AC 2010-2109: THE IMPACT OF ACTIVE LEARNING AND SOCIAL RELEVANCE ON PRODUCT DESIGN AND MANUFACTURING COURSES

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The Impact of Active Learning and Social Relevance on Product Design and Manufacturing Courses

Abstract

This paper presents the research work of a NSF CCLI project for analyzing the impact of medical device-related active learning pedagogies in two courses within the engineering curriculum: New Product Development and Manufacturing Processes. The main focus of the study is on the impact of these approaches on students' engagement and conceptual understanding of course material. A project-based learning (PBL) approach was incorporated into both courses through real medical device projects to provide students with hands-on experiences on the challenges of medical device design and development. The courses were enhanced to provide a combination of lectures on theoretical concepts and hands-on sessions focused on the medical device project to help students through the learning process and the realization of their projects. Project assessment included the expert opinion of local industry practitioners who interacted directly with the students. Analysis of the results of this approach is presented. This paper focuses on preliminary results relevant to the New Product Development course.

1. Introduction

The medical device and equipment industry is one of the fastest growing industries in the world. The U.S. is the largest medical device market and is the global leader of the medical device and technology industry. Medical devices are important for the diagnosis, monitoring, and treatment of disease, and for the compensation for an injury or handicap. The increasing life expectancy and the search for better health care and preventive therapies have influenced the demand growth for medical devices. To remain competitive in the global market, medical device manufacturers need highly qualified engineers to develop innovative and functional products.

Undergraduate engineering students are often taught theoretical concepts without having the opportunity to actually apply these concepts in a real-world context. The National Academy of Engineering (NAE) made the following two recommendations that are relevant to academic institutions: (1) academic institutions should take the steps to cultivate U.S. student interest, and aptitude for careers in engineering, and (2) academic institutions should develop and implement innovative curricula that address the engineering needs of the nation, but do not compromise the teaching of fundamental engineering principles [1].

Active learning approaches are essential for students to think about what they are learning and to increase their engagement, retention of material, and conceptual understanding. Active learning can be defined as any instructional method introduced into the classroom that engages students in the learning process [2]. Research in the adoption of active learning techniques in engineering courses has demonstrated benefits to student learning outcomes [2-5]. Along with active learning, problem-based learning (PBL) is an instructional method where relevant problems are presented at the beginning of the course to provide the context and motivation for learning [2]. Through a

PBL approach, students learn to address realistic and complex problems instead of academic and simplified tasks while developing independent learning and collaborative working skills. Moreover, challenging "real-world" projects can greatly motivate students and reinforce knowledge transfer and integration of fundamental principles [1, 7, 8].

This paper describes the ongoing work of a NSF CCLI project that addresses the NAE recommendations and the needs of the medical device industry by employing active learning techniques in two undergraduate engineering courses at the University of South Florida (USF). These two courses, New Product Development and Manufacturing Processes, complement each other as the former course introduces students to the new product development process from identifying customer needs to new product economics while the latter course introduces students to the fundamentals of product design and manufacturing processes. Both courses have been redesigned to include hands-on projects focused on real medical device design and manufacturing problems. Figure 1 shows the relationship between the two courses and the integration of active learning activities in the courses in collaboration with medical doctors and medical device industry participants.

