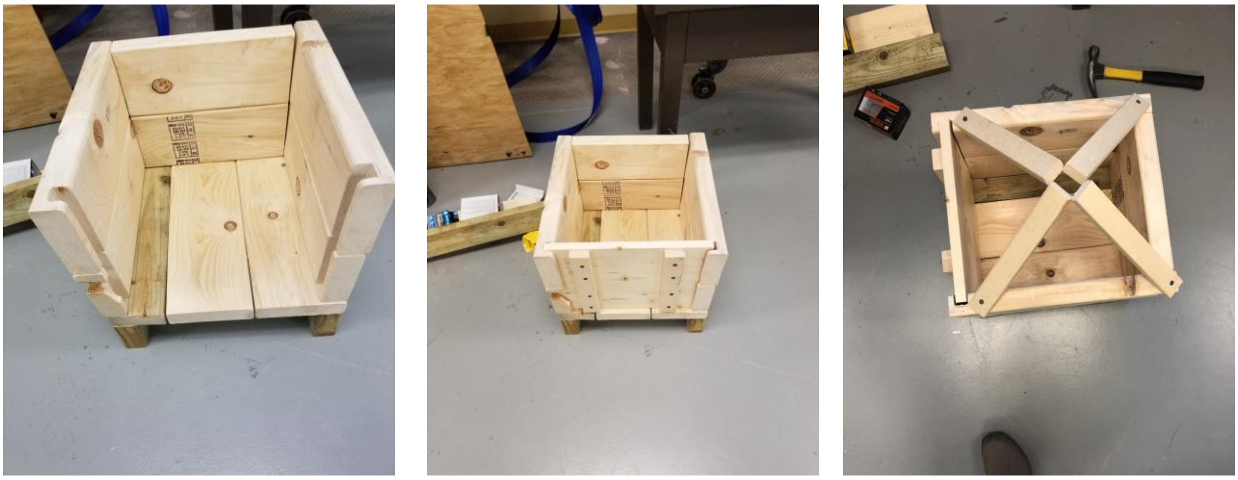
(a) (b)

Figure 1. Proof-of-principle solar-powered food dehydrator design #1: (a) hinged door is open showing removable trays; (b) completed design showing side-mounted panel door for air circulation.

(a) (b)

Figure 2. Proof-of-principle solar-powered food dehydrator design #2: (a) interior space showing four trays; (b) completed design showing solar collector.

Initial construction of one of the winning Phase 2 SFD designs is indicated in Fig. 3. All designs were implemented at 1/3 scale. In Fig. 3a, the drying chamber is shown. In constructing the walls and floor, wood dowels were used to attach the planks together. While a drill was used to create the mating holes, a simple manual hand drill could be used on location. Similarly, a chisel can be used to create the grooves that receive the sliding door (Fig. 3b). Elevated angled slats form the support structure for the roof (Fig. 3c). As seen, sunlight will enter the drying chamber through the roof via semi-transparent plastic sheeting. Incident radiation striking the walls of the dehydrator also contributes to the energy input. Both the exterior and interior surfaces were painted black in the final configuration. Air circulation through the unit occurs via natural convection as the relatively dry outside air can enter the drying chamber through an adjustable height door and/or via several mesh covered holes located on the floor of the drying chamber (not shown). Subsequently, warmer moisture-laden air exits through a mesh-covered roof vent. The completed design showing two stackable food trays and the sliding door is indicated in Fig. 4.



(a) (b) (c)

Figure 3. Phase 2 solar-powered food dehydrator design #1: (a) interior volume is framed by walls fastened together with wood dowels; (b) door slides in oppositely matched grooves; (c) roof is composed of four angled slats to which semi-transparent plastic sheeting is attached.

Figure 4. Completed Phase 2 solar-powered food dehydrator design #1; food trays are stackable.

The completed dehydrator was tested in order to gather data pertaining to the design objective of producing internal air temperatures suitable for safe dehydration of fresh fruits and/or vegetables. Testing was performed in early summer 2019 in the Northeastern United States (43.2 ^{o} N, 77.6 ^{o} W), and the test data is given below in Table 1. The data indicate that on a sunny-to-partly-sunny day with outside air temperatures between 88-91 ^{o}F, the dehydrator generated internal air temperatures that approached 115 ^{o}F (46.1 ^{o}C). This temperature is below the recommended range of 120-140 ^{o}F (49-60 ^{o}C) for the dehydration of fruits and vegetables [5-8]. A simple modification to the current design (i.e., thinner walls) is already being planned in order to determine if this concept design can generate the required internal air temperatures for safe drying for similar outside air temperatures.

Table 1. Test data for the solar-powered food dehydrator

Day	Time (EST)	$T_{outside}$ (^oF)	T_{inside} (^oF)	Comment
7/9	1:00p	81	84	sunny
	2:00p	82	95	sunny
	3:00p	83	104	hazy sun
	4:00p	84	103	hazy sun
	5:00p	84	106	hazy sun
7/10	1:00p	88	102	pt. cloudy
	2:00p	88	111	sunny
	3:00p	91	113	sunny
	4:00p	90	113	sunny
	5:00p	91	114	cloudy
	6:00p	88	104	cloudy

4. Conclusions

Given a project task of designing and building an operable solar-powered food dehydrator, five student-led teams each designed a unique design that was powered by solar energy. By merging the energy collecting and dehydrating chambers into the same volume, compact designs were achieved. Simple construction techniques were required as well, implying that the design could be built on location in remote communities and with minimal resources other than the primary building materials and hand tools. In practice, using a food dehydrator makes it possible to extend the period for which fresh food can be safely prepared and stored for later consumption when food sources are scarcer. The efforts of the first-year engineering student teams demonstrates their capability in addressing one of the global issues –zero hunger– identified and targeted by the United Nations Development Programme in their Sustainable Development Goals.

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