109th Meeting of the 1909 Conference: Advancing Thought, Research, and Practice in Technology and Engineering Education

The 2023 Conference is the 109th Conference.

Clarion Hotel, Nashville Downtown Stadium, Nashville, TN

Recreational Charging Stations via Renewable Energy: An Undergraduate Research Experience, Service-Learning Project-Phase 1

#9, Session V

Eric Deneault
Fort Hays State University
eldeneault@fhsu.edu

November 16 -17, 2023

Author Biography:

Eric Deneault, M.S., is an Associate Professor who teaches Engineering Design Technology, Construction Management, and Teaching Technology and Engineering Education in the Department of Applied Technology at Fort Hays State University.

Author's Note:

A special thanks to Dr. Dmitry Gimon and Dr. Beth Walizer for assisting with this undergraduate research experience, service-learning project.

Scholarly Abstract:

This scholarly paper delves into a groundbreaking academic initiative, the Undergraduate Research Experience (URE) coupled with a Service-Learning Project (S-LP), spanning multiple semesters at Fort Hays State University (FHSU). The project, steered by two dedicated instructors and a team of undergraduate students, undertook the challenge of defining an issue, conducting research on Recreational Charging Stations (RCS) infused with renewable energy, and securing Institutional Review Board (IRB) approval. Subsequently, students designed, administered, and analyzed a comprehensive survey, which served as the foundation for the creation of a 3D prototype of an RCS.

This ambitious endeavor symbolizes the confluence of academic collaboration, innovative thinking, and a commitment to sustainable technology. FHSU's burgeoning STEM curriculum and the establishment of the new Center for Applied Technology set the stage for this pioneering URE course. The Department of Applied Technology offered an URE course, focusing on the development of RCS integrating renewable energy, an initiative that reinforces FHSU's commitment to academic excellence.

Cross-curricular cooperation emerged as a defining aspect of the project, with active involvement from FHSU's Department of Applied Technology, Department of Informatics, and the Kansas Academy of Mathematics and Science (KAMS). With a unique blend of theoretical knowledge and hands-on experience, students from diverse academic backgrounds came together to tackle the challenge of RCS development.

The project's journey was marked by meticulous planning and coordination. Following approval from FHSU's Provost, the course TECS 406 H was born, inviting students to participate in this trailblazing URE program. Throughout its development, the project emphasized cross-curricular engagement and a student-centric approach, enabling participants to explore various facets of the problem while fostering creative ideation and interdisciplinary collaboration.

The research identified the absence of outdoor recreational spaces on campus, precipitating the need for RCS as a modernizing solution. Students navigated multiple avenues for renewable energy sources, ultimately electing solar energy for its alignment with FHSU's commitment to green campus initiatives. The design process included considerations of green energy, structural integrity, and portability.

Prototyping and renderings played a pivotal role in conveying the project's vision. The students harnessed 3D printing and computer-aided design (CAD) to create prototypes and realistic visual representations of the RCS. The project's apex arrived with a presentation to FHSU's architect, marking a milestone in the quest for campus approval and funding.

This transformative academic journey didn't stop at the campus boundaries. The students embraced the challenge of securing external funding and support, reaching out to local businesses, contractors, and potential donors. The project's global reach was affirmed through a presentation at the International STEM Education Association (ISEA) conference, propelling the students into an international academic arena.

In conclusion, this paper underscores the profound impact of the URE and S-LP model in nurturing academic exploration and innovation. It illuminates the possibilities when diverse academic departments converge to address real-world challenges, emphasizing the role of renewable energy in modernizing campus infrastructure. As the RCS project evolves, it embodies the spirit of academic excellence, sustainability, and the limitless potential of undergraduate research experiences.

Key words: undergraduate research experience, service-learning, recreational charging stations, renewable energy

Introduction

Located in the western plains of Kansas, Fort Hays State University (FHSU) was founded in 1902. FHSU boasts a total enrollment headcount of 13,443 students, with 3,631 students on-campus, 6,602 enrolled in online programs, and 3,210 participating in the international partnership program, representing more than 30 nations. This is an exciting time for FHSU, particularly for the Department of Applied Technology. The new Center for Applied Technology and Sculpture, which now houses the department, signifies a cultural shift as it aligns with the current Association of Technology, Manufacturing, and Applied Engineering (ATMAE) accreditation standards, and introduces the first ever undergraduate research course. The focus of this course centers on Undergraduate Research Experience (URE) with a Service-Learning Project (S-LP) to develop Recreational Charging Stations (RCS) with renewable energy, strategically placed across the FHSU campus.

