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ANSWERING FOOD INSECURITY:

Serving the Community With Food and Knowledge Using Technology

Courtney Simpson, *Purdue Polytechnic Institute*

ABSTRACT

The courses of Tech120, CGT110, and ENGT 180/181 and Red Gold at Purdue collaborated to design a robot that would plant and water a garden for a local community charter school. The students centered the project on the users' needs for fresh food, nutrition education, and early exposure to STEM for children. The school, Anderson Preparatory Academy (APA), is comprised of many children who come from low-income families and are in the free or reduced lunch program. Inspired from "Farm Bot," a similar system that allows for almost hands-free gardening, the "Boiler Bot" is designed to be scalable so children at the charter school can work to expand it and yield more food. The students of Purdue made certain that the Boiler Bot provided access to fresh produce, while encouraging children to take interest in STEM fields. The kids gain pride in growing food while learning about robotics, agriculture, and teamwork. APA and Purdue share a vision in which students of both schools can work collaboratively and expand on this robotic greenhouse.

KEYWORDS

food desert, food insecurity, poverty, robot, farming, STEM, technology, community school

INTRODUCTION

Free and reduced lunch rates are in excess of 84% in the K–12 schools located throughout Madison County, according to Commandant Jill Barker of APA (personal communication). TECH 120, a Purdue class that focuses on project-oriented assignments, works with Anderson Preparatory Academy (APA), a local charter school of 820 students. APA has approximately 700 students on free or reduced lunch programs, and their elementary and high schools are located in a food desert region. Food deserts "refer to areas (e.g., neighborhoods, census tracts, communities) that lack access to healthy, nutritious and affordable food" (Wright, Donley, Gualtieri, & Strickhouser, 2016). This means that APA students go to bed hungry and wake up hungry. These children are not simply hungry for physical food; their bodies are hungry for well-balanced nutrition. Many of these children lack

the resources to have three square meals per day, including lack of access to fresh fruits and vegetables. Fresh produce is less readily available than food found at local convenience stores. The students in TECH 120 aim to create a robotic greenhouse to provide fresh produce for these students' year-round.

The robotic greenhouse is used both indoors and outdoors, and it is completely scalable to whatever size needed. The project would not be possible without supportive faculty and staff to provide knowledge in their field and connect students with other professionals. Professor Jeff Heiking, who teaches CGT 110 and ENGT 180/181, provided resources and knowledge to accomplish 3-D design and printing. Many Purdue students in these classes learned how to use 3-D modeling software and how to operate 3-D printing equipment in the design process for this robotic greenhouse called Boiler Bot.

The Boiler Bot will supplement APA's current food pantry so students can have fresh produce to take home for the weekends and during the summer. APA created a food pantry where students are allowed to take home a backpack full of food on Fridays for the weekend—enough for proper nutrition and to feel satisfied. The Boiler Bot is also a way for students to feel excited about eating healthy while learning about a STEM field at the same time. This Boiler Bot will allow children of APA to use their innovative abilities to grow and expand, as adding different abilities to the Boiler Bot are endless. The Boiler Bot will continue to grow alongside technology, with the children of APA as the leaders. It is curbing the appetite for nutrition and innovation alike.

PROCEDURE

The idea of the Boiler Bot, the robotic greenhouse, was developed in TECH 120, which is a class that focuses on brainstorming, ideation, and group work. Students spend a lot of time learning how to collaborate and successfully go through the engineering design process. They observe a problem and develop a game plan to solve it. The TECH 120 class slowly accustomed themselves to engineering design, teamwork, communication, and the ability to identify and provide a user's end need. A large part of the class was focused on organizing and creating effective ways of communication between TECH 120, CGT 110, and ENGT 180/181. CGT and ENGT classes are technical in nature, so the TECH 120 class reached out for access to their skill sets. TECH 120 was primarily responsible for communicating with all stakeholders and especially APA. Commandant Jill Barker of APA

was the primary resource for questions and the design process. The classes followed a five-step solution to address and answer the problem, shown in Figure 1.

Several exercises and team-oriented activities were utilized during the process. For example, the following process taught students in TECH 120 to ask deep, meaningful questions for their interviews with community leaders and personnel.

Student teams were instructed to design an ideal clock for another team. This required students to ask detailed questions and assess the other team's needs for a clock. The design teams tended to fall into the trap of focusing on what they thought would make a good clock, rather than the end need. The activity forced students to put themselves in the end user's shoes and prototype designs that addressed their customers' needs. The teams did not actually design real working clocks, but rather showed prototypes with graphs and illustrations.

