Extended Abstract - Research Experience for Teachers (RET) Program Enhances Student Learning in Community College Engineering Courses

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Abstract **- Research Experience for Teachers is a National Science Foundation-sponsored program that provides opportunities for K-12 teachers and community college faculty members to actively participate in engineering and computer science research, with the goal of helping teachers translate their experiences into classroom activities that encourage and enhance learning for students in science, technology, engineering, and math fields.**

The authors participated in the 2012 Research Experience for Teachers program "Connecting with Community Colleges" at University of Maryland's A. James Clark School of Engineering. The program included a six-week materials engineering research project, development of curriculum elements based on the research project, implementation of the curriculum elements in spring 2013, and surveys of students to assess the effect on learning. The research experience, which involved testing of dental composites, was used to build classroom activities for two courses: Introduction to Engineering Design and Mechanics of Materials. In both classes, students were presented with overall information about the project and the authors' experiences. In Introduction to Engineering Design, the dental composites example was then used to illustrate the engineering design process, with students participating in group and individual activities that applied the design process steps to the example. In Mechanics of Materials, the research example was used to supplement an existing lecture and homework assignment relating to material properties.

Preliminary results suggest positive impact on learning. When surveyed, students said that use of a current, real-world example was interesting and motivating; it made them want to engage in the learning process; and it gave them an appreciation for specific activities involved in engineering research, beyond what they learned from textbook examples. Future work includes expanding the dental composites example to other course topics, improving the learning assessment tools, and expanding use of the activities to other courses and sections.

Index Terms – community college, learning assessment, research experience, student engagement.

INTRODUCTION

The National Science Foundation sponsors Research Experience for Teachers (RET) in Engineering as a program to introduce K-12 teachers and community college faculty members to research experiences. The overall goals of the program are to build long-term relationships and help teachers translate their experiences into classroom activities that encourage and enhance learning for students in science, technology, engineering, and math (STEM) fields.

PROGRAM OVERVIEW

Research Experience for Teachers "Connecting with Community Colleges" is a three-year program that started in June 2011 at the University of Maryland (UMD) in the A. James Clark School of Engineering (Clark School) in the Department of Materials Science and Engineering (MSE) [1]. This program was designed to bring up to twelve community college faculty members to the university campus each summer for a six-week program.

The purpose of this National Science Foundation Research Experiences for Teachers in Engineering program is to increase the interest of community college students in Science, Technology, Engineering and Mathematics (STEM) research and innovation. The goals of the project are to [1]:

1. Engage community college faculty in cutting edge research;
2. Design relevant classroom materials based on the research experience of the community college faculty with the intent to foster student awareness, interest, and preparation for STEM academic studies and careers; and
3. Build relationships between community colleges in Maryland and the A. James Clark School of Engineering to facilitate the successful transition of Associate Degree students into the University of Maryland.

During the six-week summer portion of the program, participants engaged in research projects with Clark School faculty mentors, attended seminars on STEM-education related topics, engaged in round-table discussions with University of Maryland staff and faculty, and took part in curriculum development workshops. Participants developed curriculum elements using Understanding by Design® (UbD)™ [2], a systematic "backwards planning" process to design lesson plans based on learning objectives. These curriculum elements translated the research into classroom activities in many forms. Some faculty members developed activities to augment existing materials; others developed new lessons or assignments. A few developed new courses.

The basis for this article was a dental composites research project conducted in the Department of Materials Science and Engineering in summer 2012. The research project was part of a larger effort to evaluate mechanical properties of various dental composite materials. The authors' involvement included mixing of composite materials, fabrication of test samples, mechanical testing of the samples, and analysis of the data.

IMPLEMENTED CURRICULUM ELEMENTS

Curriculum elements based on the authors' research were implemented in two course sections at Anne Arundel Community College (AACC) in Arnold, Maryland. The first course was Introduction to Engineering Design (EGR120), a 3-credit lecture and lab course required for all students seeking an Associate of Science engineering transfer degree. The second course was Mechanics of Materials (EGR211), a 3-credit lecture elective usually taken by students who plan to major in mechanical or civil engineering after transferring to a four-year college.

Introduction to Engineering Design

The curriculum element for Introduction to Engineering Design used the dental composites project to illustrate the first three steps in the 10-step engineering design process defined by Oaks et al. [3] (Figure 1). It included:

- An introductory discussion about the research project to provide students with background about the subject.
- An ungraded in-class group assignment where students defined steps 1 and 2 in the development of a new dental composite material.
- A graded individual homework assignment and in-class presentation where students performed step 3 by finding and summarizing appropriate references.

Mechanics of Materials

The curriculum element for Mechanics of Materials was used to augment an existing lesson introducing mechanical properties of materials. The approach included:

- A lecture discussing stress-strain diagrams, tensile testing, modulus of elasticity and other mechanical properties.
- Hands-on demonstrations using ductile and brittle food samples.
- YouTube videos of tensile testing.
- An overview of the dental composites research project to provide a real-world example of how properties are used to classify materials.
- A graded homework assignment to create stress-strain diagrams from experimental data to determine key material properties.