Through cross-curricular collaboration, various entities have contributed to the RCS project. These include the Department of Applied Technology, the Department of Informatics, and the Kansas Academy of Mathematics and Science (KAMS). The Department of Applied Technology, located in the Werth College of Science, Technology, and Mathematics, offers a combination of theoretical coursework and hands-on experience to prepare students for careers in the ever-changing field of applied technology. The Department of Informatics, housed in the Robbins College of Business and Entrepreneurship, focuses on concentrations in information, networking, telecommunications, and offers various minors and certificate programs, along with several graduate degree programs. KAMS, a division of FHSU Student Affairs, was established by legislative action, SB139, in 2006 and offers residential learning experiences for high-achieving high school students in Kansas.

Literature Review

The URE at FHSU involves collaborative faculty-student work on scholarly projects within the university departments. This experience can be one of the most memorable for both faculty members and students. The URE project provides students with the opportunity to “gain hands-on experience outside the classroom and develop research skills for academic and professional pursuits” (FHSU, 2002).

Service-learning projects as defined by FHSU (2002), is “a method of teaching and learning that integrates community service activities into academic curricula and expands the learning of students from the classroom to the community.” One type of experiential learning experience possible at FHSU is S-LPs, which are carried out by exposing university students to the surrounding community (Wallert & Walizer, 2015). According to Hofstetter-Duffy (2002), “Students need some background before their main interaction with the selected community.” Hofstetter-Duffy shares that there are four key components to service-learning: preparation, action, reflection, and assessment (2002). When reviewing the literature, Cook-Benjamin and Rackaway found that the benefits of service-learning for higher education students taking classes on campus are relatively abundant and beneficial (2016). In 2014, Deneault was involved in a grant and publication based on a Read4Respect Service-Learning Project: Motivating and Engaging Students in Reading (Zelenka, Deneault, Dreiling, & Walizer, 2016), which inspired his idea of a S-LP researching RCS on the FHSU campus.

Recreational charging stations with renewable energy are not a new concept on university campuses. For instance, solar charging stations were proposed by students, faculty, and staff members of the Green Fee Committee in the College of Natural Sciences at University of Texas (UT) at Austin. Students at UT initiated this project to foster a cohesive undergraduate research community (University of Texas, 2014). The Green Fee Committee funded the charging stations project in 2010 to support the Committee's mission of an environmentally conscious campus initiative (Noreiga, 2014).

Vanderbilt University introduced charging stations to the campus with practical applications of alternative solar energy that benefit students, faculty, and staff members. This utility conservation project was proposed by students with peer input. Using solar-powered charging stations, the university community now has the ability to charge their personal electronic devices while enjoying the outdoors (Entman, 2012).

Purpose and Methods

In the fall of 2016, the Department of Applied Technology, Department of Informatics, and the Kansas Academy of Mathematics and Science (KAMS) initiated an action research project as part of an URE, emphasizing student collaboration through an innovative STEM S-LP. Mr. Eric Deneault, associate professor in the Department of Applied Technology, and Dr. Dmitry Gimon, former assistant professor in the Department of Informatics, discussed a potential URE via a S-LP. Initially, Gimon expressed concern about the need for additional outdoor spaces at FHSU to enhance students' gathering, relaxation, collaboration, and appreciation of the campus's historical beauty. Deneault suggested incorporating green energy into the outdoor space enabling students to charge their portable electronic devices while enjoying the outdoors.

As the URE, S-LP idea took shape, the instructors met with the FHSU Provost to seek approval for the development and implementation of an undergraduate research course involving students from the Department of Applied Technology, Department of Informatics, and (KAMS). While instructors developed the curriculum, meetings were also held with the Dean of the Werth College of Science, Technology, and Mathematics to discuss the course's logistics. With strong support from the Dean and the Department of Applied Technology's Chair, the proposed course, TECS 406 H Problems in Technology Studies: Research Recreational Charging Station, was assigned a course number and title, with enrollment beginning in the spring 2017 semester, under the leadership of instructors, Deneault, and Gimon.