Before the group got involved with designing the Boiler Bot, they first interviewed Jill Barker, APA's commandant. The Purdue students asked questions about mechanical requirements as well as limitations surrounding the project. The students also interviewed Second Harvest Food Bank to understand food insecurity in the local community of Anderson. They provided students with insight into their day-to-day operations, the customs of low-income families, and their goals to provide food, as well as a safe environment for families to get assistance. With this information, the students had an understanding of their user's end needs.

Figure 1. Problem-solution process.

Children who live in low-income households typically struggle with food. According to a research article sponsored through a public health committee about food insecure households, “household food insecurity was significantly associated with the household economic status, where poor households were more food insecure than wealthy households” (Tamiru et al., 2016). These homes have less food, and typically unhealthy kinds, due to factors such as fewer grocery store options, lower education levels, and family eating habits. Low-income families often rely on public transportation and may not own a personal vehicle. “Access to a car is, for

Figure 2. FarmBot.io original inspiration.

most, a more important consideration than access to a full service supermarket” (Wright et al., 2016). Lack of transportation limits where families can shop, and neighborhood convenient stores may be the only option.

The classes were split into teams based on their skill sets. These teams consisted of greenhouse set-up, garden beds, robot frame (hardware), robot electronic functions, farming implement heads (watering and seeding), and system design (electricity and water). Each team member drew up three designs for their team, and the team chose the five most favorable designs. The students had practiced design thinking through various team exercises early on in the class. The use of radical ideation helped the students keep ideas flowing, which could later be tweaked or combined with other ideas to quickly produce quality designs. After the teams settled on a couple of good options, the CGT 110 (design class) students were asked to revise their concepts and use AutoCAD to create finalized designs.

The TECH 120 professor and project leader, Lorri Barnett, helped in allocating funds from class grants for purchasing equipment, materials, and tools. The students met at a vacant building off campus to work on the Boiler Bot. The students used a simple hoop house-style greenhouse. From this, they built the garden bed for the robot

and attached the frame on which the robot functions. The power system is a 110-volt line running along the ceiling, and the water system was composed of half-inch polyvinyl chloride (PVC) with a built-in fertilizer and water pressure reducer. While the students on the frame, greenhouse, and systems teams were working on the greenhouse mechanics, others were working on farming implement heads and the robotics (programming raspberry pi and Arduino microcontrollers). It is important to note that the students felt that one semester was not enough time for the Boiler Bot to meet the end user’s needs. Instead of producing a functional product to meet the client’s need, the students produced a plan for the future with scalability options. The original FarmBot has the robot mounted to a raised planter bed. While this is sufficient for one family, one bed will not feed many families, let alone ~700 children. The TECH 120 students had neither the funds nor the time to build multiple robots mounted to multiple beds. Instead, the students designed a way for the robotic frame to be mounted to a mobile frame on casters so that it could be moved to multiple planter beds. The students wired and plumbed the greenhouse to work with three planter beds. See Figure 2 and Figure 3 for the

Figure 3. Unveiling of the Boiler Bot.

contrast between the FarmBot original stationary design and the greenhouse set up by Purdue students.

While students worked on building a working prototype for APA, they also worked on deliverables for the Boiler Bot project. On December 15, 2016, the Purdue students handed ownership of the Boiler Bot over to APA. They presented a PowerPoint during the ceremony over the entire Boiler Bot, a technical report, poster for the prototype prevailing, GANTT chart and timeline, communication plan including a stakeholders listing, a follow-up with stakeholders, and the prevail and prototype setup.

RESEARCH CONDUCTED BY STUDENTS

Interview With Jill Barker

- Number of people to assist? Nearly 700 families.
- Seasonal option or a continuous cycle? Controlled environment would be best and they would love to be able to grow food all year long.
- What do you hope to accomplish with this project? Food for hungry kids, nutritionally healthy produce, and proper education on the produce and health awareness. Proper training so the project is sustainable.
- Do you have a plan to protect the project from wildlife, weather, and intruders? Plot is within a security fence. Second Harvest Food Bank will store the majority of the food.
- Who will maintain it during the summer? The kids do community service during the summer so there will be no problem having someone maintaining it at all times.
- Who would be some good people to talk to for information? Second Harvest Food Bank and new purpose ministries.

The students also did independent research regarding food deserts and the use of technology and robotics in farming. The findings validated their reasons for creating the Boiler Bot and indicated it had a future to grow with appropriate technology. The group found that living in a food desert leads not only to poor nutrition, but also to attendance, behavior, and attention issues in class. Luckily, the students of Purdue Polytechnic Anderson discovered that they would be able to provide fresh, nutritious produce while giving APA students the ability to build on this project for generations to come.

