LEARNING BY RESEARCH: A REVIEW OF UNDERGRADUATE RESEARCH EXPERIENCE IN THE SCHOOL OF ENGINEERING TECHNOLOGY

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Abstract

With the recent increased emphasis on applied learning activities, it is becoming more common for higher education institutions to include undergraduate students in research experiences both in and out of the classroom. For the in-class research activities, many faculty are redesigning their course projects to include a research component where students are exposed to conducting research from literature review to data collection and analysis. Outside the classroom, many college, school and department-wide opportunities are available that promotes undergraduate research experience. Many faculty receive internal and external grants to involve undergraduate students in their research projects. These research experiences provide valuable opportunities for undergraduate students where they can present and publish their research along with their faculty advisors. A variety of research experiences are developed and currently ongoing at the School of Engineering Technology at Farmingdale State College, SUNY. This paper will provide an overview of the undergraduate research experiences and the employed strategies to involve undergraduate students in research activities. The role of International Energy and Sustainability Conference (IESC) – Student Poster Presentation Day organized by the Renewable Energy and Sustainability Center at Farmingdale State College will be discussed. A review of past and present research projects along with the platforms that are available for undergraduate students to present and publish their research will be discussed.

Introduction

As the technological and engineering advancements continue, higher education institutiosn face the challenge of building strong curriculums to meet the continuing advancements while addressing the social consequences and implications of these advancements. Including social implications of engineering design in engineering curriculum is one of the major objectives supported by the Accreditation Board for Engineering and Technology [1]. One way to

integrate societal needs and challenges into the engineering curriculum is through incorporating hands-on projects, research-based learning and applied learning activities. These experiences provide students an environment to work on an engineering project while promoting critical thinking regarding the societal needs and implications. These projects also provide undergraudate students a great experience as many may not know much about the type of problems engineers encounter and solve. Many of this generation want to make the world a better place but may not perceive that they can do this with engineering. In order to recruit them, it is necessary to educate them on the social relevance of engineering and show them how technology enriches lives, help communities and make the planet a better place to live by preserving the natural resources, looking for alternative and renewable resources and saving energy [2-4].

In an effort to provide students the learning experience through engineering problems, many faculty started to mentor undergraduate students in research projects. The inclusion of undergraduate students in teaching institutions and undergraduate only institutions is even more crucial, as these projects provide an excellent platform for students to learn and apply the theoretical concepts they learnt in the class. Farmingdale State College encourages their faculty to include and mentor undergraduate students in their research projects, labs and hands-on learning experiences inside and outside the classroom. These research experiences provide valuable opportunities for undergraduate students where they can present and publish their research along with their faculty advisors. The process of conducting research, developing solutions to the research problem, preparing abstracts, presentations and manuscripts as well as presenting their work in a conference setting proves to be a great learning experience for undergraduate students.

These in-class and outside of the classroom learning opportunities through research projects and applied learning activities provide students very valuable learning experiences, and prepare them for their professional career after graduation, which helps them when they seek employment. According to the 2014-2015 “Six Months After Graduation Survey” outcomes more than 90% of the Farmingdale State College students secured a job within six months of graduation, where 47% secured their jobs prior to graduation [5].

Overview of School of Engineering Technology at Farmingdale State College

Farmingdale State College is part of State University of New York and was founded in 1912 in Long Island, NY. Currently there are 4 schools in the College: Arts and Sciences, Business, Engineering Technology and Health Sciences. The school of Engineering Technology houses 6 departments: Architecture & Construction Management, Automotive Technology, Aviation, Security Systems/Law Enforcement Technology, Electrical & Computer Engineering Technology and Mechanical Engineering Technology. These departments offer a vast array of

AAS and BS programs. In addition, these degree programs carry accreditation from a variety of accreditation institutions such as: ABET and ATMEA.

In the school of Engineering Technology, research is an important component as a part of the student learning experience. The mission of the School of Engineering Technology at Farmingdale State College *"is to promote the transmission, expansion, and application of technical knowledge through teaching, research, and community service*"[6]. Following the school's mission, many faculty employ in-class research activities and assignments where students learn how to conduct literature review, identify the related and useful information, conduct experiments, and analyze and conclude their findings. These research experiences provide an invaluable learning approach while preparing students for the challenges as they employ critical thinking and problem solving skills to address research project related challenges. In addition to the in-class research activities, many of the students work closely with their faculty to participate in research projects outside of the classroom. Many Engineering Technology faculty have research projects and laboratories where they mentor undergraduate students.