Emphasis was placed on cross-curricular elements during the course development, highlighting the strengths of the two departments and KAMS on the FHSU campus. Instructors wanted the project to be student-centered, allowing students to explore ideas without immediate direction on how to solve the problem. The goal was to encourage cross-curricular collaboration and incorporate at least one idea from each student into the final design of the project.

Over the first few weeks, students conducted surveys, compiled results, and conducted research. They then presented their findings, shared ideas for solving the problem, and discussed possible project designs. The next four weeks were devoted to sketching and designing the RCS, a process that required time and consideration due to the numerous excellent solutions. Instructors identified the best solutions and narrowed the ideation into a final direction.

Students and instructors collaborated to develop a design, incorporating as many students' ideas as possible into the blueprint. The students went through a series of design iterations, from the first generation to second generation, ultimately arriving at a final design, that satisfied all stakeholders. During this process, discussions arose regarding wind, solar, and mechanical energy attached to the RCS. The students initially considered a sun-tracking solar roof design but found it to be logistically and financially impractical. They instead opted for an offset gable roof design with three solar panels on each side, which improved the design's aesthetics.

Throughout the design process, students addressed various questions about the seating, including whether it should be fixed or portable, open or bench style, ADA compliant, and potentially incorporate a swing. The students decided to make the swing the focal point of the design, based on strong support from polling data.

After completing the design, the students presented their project to the FHSU Architect, seeking approval to place the recreational solar charging station on campus. The school architect liked the proposed design but provided valuable insights into materials, code requirements, and design adjustments. The students conducted further research to meet these requirements. Once the design reflected the changes suggested by the school architect, the students held a formal presentation for the dean, chairs, and school architect, hoping to secure the necessary funds for constructing the RCS.

Following the formal presentation, the students were challenged to seek additional funding for their project. The dean encouraged them to reach out to potential donors, businesses, and contractors who might support their undergraduate research project. The dean then committed to matching the total contributions generated from fundraising.

Materials and Procedures

Problem:

When defining the problem, students discovered that outside of the main buildings on campus, there are no campus attractions or recreational spaces beyond a park bench. Furthermore, there are no outdoor collaboration spaces for students to work or dual-purpose outdoor lecture spaces. Currently, there is not a designated area encouraging people to enjoy the outdoors. Students felt that the traditional and historic campus needed to be modernized.

Research:

Prior to conducting any research, the instructors, along with students enrolled in the URE course, completed Internal Review Board (IRB) training, enabling them to administer a survey and collect data. While conducting research, students in the URE course expressed their desire to power the RCS with green or renewable energy. Options discussed included wind, solar, and mechanical energy. Given the university's existing wind turbines that provide a bulk of the campus's energy, students considered the idea of wind energy but decided against it due to safety concerns of connecting a turbine to a recreational seating area.

Ultimately, students decided upon a roof design incorporating solar energy with batteries located under the bench seats to store excess energy. They also explored the idea of incorporating mechanical energy into a swing design, using a DC motor, sprockets, and chains. However, after researching swing energy, it became apparent that one would have to swing quickly and for an extended period to produce enough energy to charge portable electronic devices. However, advancing the swing energy was important, so the decision to include a digital readout of how much energy was being generated by the swing functionality was seen as an educational opportunity for those enjoying the RCS.

Criteria and Constraints:

Students aimed for a portable design, and weight was a significant factor. They studied various materials, considering that using steel for the RCS structure would be extremely heavy. Students found aluminum to be a suitable alterative, as it offers comparable strength but is much lighter. Location and placement were also essential considerations. Most students preferred placing the RCS in the campus quad, central location of the campus. This area, however, receives limited sunlight due to the height of the surrounding buildings and existing trees. Students also considered human traffic patterns to determine the best placement to maximize RCS usage while ensuring ADA compliance for accessibility.

Architectural Design:

Initially, the students' approach to their design was to incorporate all the trees on campus. Most of the initial sketches featured a leafy design, with small solar panels integrated into the branches to create a leafy effect. Only one of the original sketches took the form of a traditional seating area or gazebo. The logistics of using individual solar panels posed a significant problem. At this point, not all the criteria had been established, and the biggest issue with the tree design was that it would have to be placed in a permanent location. However, the students had already determined that portability was beneficial. Additionally, the RCS needed to stay true to the campus tradition and architectural appeal, incorporating materials that complement the campus aesthetics. Students are still deciding where to feature the native limestone.