Typically, fresh food is more expensive than processed foods. Purdue students took a day to visit local supermarkets, observe customer's buying habits, and speak

with employees. A store employee said, "lower income families buy what they can afford. Food and the cost of living has gone up, while wages remain minimal for many Americans." Students aimed to go to large supermarkets in poorer areas of the community, but they realized these were not in walking distance of low-income areas. "Findings suggested that predominantly white census tracts had five times the number of supermarkets that black neighborhoods had" (Wright et al., 2016), resulting in money going toward transportation costs. It makes sense for lower-income families to simply shop at, as the name implies, convenience stores.

The Purdue students aimed to provide a fun way for children to learn about robotic technology, farming, and healthy eating. Food insecurity can lead to negative consequences regarding a child's education, such as absenteeism and issues concentrating in class. "The frequency of adolescent school absenteeism was significantly high (50.20%) among food insecure households compared to their peers whose households were food secure (37.89%)" (Tamiru et al., 2016). Some argue that children who are food insecure should want to be at school with the promise of a lunch meal, but physical health and classroom compliance often interfere. Children who live in food deserts are not simply underfed, but often face obesity. Spatial inequality in food deserts results in fewer resources, leaving these children with less than adequate nutrition and energy required to maintain a healthy, growing body. This affects the brain and leads to social and academic problems. Students discovered that many families of APA are Hispanic immigrants who have a language barrier that hinders the parents from seeking assistance. According to an academic journal from University of Rhode Island, in "parental reports of child behavior, non-Hispanic Whites were significantly more likely to report problem behavior than either Hispanic group" (Gorman, Zearley, & Favsul, 2011). Purdue students believed that the Boiler Bot could provide education through imagery and hands-on activities, helping children of all nationalities to be involved and to learn.

The Boiler Bot provides students with an exciting twist to food education by creating an ever-changing, custom curriculum. While the traditional health class provides a similar curriculum, the Boiler Bot will allow students to dream. The Purdue students wanted to design a robot able to expand capabilities, so students researched what robots in agriculture are already doing. The original Farm Bot (source of inspiration for the project) tested soil moisture, spotted weeds and smashed them back into the dirt, and connected to an app to customize gardening. Students discovered that a group of engineering students from

Zhejiang University of Technology created a backpropagation neural network. A camera would pick up specific pigments of a cucumber to identify it as produce and pick it from the garden. A special gripping mechanism incorporated texture analysis into the identification process. The recognition rate was 76% out of 40 cucumbers. While these capabilities are in fact advanced, the students believe this will encourage children to continue working on the Boiler Bot with them to optimize its capabilities.

RESULTS

While the Purdue students implemented a robot capable of farming, the robot is an innovative product that will allow for a productive relationship between APA and Purdue. The classes TECH 120, CGT 110, and ENGT 180/181, and the company Red Gold, focused their energy on planning a product and a system that met the user's needs. Much time was spent documenting findings, and thinking futuristically, to prepare for problems that could arise with the Boiler Bot or the system. The students felt they had provided the planning and orchestrated part of the project; however, the Boiler Bot is ready for expansion and improvement. Projects of this size require time to ensure that kinks are worked out. Since the first semester was dedicated to setting up an operational system, it will be simple for APA and other Purdue Polytechnic classes to make changes and improve the Boiler Bot. As the user needs change over time, a technology-driven project like this allows modifications to adapt for such needs.

Currently the Boiler Bot is not capable of yielding a significant amount of food with only one planter bed, but the scalability of the robot will allow for expansion of the prototype. The Boiler Bot will be perfect for the kids at APA to work alongside Purdue students in the spring. As the plants are growing, the students can focus on making the robot portable so it can move to more planter beds. This will save on the amount of materials used and reduce cost. The Purdue team created the watering system and power supply to accompany a three-bed greenhouse. Time did not permit the team to make the robot portable, so the students mounted the robot frame to the planter bed. The students did this in a fashion that will make it easy to remove the frame from the planter bed and mount the robot to a portable frame that will roll from bed to bed.

The majority of students who worked on the Boiler Bot were from mechatronics, engineering technology, and organizational leadership. Involvement with a project such as this one was an ideal way for students of any

major to learn about industry, as well as themselves. Every student was a part of something big and learned to adapt to challenges such as miscommunication, budget and time constraints, differences in design process thinking, and more. For many students, this was a first-time encounter with developing a machine that carries out precise, complex actions automatically, as well as working on an interdisciplinary group, community-based project. The takeaway was self-development, awareness, and learning to adapt to challenges engineers encounter in industry.

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AUTHOR BIO SKETCH

Courtney Simpson completed her freshman year at the West Lafayette campus of Purdue and is now a sophomore majoring in mechatronics at Purdue Polytechnic in Anderson, Indiana. She currently is working alongside her colleagues at Purdue University on projects that advance both their education and the community. If you cannot find her working on an innovative project at school, you will find her working for her family's heating and air conditioning company. Simpson plans to pursue her MBA upon completion of her bachelor's degree and to pursue a job in the aerospace industry.

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