Although it is not possible to talk about all the research projects currently ongoing at the School of Engineering Technology, in this paper, we will provide a sample of past and present research projects that involve undergraduate students. Project information, how the undergraduate students were involved, and how the project outcomes are disseminated will be discussed.

Undergraduate Research Projects at School of Engineering Technology

The School of Engineering Technology at Farmingdale State College is striving to promote research experience to undergraduate students. This paper provides the vast array of samples of ongoing and completed projects that takes place at the college.

1. **Design of an Environmentally Friendly Smart House**

The goal of this undergraduate student research project is to attract and motivate students to do research in the area of *Smart Home* systems using analog and digital programmable devices as part of their research experience and applied learning while encouraging their participation in national and regional conferences and contests. A team of Electrical Engineering Technology (EET) undergraduate students worked on this research project. The project focused on: *(i) energy savings; (ii) security (iii) safety and (iv) increased comfort for users.* The entire system was built around an inexpensive microcontroller platform, the Arduino platform, using real sensors and actuators. Sophomore and junior Electrical Engineering Technology students completed this project.

2. **Smart Charge Controller**

The need for renewable sources of energy has been dramatically increasing over the years and is expected to continue in the future. Thus, the need for new technology to efficiently and

practically utilize these energy sources is of paramount importance. The goal of this undergraduate research project is to design a Smart Charge Controller (SCC) that efficiently obtains power from three different renewable energy sources at the same time and supply the energy to power consumers. The design was simulated using National Instrument's Multisim software [7]. This project was completed by two Electrical Engineering Technology students.

3. Solar Water Heating System

The selection of solar collectors and system designs always posts a challenge to consumers in terms of cost, efficiency, maintenance and the payback period. The main objective of this undergraduate research project is to evaluate the efficiency of these collectors, to optimize the heat energy output from the collectors and to investigate the technical challenges in different system designs. A multi-function solar thermal system has been designed and fabricated for this project. This project was completed by four Mechanical Engineering Technology Students.

4. Evaluation of Vanadium Redox Flow Battery Electrolyte and Cell Design

Vanadium Redox Flow Batteries (VRFB) have proven to be successful in large-scale energy storage testing for power grid integration and large facilities so far. One of the challenges in VRFB, however, is the low power density. In this current undergraduate study, several different VRFB cell designs were constructed. Charging and discharging characteristics, as well as, the performance of the VRFB cells were evaluated. Electrolytes composed of Vanadyl dissolved in sulfuric acid were also investigated in this work. This project is completed by two Mechanical Engineering Technology undergraduate students.

5. Investigation of Vanadium Pentoxide for use in Redox Flow Batteries

The Vanadium Redox Flow Battery (VRFB) ensures an optimal strategy for energy storage over the use of conventional batteries. While, the VRFB system provides outstanding recharging cycle life it suffers from low power density. This undergraduate research project reviews current and undergoing research and development progression pertaining to Vanadium and Redox Flow systems while demonstrating the use of Vanadium as a single element in the electrolytic solution used in VRFB system. This project is completed by one Mechanical Engineering Technology undergraduate student.

6. Robust Information Security System

Over the years, techniques, such as steganography and cryptography, have been employed as means of information security. These methods include, but are not limited to, invisible inks, microdots, character arrangement, digital signatures, covert channels, and spread spectrum communications. Though these methods of information security have been effective over the years, their robustness have been questioned by attackers. This undergraduate research project developed a technique that utilized discrete-algorithm cryptographic protocols as well as steganography methods, such as the least significant bit (LSB) insertion into digital images,

masking and filtering, is proposed. This project is completed by a sophomore level Computer Engineering Technology student.

7. Schedule Selection for Sustainable Production Lines

This undergraduate research study focused on the development schedules for production lines to achieve sustainability. The production line is modeled and simulated using discrete-event simulation software, ARENA by Rockwell Automation [8]. The simulation results are used to improve the sustainability of the line through Failure Modes and Effects Analysis (FMEA). Best preventative maintenance schedule is selected using a multi criteria decision-making approach. This project is completed by a Mechanical Engineering Technology undergraduate student.

