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Introducing Entrepreneurship Thinking into STEM Curriculum through Hands-on Projects

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Abstract

The research discussed in this paper is motivated to explore how to improve STEM interest and retention in engineering majors by introducing hand-on project, which combining STEM learning with entrepreneurship thinking, into the freshman engineering curriculum. The innovative curriculum was implemented and data was collected in Spring 2012, Fall 2012, and Spring 2013 semesters for student takers and non-takers of the Engineering Innovation Hands-on Project courses. In each semester, pre-class and after-class survey were conducted, and totally 343 student surveys were analyzed. In Spring 2013 semester, a comparison study was done with 38 students who took the Entrepreneurship Hands-on Project (51%) and 36 students who did not take the project (49%). Significant interest gains were found for all student takers. The authors also compared different results from two courses and found same curriculum innovation may have different effects and results when applying into different STEM courses.

1. Introduction

Research in engineering education over the past 15 years has shown that US undergraduate engineering student enrollment in decline while the demand for qualified engineering graduates is expected to increase [1]. The U.S. Bureau of Labor Statistics (BLS) predicts a 22% growth in jobs for fields related to Science, Technology, Engineering, and Mathematics (STEM) between 2004 and 2014 [2]. It revealed that fewer than 40 % of students who enter college intending to major in a STEM field complete college with a STEM degree today [3]. The engineering graduation rate is even lower for Texas Higher Education institutions [4]; even worse, the 4-Year graduation rates of Texas A&M University-Kingsville is under 20% in the past 12 years (from year 1999 to 2011). Research by ACT indicates that fewer than one in five 12th graders have both high interest in STEM and high proficiency in mathematics—precursors to success in STEM undergraduate program [2]. It has also been noted that many students made their decision to leave an engineering major within the first two years, the period during which they are taking engineering prerequisites and before taking any (or many)engineering courses [5]. One of the potential reasons for the current crisis is that students in their first two years are given little exposure to the many possibilities that an engineering career can offer, while they are taking math and science courses taught outside of engineering departments. Encouraging our youth to pursue careers in the STEM fields has been viewed as crucial in recent years, to meeting humanity's needs, both nationally and globally [6]. It suggests that few students-even those who have had some prior exposure to engineering-know what engineers do, and this affects their commitment to the engineering major [5]. As a result, programs that expose students to engineering experiences and/or projects early in their college studies might have a greater chance of both enticing students to persist and interesting them in specific sub-fields of engineering.

In the paper, it presents a project that is motivated to explore how to improve STEM learning outcomes and interest of engineering majors by introducing hand-on projects, which combining STEM learning with entrepreneurship, into the freshman engineering curriculums(MEEN 1310-Computer Based Graphics and Design I and MEEN 1320 Fundamental of Numerical Method). This project develops a new STEM-preneur learning environment through engineering innovation hands-on projects. The new STEM-preneur learning modules help students understand STEM concepts,

stimulate students' interest, enhance the ability of teamwork, and improve entrepreneurial thinking through hands-on experiences. This curriculum innovation will also give the students the opportunities to work on the real life hands-on projects at an Innovation Lab that serves as a connection between college and local industries. A specific evaluation plan by using the latest advanced data analysis software is designed to address progress, achievement, and impact of the project objectives and overall goals.

2. Project Design

Students are required to do a semester long group project focuses on integrating Innovative Engineering Project with Entrepreneurial thinking. Students choose a topic related to engineering innovation, and apply the knowledge learned in MEEN 1310 or MEEN 1320 and entrepreneurial thinking in the project. Each group has five to six students. Three presentations and reports are required. The first presentation and report is focused on topic selection. Students have to justify the rational of the selected topic and how they are going to use both the entrepreneurial thinking and engineering knowledge in the project. The second presentation and the report is the progress report, and the last one is the final complete report.

References and the sample project topics are given to the students. Students are encouraged to meet with the professor during the lab hours to discuss the progress and questions of their projects. Engineering thinking includes (not limited to) existing product modification/redesign and new product design. The team needs to

1) Justify their selection by finding the current design disadvantages or current market/customer requirements,
2) Modify the current design and present the new design using engineering drawings,
3) Justify their new design using entrepreneurial thinking.