Materials:

After examining various materials, aluminum was chosen for the frame. The base will be made from aluminum C-Channel and aluminum sheet plate with two slots in the bottom to accommodate a forklift for ease of movement. The bench seat boxes will double as battery storage compartments and will be made of aluminum sheet plate, while the seats will be made from foam and exterior-grade vinyl. Countertops will be made from laminated wood. The swing will be made from steel and will be double-sided. The mechanism for the swing energy will consist of a DC motor, sprockets, and a chain. The roof will be made from aluminum I-beam with aluminum purlins for attaching a metal roof. Solar panels will be placed on the top of the roof to provide most of the energy. A wire harness will travel down from the roof through the aluminum square tubing, underneath the flooring, and into the battery storage. The energy will be converted into usable 110-volt and Universal Serial Bus (USB) outlets running along the top side of the countertops for charging electronic portable devices with Ground Fault Circuit Interrupter (GFCI) protection.

Environment:

The environmental conditions in Hays, Kansas were a significant concern, leading students to question whether there were enough suitable days throughout the year for the RCS to be a feasible solution to the problem of not having an outdoor recreational space on campus. Therefore, the design had to incorporate features conducive to three seasons: fall, spring, and summer, with winter not being an option. The roof design was vital to keep out all weather elements, and a wind block near the RCS was also considered to enhance the user experience.

Prototyping:

Throughout this process, students utilized the additive manufacturing machine to 3D print a working prototype of the RCS. This was valuable for individuals who had difficulties understanding the spatial design of the RCS. Additionally, the prototype was an affordable and time-efficient way to check for interference and engineering design components of the RCS. During the final stages of the design, students applied material properties to the drawings, creating a realistic rendering of what the RCS would look like upon completion through computer aided design processes. The combination of the prototype and rendering allowed the class to present their project to a wide audience, explaining in detail what the finished product would look like and how it would function.

Continuation and Future Implementation

The students presented their project to conference attendees at the International STEM Education Association (ISEA), providing them with an opportunity to gain experience by presenting to an international audience and expanding their networking and professional resumes. The students dedicated many hours to prepare for this international conference presentation, highlighting their research and design accomplishments throughout the semester, and emphasizing the work they are continuing to do to ensure the project is completed on schedule.

As part of the course project, students presented at the ISEA conference. Afterward, they shred individual goals for the subsequent course and the final RCS project. These goals were personal and included their expectations for the completion of the URE course and service-learning RCS project.

References

Cook-Benjamin, L., & Rackaway, C. (2016). The Feasibility of Virtual Service-Learning. The Advocate, 23(1), 16-24.

Entman, L. (2012). Solar Charging Stations for Personal Electronics Installed on Campus. Retrieved November 1, 2017, from https://news.vanderbilt.edu/2012/05/07/solar-charging-stations/

Fort Hays State University. (2007). Research and Scholarly Activities: The Undergraduate Research Experience at Fort Hays State University. Retrieved from http://www.fhsu.edu/ure/

Fort Hays State University. (2007). Service-Learning. Retrieved October 30, 2017, from https://www.fhsu.edu/ccl/service-learning/

Hofstetter-Duffy, C. (2002). Key Components of Service-Learning. Retrieved October 30, 2017, from https://www.fhsu.edu/ccl/service-learning/Key-Components/

Noriega, C. (2014). Two Solar-Powered Charging Stations Installed on Campus. The Daily Texan. Retrieved November 1, 2017, from http://www.dailytexanonline.com/2014/07/30/two-solar-powered-charging-stations-installed-on-campus

University of Texas at Austin. (2014). Sustainability: Solar Charging Stations. Retrieved November 1, 2017, from https://sustainability.utexas.edu/solarstations/

Wallert, K., & Walizer, B. (2015). T-shirts for College Bound Students: A School-University Service-Learning Project. The Advocate, 22(3), 1-11. Retrieved from http://www.atekan.org/wp/journal-2/

Zelenka, V., Dreiling, K., Deneault, E., & Walizer, B. (2016). Read-4-Respect Service Learning Project: Motivating and Engaging Students in Reading. The Advocate, 23(1), 16-24. Retrieved from http://www.atekan.org/wp/journal-2/