8. Solar Charging Station

Utilizations of solar energy in remote areas such as parks, sporting events and outdoor recreational facilities, where grid-based electricity either is not available or not feasible can be a great solution for powering small devices such as cell phones, or laptops. This research focused on the construction of a cost-effective solar powered gazebo. A charge controller that regulates the flow of energy to and from the bank in order to prevent overcharging was built. The system can produce 300 watts at optimal capacity and can simultaneously power several devices as effectively as plugging into the energy grid. Two undergraduate Electrical Engineering Technology students completed this research.

9. Development of Innovative Methods to Teach Sustainability

This undergraduate research project focused on developing an innovative teaching approach to teach the sustainability concept to students using a wind simulation system. The wind simulation is set-up to imitate how an actual wind turbine work and perform over changes of wind, speed, pitch and elevation. The research project proposed Lucas-Nuelle wind simulator as the teaching method to demonstrate wind turbine operation and design. Three undergraduate Architectural and Construction Management Engineering students completed this research.

10. Involvement of Technology in the Education of Renewable Wind Energy

This undergraduate research project proposed the use of LabVolt [9] Wind Turbine simulation system, to teach wind energy and wind turbine functions to replicate the behavior of an actual wind turbine. The LabVolt software demonstrates how real wind turbine would work and how the changes in wind speed, wind direction, elevation, air density, and temperature effects the wind turbine. Five undergraduate Architectural and Construction Management Engineering Technology students completed this research.

11. Development of a Robotic Manufacturing Cell

The goal of this undergraduate research project was to study, simulate and build all required components of a robotic manufacturing cell. A multi-cell manufacturing cell was built using spare parts of educational robots that was added to a turntable and multi-step “oven simulator” designed and built by the student. A computer software program to control the robot was

developed to synchronize the operation of each manufacturing cell and coordinate the robot's operation based on a predefined manufacturing plan.

Dissemination of the Research Outcomes

The primary method for students to disseminate their results is to present their projects in conferences. Farmingdale State College (FSC) has been hosting the International Energy and Sustainability Conference (IESC) [10] annually since 2012. The conference consists of a half-day student poster presentation competition event and a full-day technical conference on energy and sustainability related topics. Graduate, undergraduate, and high school students are invited to present their research projects at the student poster competition event. The second day of the conference is dedicated to oral presentations. Experts and industry leaders are invited to present emerging technologies and future directions in their fields. Prospective presenters are also invited to submit original technical papers. Students who present at the poster presentation competition event will also be invited to attend the full day conference where they can learn from experts and industry leaders on emerging technologies and future directions in their fields.

One of the main purposes of the IESC conference is to support co-curricular activities, engage students in future research projects, and more importantly, provide a platform for faculty and students to exchange ideas and disseminate their findings and results. The student poster competition event provides a platform for students to improve their communication skills and gain technical presentation experience. In addition, the poster competition event serves as a learning experience, as students will learn from their peers and receive valuable comments from the judges and other faculty. In addition to the IESC conference, faculty mentors also encourage their students to present their projects in other conferences such as Advanced Energy Conference [11], CSTEP Conference [12], SUNY Undergraduate Research Conference [13] and Long Island Systems, Applications and Technology Conference (LISAT) [14].

Conclusions and Future Work

Incorporation of research-based learning at the undergraduate level provides many opportunities for students. As a result of these and many other research activities, students received scholarships from various professional organizations, secured internships at research laboratories and applied for graduate education and graduate schools. As the future direction of the undergraduate research projects, faculty at the school of Engineering Technology at Farmingdale State College will continue to offer research projects and continue to actively involve students in various research activities.

Acknowledgements

The authors of this paper would like to extend their appreciation for the support they received from Farmingdale State College President Dr. John Nader, Farmingdale State College Acting

Provost and VP for Academic Affairs Dr. Laura Joseph, Farmingdale State College School of Engineering Technology Dean Dr. Kamal Shahrabi, faculty and staff at Renewable Energy and Sustainability Center.

Some of the projects included in this paper was supported by Title III - Students First Grant, SUNY STEM Research Passport Program Grant, W.E.B DuBois Faculty Student Research Experience Program Grant, Farmingdale State College Summer Research Program, and STEP/C-STEP Program.

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