Multidisciplinary Projects to Enhance Undergraduate Student's Research Opportunities at a Liberal Arts Institution

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Abstract

In 2009, a collaborative work started at Muskingum University between the recently created Physics and Engineering Department and the Geology Department. The goal of this collaboration was the creation of research and experiential learning opportunities for faculty and students in both departments. Combining solid classroom curricula with a level of field work and independent study, three different projects were developed between the departments with the financial support of the institution.

The first project was focused on measuring electrical resistivity of soils to determine soil anisotropy. This project gave undergraduate students the opportunity to work on the field, taking measurements, and perform research about the properties of soils and rocks and their electrical parameters. The second project was designing and building a laboratory system for the quantitative test of limestone erosion. Undergraduate students from both departments had the opportunity to work on the design and/or testing of the system. The final collaborative project, also involving the Department of Chemistry, is studying the electrical, chemical, and petrological characteristics of shale rock. This project is expected to give more research and experimental opportunities to undergraduate students. This paper describes the details of these projects and how the faculty and the students involve in and benefit from that collaboration.

Introduction

Muskingum University actively seeks-out, promotes, develops, and implements programs and opportunities that will benefit faculty and students at all levels. The goal is to enhance teaching, research and professional abilities of the faculty and keep the university's classrooms current and invigorated, and the students engaged and motivated [1]. Based on that mission, Muskingum University encourages collaborative research across disciplines within the institution.

Projects presented in this work are part of this initiative. All three projects received Faculty Development Grants. These grants support research, creative endeavors, production and writing, plus related travel, along with other professional activities that contribute to the further development of faculty. Faculty-student collaboration on research and creative projects is also supported with the Muskingum University Summer Fellows Program. Each student selected as fellow is provided with University housing free of charge for the period of their fellowships, and receives a stipend during the time-frame within which collaborative research is conducted.

The collaborative work between the recently created Physics and Engineering Department and the Geology Department started in 2009. The Physics and Engineering Department is part of the Science Division and is housed in the Science Building. This physical proximity with other Science Departments increases face-to-face interaction between the faculty making the coordination of work and exchange of one another's ideas and expertise more effective. Projects between the Geology, Chemistry, and Engineering are presented and students' participation and outcomes are discussed.

Research Projects

1. Investigation of soil anisotropy by measuring the resistivity of soil

In this research a simple, practical, and accurate geophysical method to measure the soil anisotropy in the Karst areas of Kentucky and Virginia was proposed. The goal was to use resistivity measurements of the soil in the research area and relate those values with the soil anisotropy. From the academic point of view, the goal was to enhance the development of the new engineering program at Muskingum University and promote interdisciplinary collaboration between the departments of Physics and Engineering and Geology.

Data collection for this research was done during the summer of 2011. Two first-year undergraduate engineering students were nominated for the Muskingum University Summer Fellows Program. Both students received the award to work in this project. They spend the summer learning about resistivity measurements in soil and the different types of soils in the area of the research. Lectures and independent study was used to guide the students during their work. They learned how to use the equipment necessary for the data collection and performed field work. Also, students develop an inversion algorithm to convert the resistance data into resistivity values. As part of the requirements of their fellowships, students prepared a final report detailing all their research experience. Figure 1, shows the students and the professors involved in the project collecting data of soils.

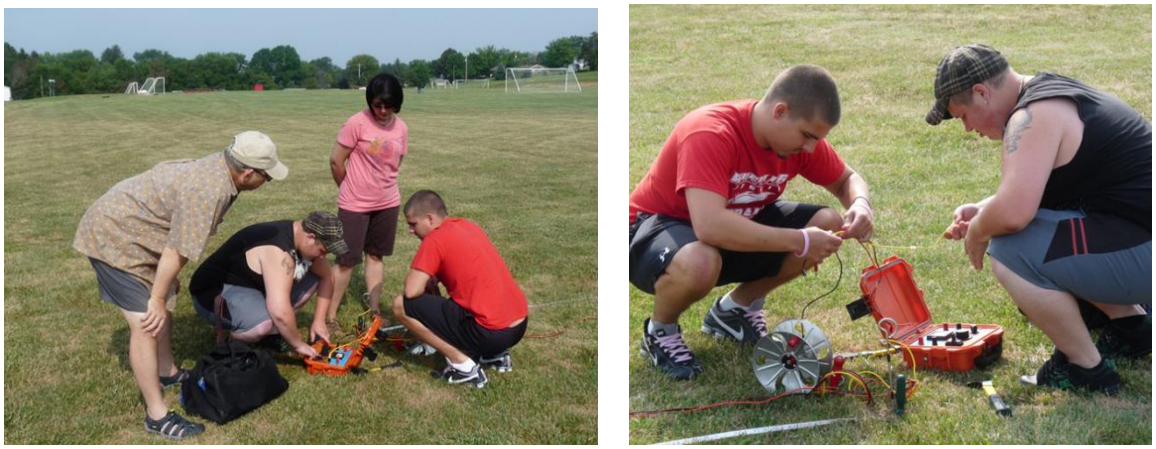

Figure 1. *Lef:*. From left to rigt- Dr. Law, Mr. Brandon Leyda, Dr. Soto-Cabán, and Mr. Brian Sayre. Students were learning how to read the resistivity meter before taking soil measurements. *Right:* Mr. Brian Sayre and Mr. Brandon Leyda preparing the equipment to take measurements.