Entrepreneurial thinking includes (not limited to) brain storming, teamwork, economic analysis, payback period analysis, market analysis, and decision making. Results (or part of the results) should be able to be presented using engineering drawings, including freehand lettering/sketching, orthographic projection, and etc. Peer reviewing will be used to evaluate their projects. Each presentation will be evaluated by both instructor and peer groups. By the end of the semester, each student will submit a self-evaluation and she/he will also be evaluated her/his teammates.

At Spring 2012 semester, we chose both the two courses MEEN 1310 and MEEN 1320 to see the impacts of EIHP for students, but the result showed that MEEN 1310 had much better effects than MEEN 1320 caused by the natural differences of two courses. As a result, we applied the only MEEN 1310 course for Fall 2012 and Spring 2013 semester students to further verify the interest gains result from Spring 2012. Moreover, to define the impacts between project takers and non-takers, at Spring 2013, we divided students in course MEEN 1310 into two groups: case group (project non-takers) and control group (project non-takers). Table 1 shows the basic information of two courses.

Table 1. Summary of MEEN 1310 and MEEN 1320

Courses		
Code	MEEN 1310	MEEN 1320
Name	Computer Based Graphics and Design I	Elementary Numerical Methods and Engineering Problem Solving
Credit	3(2-3)	3(2-3)
Content	Introduction to computer-aided engineering design and analysis; principles of graphics, solid modeling,	Engineering problem-solving using high level programming language and numerical computing software. Programming logic; linear algebra and

	integrated applications of software in engineering drafting, design and problem solving.	matrices; solutions to systems of linear equations; interpolation and curve fitting; numerical integration and differentiation.

3. Evaluation Results

The data were collected across three semesters, from Spring 2012 semester through the Spring 2013 semester. The data set totals 343 engineering students, 144, 125, and 74 for Spring 2012, Fall 2012, and Spring 2013 respectively. Spring 2013 semester has 38 students (51%) who took the Engineering Innovation Hands-on Project and 36 students (49%) who did not take the project. The whole sample includes 58 women and 270 men. There are 7 Asian, 33 Black, 195 Hispanic, 86 White, and 2 Native American students. An additional 20 students were classified as “unknown ethnicity” and thus are not included in the ethnicity analysis. The study sample includes only students who took the EIHP courses.

Student reaction was measured at Spring 2012, Fall 2012, and Spring 2013 semester for all students in the sample. Horizontal & longitudinal comparative analysis, correlation analysis (ANOVA), and logistic regression analysis were used for the result analysis.

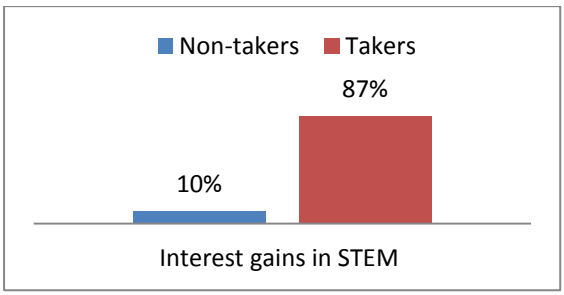

Figure 1. Interest gains between project Takers and non-takers

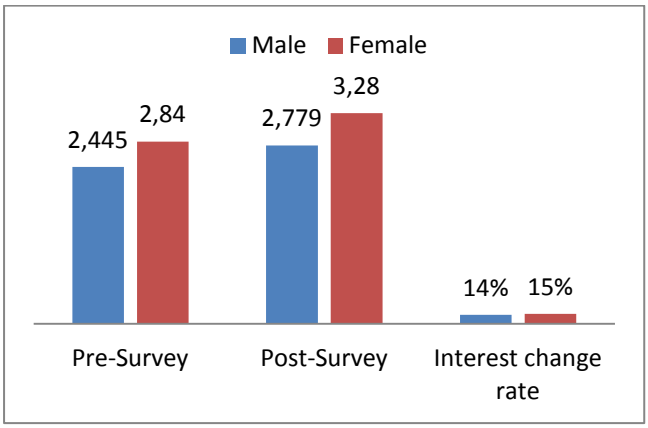

Figure 2. Interest change between Male and Female

Results for the differences between EIHP takers and non-takers of the EIHP course are presented in Figures 1. EIHP course takers were retained at a significantly higher interest gains (87%) than the non-takers (10%). Across all students at Spring 2012, Fall 2012, and Spring 2013, this pattern holds for both men and women (Figure 2). Through Horizontal & longitudinal comparative analysis and ANOVA, we further explored the interest rate data for any different impacts of the EIHP course on women. The data in Figure 2 clearly shows that women had higher interest than men on STEM

both before and after taking EIHP course, but we found the interest gains of EIHP between women (15%) and men (14%) is almost the same.