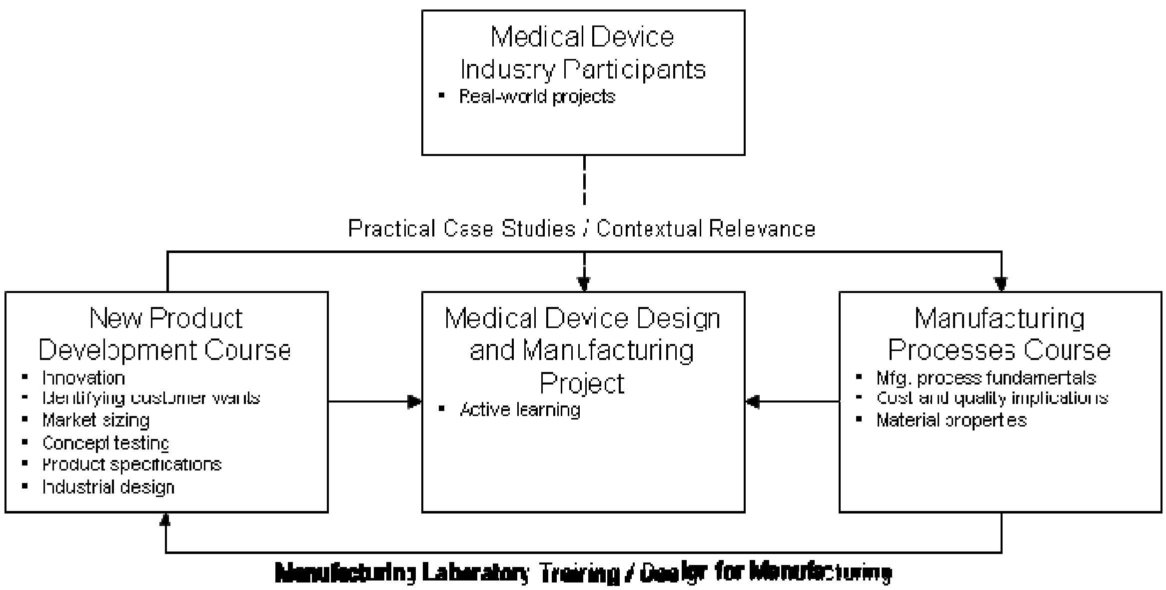

Figure 1. Overview of the project.

This paper presents our preliminary results from the New Product Development course, which was taught on two different semesters to two different student groups. The first group was the control group who experienced the original version of the course while the second group was the treatment group who experienced the redesigned version of the course. A project-based learning approach was used in the redesigned course through the incorporation of a real engineering medical device project. The project consisted on designing and prototyping a medicine bottle opener to assist geriatric citizens. The course was redesigned to provide weekly team activities focused on the medical device project to help students through the learning process and the realization of their projects. Data has been collected from the control and treatment groups and has been analyzed to assess the impact of the proposed active learning pedagogies in the course.

2. Methodology

The focus of this study is on the impact that medical-related active learning approaches have on students' engagement, retention of material, and conceptual understanding of course material. The study tracks control and treatment groups as they participate in the course. The control group is a cohort of students experiencing the original version of the course. The treatment group is a cohort of students experiencing the redesigned version of the course that integrates active learning strategies based on real medical device projects. This paper describes the redesign of one of the participant courses: New Product Development. The description and preliminary results from the Manufacturing Processes course have been presented in our previous work [9].

2.1 New Product Development course

The New Product Development course at USF consists of undergraduate and graduate students, as well as on-campus and distance learning students. Moreover, the course is comprised of both engineering and business students. The objective of this course is to develop an understanding of how to profitably create, manage and grow a new product with resource constraints. The course is designed to prepare business, engineering and entrepreneurship students to contribute to the development of strategies and tasks relevant to new product development. The skills developed enable students to analyze and develop product strategies regardless of their specific functional role. There are no prerequisites for the course.

Before the redesign, the course was taught through a series of lectures, case studies, guest speakers, and a final group project. The final group project required teams to identify a product that had been introduced to the market within the last year. The students then had to analyze the product in terms of concepts introduced throughout the semester. Students were not required to develop a new product themselves, only analyze a product already developed by another firm.

2.2 Incorporating a project-based learning (PBL) approach

The New Product Development course was altered to incorporate a project-based learning approach. Specifically, a team project was introduced in the beginning of the semester that required teams of students to develop a new product based on an open-ended concept. The team project involved the analysis, design and production of a functioning product prototype. Student teams were required to design and produce innovative product prototypes to meet identified customer needs with consideration of cost and functional constraints established for the new product. In addition to providing an opportunity to reflect on the major topics discussed in the course, this assignment also permitted students to work in a team environment to produce a deliverable in the form of a functioning product prototype. Local entrepreneurs and practitioners in the medical device industry provided assessment of the final projects.