Students presented their work and research experience during the 2011 Annual Fall Research and Internship Forum celebrated in Muskingum University. Also, they prepared and presented a poster during the 2012 ASEE North Central Section Conference celebrated at Ohio Northern University in Ada, OH [2] (Figure 2).

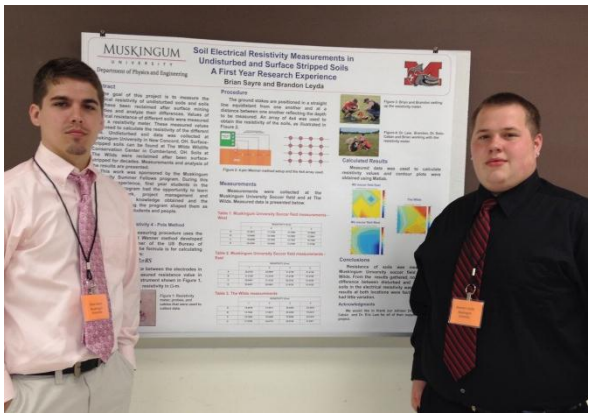

Figure 2. Mr. Brian Sayre and Mr. Brandon Leyda presenting the results of their project at ASEE North Central Section Conference 2012 celebrated at Ohio Northern University.

2. Building a laboratory system for the quantitative test of limestone erosion

The scope of the second project was to build a laboratory system to satisfy the needs of a geological study. The Geology Department is performing a research to investigate the effects of mechanical erosion on limestone, caused by underground water flow. For this purpose, an apparatus to simulate the flow on the limestone samples was needed. Physics and Engineering Department is collaborating with the Geology Department on this project and the study has been continuing since fall 2010 semester, involving several groups of students in design and research.

After performing a preliminary study on the subject, the design objectives and constraints of the system were determined. To do this, engineering students met with geology professors and students, interviewed them, and created a survey. These constraints were used for the design project assigned to senior students in the course PHEN 420 – Fluids Mechanics. A group of three students worked on the theoretical design of the required system during spring 2011 semester. A preliminary design, presented in Figure 3, was generated. Outcomes of student work were used in a proposal submitted to the Muskingum University Faculty Development Grant. The proposal was accepted and the study was granted for 2011-2012 academic year.

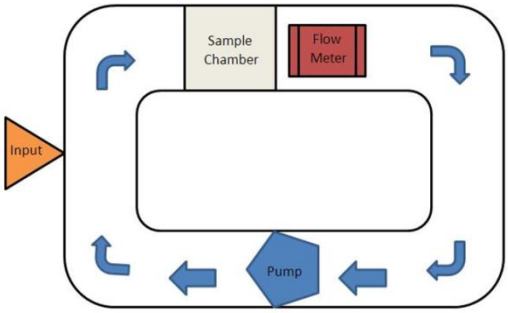

Figure 3. Outline of the preliminary design of the erosion testing system.

A water circulation apparatus, shown in Figure 4, where the flow speed could be controlled and monitored, was built in fall 2011 semester by using the grant's budget. Students' preliminary design results were also taken into consideration during the final design and production of the apparatus. After the completion of the system, undergraduate students majoring in Geology have been testing limestone samples which were collected from different areas of Ohio. The summary of the initial studies was presented by two participated students in the 2012 North Central Annual Meeting of Geological Society of America at Dayton, OH [3].

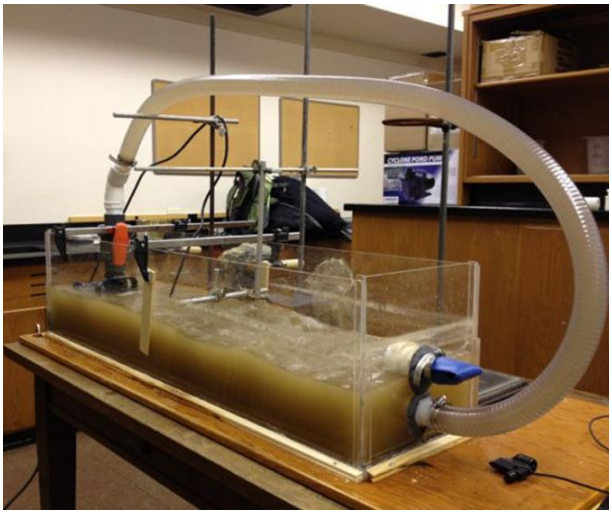

Figure 4. Water circulation system for testing limestone erosion.