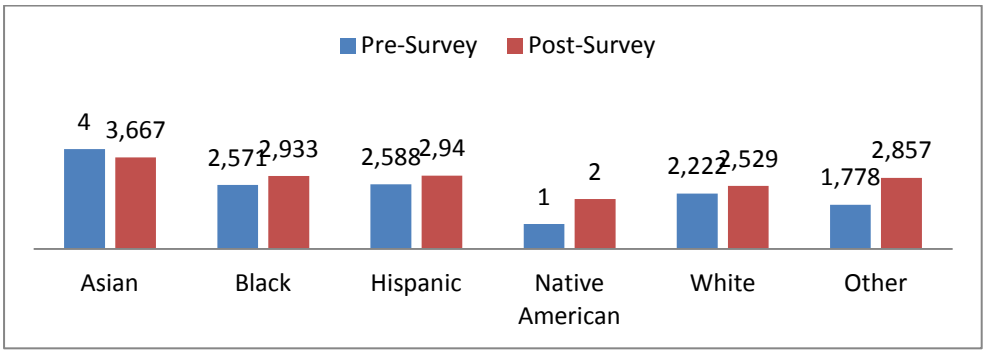

Figure 3. Interest change by ethnicity

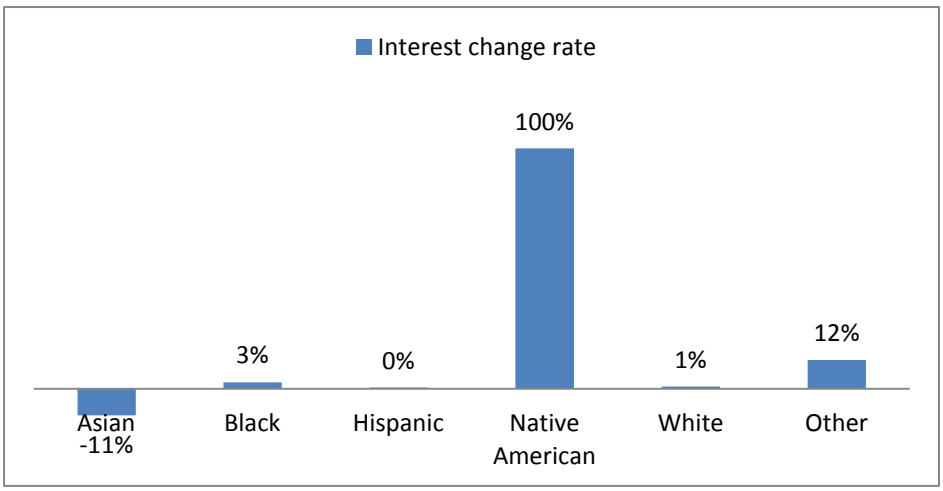

Figure 4 Interest change rate by ethnicity

We further explored the change of interest data by student ethnicity (Figure 3), motivated to do so by a range of interest changes (Figure 4), from an apparent 100% interest improvement for Native American students to 11% interest deterioration for Asian students. However, from Figure 3, we found that Native American students had the lowest interest in STEM from Pre-post survey data, but Asian students always kept the highest interest.

4. Conclusion

Across all our students, significant interest gains in STEM by takers of the EIHP classes. This three semester study contains three main parts as three case study, for each part was placed in the three different semesters. Case study 1, at Spring 2012, we compared two fittest classes among undergraduate courses in Mechanical Engineering at Texas A&M University-Kingsville, and chose a better one for further step study. Then, case study 2 at Fall 2012 semester, we evaluated the class, and got better feedback which further verified the feasibility and scalability of EIHP. To find out effects differences from EIHP takers and non-takers, for case study 3, we set two different group (case group and control group) and observed the results at Spring 2013 semester; the result was improved and enhanced for the integrity and scientific of the research.

References

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