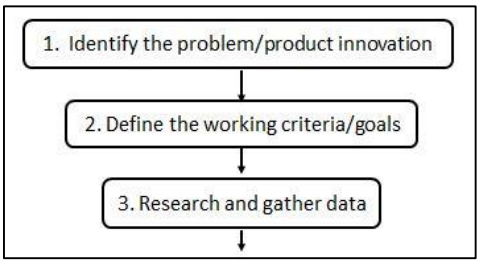

FIGURE 1
ENGINEERING DESIGN PROCESS (OAKS, ET AL.)

ASSESSMENT OF STUDENT ENGAGEMENT

Methods

In order to evaluate success of the program, an attempt was made to determine the extent to which the research-inspired curriculum element enhanced students' learning and engagement. Delivery of the curriculum elements was observed by the RET program Principal Investigator in both classes. Following the delivery, informal discussions were held with the students. The students were willing to share their perceptions. Some common themes expressed included appreciation of a subject area relevant to everyone where no one in the class was an expert and enjoyment of the change of pace. In EGR-120 the students liked the fact that the in-class activity was challenging with multiple possible answers. They also liked that it was ungraded so that they weren't afraid to be creative. In EGR-211 the students valued an example where the data wasn't "perfect" so approaches to handle imperfect results were discussed.

In addition to the class discussions, survey instruments were developed to get feedback from students. In EGR-120, a written survey was administered approximately four weeks after the curriculum element was completed. In EGR-211, students were given the survey after the related homework assignment was submitted, approximately one week after the classroom portion of the curriculum element.

The EGR-120 students were asked to rate their experience on a Likert Scale with two questions:

- How effective was the dental composites case study project in meeting the course objective of understanding the engineering design process?
- How well do you think the case study contributed to your understanding of the design process compared with other course activities and assignments?

Students were also asked which part of the curriculum element was the most engaging and which one helped the most with understanding the engineering design process.

The EGR211 survey asked students to rate the following using a Likert Scale regarding their effectiveness in helping them complete their homework assignment:

- In-class lecture and discussion
- Textbook
- Assigned on-line learning materials

Students were also asked a series of free-response questions to determine the level of student engagement, including:

- Now that well over a week has passed since this lecture took place, what is one thing that you still recall that you learned from class that day? (No peeking back at your notes!)
- In what way do you feel the dental composites example contributed to your knowledge compared to the textbook material?

Results

Figures 2 and 3 show survey results. Response rates were eight out of eight enrolled students in EGR120 and nine out of thirteen enrolled students in EGR-211.

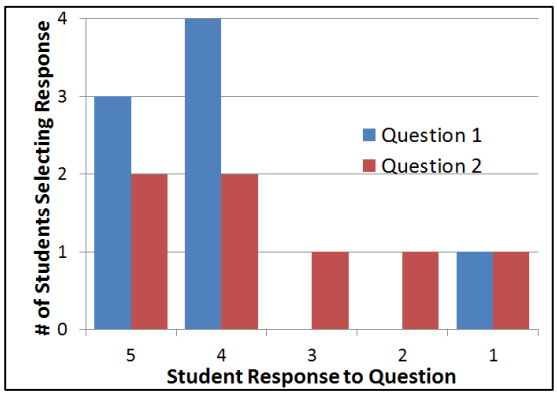

FIGURE 2
EGR-120 RESPONSE: 5 IS "VERY HELPFUL", 1 IS "NOT HELPFUL"

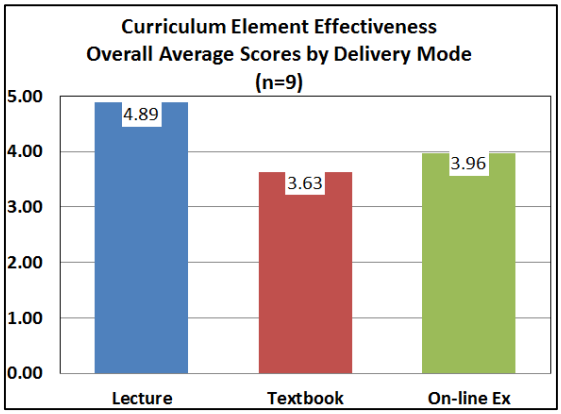

FIGURE 3
EGR-211 STUDENTS' PERCEPTIONS OF EFFECTIVENESS: 5 IS "VERY HELPFUL", 1 IS "NOT AT ALL HELPFUL"

ADDITIONAL RESULTS

In addition to the curriculum elements, contacts made with University of Maryland staff and faculty provided other benefits to students. One outcome of the dialog with staff and faculty was an event in February 2013 in with thirty current AACC engineering students visited the Clark School at UMD. The visit included a transfer information session, panel discussion with former AACC, now UMD, engineering students, a presentation on current research in air traffic management by UMD graduate students, and a manufacturing lab tour. The success of the trip can be attributed to connections made during the RET program.

FUTURE WORK

Both authors plan to refine and continue to include their curriculum elements in their classes. It is expected that a related curriculum element will be developed based on Ms. Wyler's participation in the 2013 summer RET program.

Based on the success of the implementation of these curriculum elements, they are targeted for inclusion in the curriculum materials that will be available to other faculty on the "Connecting with Community Colleges" website.

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