Based on the results of this project, another system design was assigned to students in the Fluids Mechanics course in spring 2012. Students again studied on the theoretical design and presented their solution (Figure 5). A second Faculty Development Grant was granted for the 2012-2013 academic year and the construction of the system is still under development. Meanwhile, new data and results were submitted for publication.

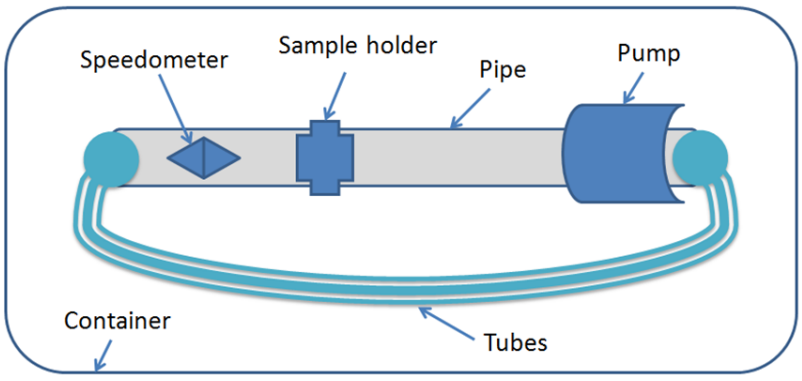

Figure 5. Outline of the new design for the erosion testing system.

3. Study of the electrical, chemical, and petrological characteristics of shale rock
The goal of this research is to establish a quantitative relationship between measured electrical parameters and the chemical and petrological characteristics of shale rock. This research is based on the successful experience of the Faculty Development research project in 2009-2010 and the Summer Fellows Program work in 2011, where the resistivity of different soils was measured and the soil anisotropy was analyzed. The target rock specimen is the energy related gas or organic-rich black shale. Electrical resistance measurements will be used to quantitatively describe the different rock samples. Rock samples for this study have been collected in Central New York, Pennsylvania, and Central Ohio. This research is conducted by the Physics and Engineering Department, in collaboration with the Chemistry Department and the Geology Department.

Scanning Electron Microscope housed in the Physics and Engineering Department will be used to observe the shale and the Gas Chromatography Mass Spectrometry housed in the Chemistry Department will be used to provide the chemical composition of organic substance. Cutting, drilling, polishing pulverization of shale samples will be conducted in the rock lab of Geology Department. Some of these steps will involve students that will be nominated as Summer Fellows. These students will be learning about rock composition and the use of the required lab equipment.

Student Outcomes

Learning objectives for these projects satisfy student outcomes (a) to (k) listed in Criterion 3 of the 2012-2013 ABET "Criteria for Accrediting Engineering Programs" [4]. Undergraduate engineering students of different levels had the opportunity to work on real-world projects where they experienced different phases of a design. They first had to identify the needs and worked on the possible solutions where they need to apply their knowledge of mathematics, science, and engineering. They also worked on the redesign of a system.

The Summer Fellows were first-year "undecided" students. This opportunity helped them with their major declaration decisions, as stated in their final project report and a questionnaire they answered at the end of the summer. They are now in their junior year and are in the top 5% of their class. During this research project, they had the opportunity to do field work and independent study where they demonstrated their ability to conduct experiments, as well as to analyze and interpret data. They improved their computational skills using Matlab to generate the inversion algorithm needed to interpret the data.

Another educational benefit is due to the multidisciplinary nature of the projects. Professors and students from engineering and science departments collaborated during the project, which enabled both sides to learn from each other and look from other's point of view. Multidisciplinary teams were assessed in terms of effective collaboration, team communication skills, ability to work together to convey ideas, readiness to accept feedback, and ability to use team decision making processes in solving their problem. All these areas of team function received very high ratings in the course assessments. The scale used for assessment was from 1 to 3, where 3 = exceeds expectations, 2 = meets expectations, and 1 = below expectations.

All the students involved in these projects were required to communicate their results by writing reports and oral or poster presentations. They also had the opportunity to be a part of a scientific research and more closely follow the steps like proposal writing, grant application, and budget management. Communication skills were assesses in terms of convey understanding and use active listening skills to move a conversation forward, correct grammar, punctuation, and spelling in written assignments and oral presentations, present written assignments and oral presentations clearly, concisely, logically, and professionally, and effective use of visual aids for written assignments and oral presentations. Same scale from 1 to 3 was used for this assessment. All areas of communications skills received high ratings.

Geology students were not assessed in their courses, but they also benefit from these projects having the opportunity to do field work and work in multidisciplinary teams.

Conclusions

Projects had been developed at Muskingum University, a small liberal arts institution, to enhance undergraduate student's research opportunities. A successful collaboration between science and engineering faculty has been established with the full support of the institution. As a result of this collaboration, undergraduate students had the opportunity to work outside the classroom in multidisciplinary teams and experience practical research. They also enhanced their communication skills by presenting their works in professional environments. Eventually, these experiences enable them to improve their ability to compete for entry-level engineering positions in industry or engineering student positions in graduate school.

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