The product selected for this term was a medicine bottle opener to assist geriatric citizens. This device was selected due to its medical device affiliation, the clear societal impact of the device, and the perception that students could quickly grasp the functional concept of such a device. The guidelines for the project were broad and the functional problem the product addressed was open-ended. Thus, teams could develop a device that focused on a specific bottle type or they could attempt to develop a single device that could effectively open several types of medicine bottles. To gain information regarding possible concepts, students were encouraged to find competing products on the market and to interview potential users of such devices. This gave students a better understanding of the market segment and the potential impact of such a device on the lives of individuals in society.

Course lectures were designed to cover specific course topics relevant to product development (e.g. market opportunity recognition, market sizing, product specifications, industrial design, prototyping, etc.). This more didactic portion of the course was complimented with business cases that provided an opportunity for substantive discussion of real life issues that arise during the product development process and the ambiguity that oftentimes surround them.

Teams of five to seven students were formed to work on the medical device project for a period of 10 weeks. Given that half of the students were business school students, each team was given a tutorial assignment that introduced them to SolidWorks®. For final project prototypes, once the team designs were approved for fabrication, teams were scheduled at the lab and the designs were fabricated using two rapid prototyping machines: a Dimension® Fusion Deposition Modeling (FDM) machine and a ZCorp® 3D printer. Some teams opted to fabricate their prototypes using other manufacturing equipment.

3. Preliminary Results

Assessment materials have been developed and the collected data analyzed in collaboration with the Center for Research, Evaluation, Assessment and Measurement at USF. These materials collect students' perception and experiences as well as learning outcomes. Students enrolled in both the control and treatment groups of the course participated in the course evaluation and responded to anonymous questionnaires via online surveys. Each question used a four-point Likert scale with 4 being "a lot" and 1 being "not at all".

In one set of questions, participants were asked to what extend certain class activities facilitated their understanding of new product development. The majority of respondents in the control group indicated that all four activities (i.e. weekly individual case reports, weekly team product presentations, weekly team case presentations, and the final group project) facilitated their understanding "a lot." This was not the case for the treatment group where a majority of the respondents indicated that only the final group project facilitated their understanding of new product development "a lot." One possible explanation for this result is that students in the treatment group perceived the final project that involved physically developing a prototype of the new product a greater learning experience relative to the other course assignments, whereas the control group perceived their less hands-on group assignment to be on par with the other course assignments. Some corroborating evidence is found in the written feedback from the students.

For example, when asked what suggestions or improvements would you suggest for future administrations of this course, one student in the control group responded "modify the group project so the students are inventing a product." Similarly, another respondent from the control group provided the additional comment that "more hands-on activities for utilizing technology in new product development [would improve the course.]" Refer to Figure 2 for a visual comparison of the control and treatment groups.

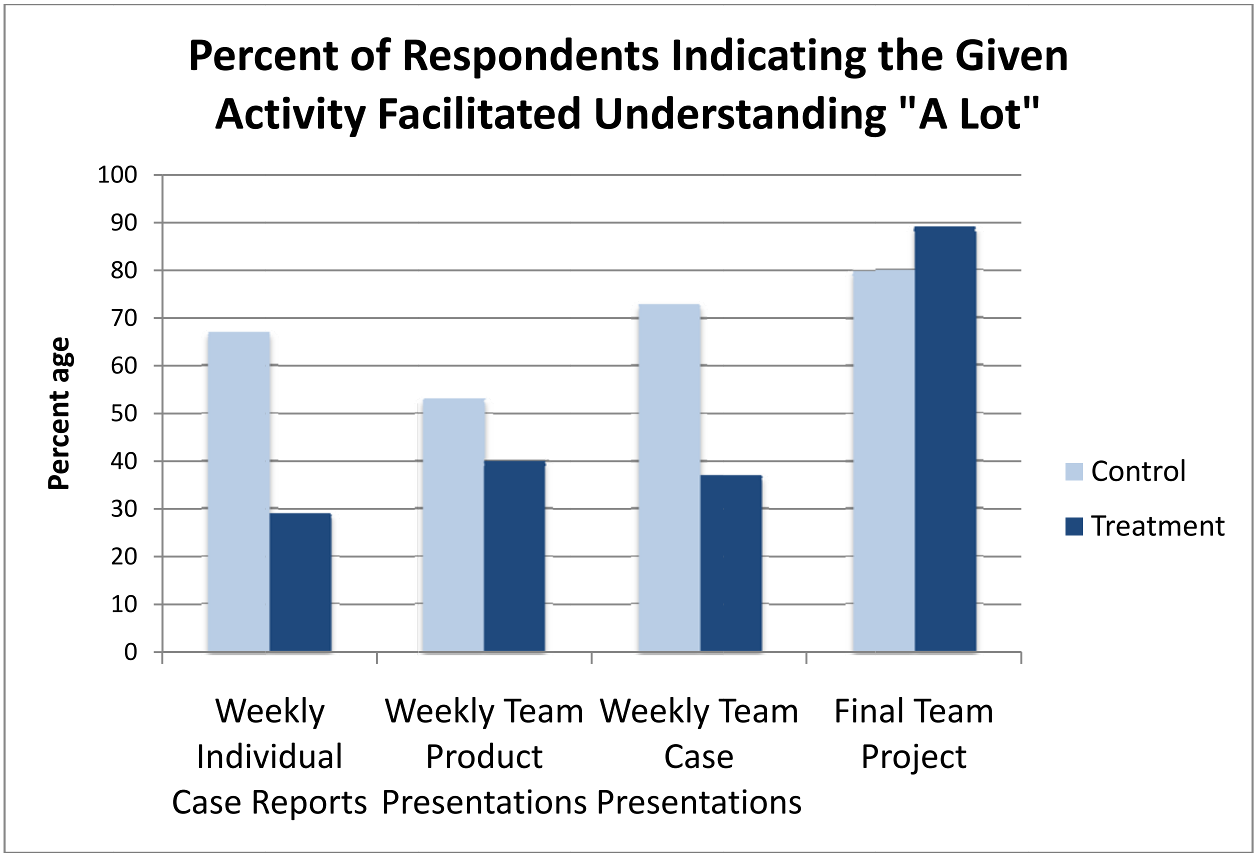

Figure 2. Results from student evaluations after the medical device project was completed.

4. Summary

This paper presented the ongoing work of a NSF CCLI project for analyzing the impact of medical device-related active learning pedagogies in New Product Development and Manufacturing Processes courses within the engineering curriculum with an emphasis on the former course. A project-based learning (PBL) approach was incorporated into the New Product Development course through a real-world medical device project and local entrepreneurs serving as judges in the assessment of final projects. The course was redesigned to provide a combination of lectures, case studies, guest speakers, and a hands-on final team project that required the design and development of a functional product prototype. Preliminary results show that a majority of students in the treatment group found the medical device project to facilitate their understanding of product development "a lot." This was not the case for other course activities. This suggests the significance of this PBL activity in the learning process. The final project did not stand out from other activities in this manner for the control group. The primary difference between the two groups was the nature of the final team project. The final project for the control group did not involve physically building a new product, but merely focused on the evaluation of an existing new product.

Additional data from the control and treatment groups have been collected and are currently being analyzed to determine the impact of these active learning approaches on students' learning. It is expected that active learning approaches related to medical devices will increase students' engagement and conceptual understanding of design and manufacturing principles while increasing their awareness on the impact these activities have on the medical device industry and society as a whole.

Acknowledgments

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