Work in progress — Implementing and evaluating efforts to engage interdisciplinary teams to solve real-world design c....

Conference Paper *in* Proceedings - Frontiers in Education Conference · October 2011

DOI: 10.1109/FIE.2011.6142850

4 authors, including:

Maria Oden
Rice University

Marcia Kilchenman O'Malley
Rice University

Gary Woods
Rice University

Work in Progress – Implementing and Evaluating Efforts to Engage Interdisciplinary Teams to Solve Real-World Design Challenges

Z. Maria Oden, Marcia K. O'Malley, Gary L. Woods, Tracy M. Volz
Rice University, moden@rice.edu, omalleym@rice.edu, gary.woods@rice.edu, tmvolz@rice.edu

Abstract - **Young engineers entering an industry job are likely to be immediately placed into a division or team that is comprised of people from a wide variety of educational backgrounds. This will include other engineering disciplines and, depending on the industry, individuals with business, marketing, public relations, policy or science backgrounds. This work in progress describes our initial efforts to implement and evaluate outcomes from collaboratively teaching capstone design and assigning interdisciplinary teams to solve real-world design challenges as part of the course. Initial data demonstrate that these teams are more successful than their single discipline counterparts in achieving outstanding success in their projects as indicated by a larger proportion of interdisciplinary teams earning design awards, both local and national.**

Index Terms – Interdisciplinary design, Collaborative design education, Capstone design, Engineering design

BACKGROUND

Engineers can be better prepared for the challenge of working on interdisciplinary teams in industry if they are exposed to significant interdisciplinary experiences while they receive their education. Criterion 3 Student Outcomes (d) in the ABET Engineering Accreditation Commission requirements for engineering programs requires that engineering graduates must have a demonstrated ability to work on multidisciplinary teams [1]. It is a commonly accepted leadership principle that interdisciplinary teams will be more effective at achieving a desired outcome [2]. Several researchers have reported improved student outcomes as a result of interdisciplinary teams of faculty collaborating to teach design courses [3], [4]. Additionally, there are reports from several groups that describe outcomes from interdisciplinary design teams [5], [6]. We believe that students working on interdisciplinary design teams will enjoy greater success than teams of students from single disciplines. When they leave school, we expect these students will also have an advantage over their peers who have not worked in an interdisciplinary team. This work in progress aims to ascertain if these assertions are correct.

Prior to 2008, the bioengineering, electrical and computer engineering and mechanical engineering departments had occasionally offered collaborative, interdisciplinary projects to their students. These efforts were sporadic and would only account for 2-4 teams (~10-15%) annually. These were challenging efforts because the various design classes had differing expectations and timelines that had to be modified to meet the needs of each department.

In 2008, the Rice University Brown School of Engineering opened a facility, the Oshman Engineering Design Kitchen (OEDK), dedicated to undergraduate engineering design efforts. The primary goals for the facility were to: (1) provide a space where undergraduate students from each of the 8 departments within the school could work on their engineering design problems, (2) provide a venue for departments enhance opportunities for students to work on real-world, interdisciplinary design challenges, and (3) develop additional opportunities for younger undergraduates to participate in engineering design activities. Since one of the goals of the OEDK was to offer interdisciplinary design challenges to the students, the faculty teaching the courses in these departments decided to collaborate on course content, timelines and expectations.

In this paper we report the initial outcomes of our collaboration and discuss our ongoing effort to measure the effects of this collaboration student team success.

METHODS

The collaborative capstone course for bioengineering, electrical engineering and mechanical engineering students has been taught for two academic years. Each department maintains its own official course, requirements and instructor. However, the courses meet simultaneously approximately 75% of the time and share a course schedule, deadlines and deliverables. Table I shows the topics covered collaboratively. For each topic we choose the instructor best suited to deliver the material. In addition, we invite experts from across campus to teach specific material such as the business planning and teamwork modules. The best features of the individual courses were combined to result in a better course. Additional material is covered, as needed, by the instructor with his or her own students.

In addition, we have made a significant effort to offer and encourage the teams to work on real-world challenges. We define a real-world challenge as a project having an external stakeholder interested in obtaining a viable solution to the problem for actual implementation.

This may be an industrial sponsor, physician, community organization, faculty or other professional. These challenges often require more expertise than an individual discipline may provide.

TABLE I
TOPIC COVERED IN COLLABORATIVE CAPSTONE CLASS

Design process	Business planning
Communication and documentation	Elevator pitch competition
Intellectual property	Industry demonstrations
Leadership and teamwork	Life Cycle Analysis
Brainstorming	Engineering economics
Project management	Design of experiments
Project planning	Human factors in product design
Safety and environmental issues	

RESULTS

A wide variety of positive outcomes are beginning to emerge from our efforts to teach the collaborative engineering design course and to include interdisciplinary design teams in our course. The program has gone from having 15-20% interdisciplinary teams per year to having 30% this year (Figure 1). These teams have been able to successfully tackle design challenges that would be quite difficult to accomplish with students of only one major. As a consequence, these problems are often more realistic representations of the design work that the students will face in industry.

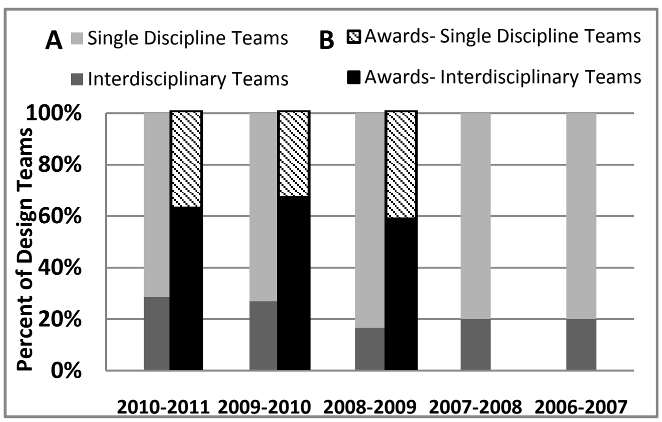

FIGURE 1
A. PROPORTION OF SINGLE DISCIPLINE AND INTERDISCIPLINARY CAPSTONE DESIGN TEAMS IN BIOENGINEERING, ELECTRICAL ENGINEERING AND MECHANICAL ENGINEERING BY YEAR. B. PROPORTION OF AWARD WINNING TEAMS THAT WERE SINGLE DISCIPLINE AND INTERDISCIPLINARY TEAMS. (NOTE THESE RESULTS ARE ONLY AVAILABLE FOR 2008-PRESENT)

Students are sometimes hesitant to participate on interdisciplinary teams because of the added complication of working with and relying on the expertise of peers that they do not know well. By ensuring that the requirements and deadlines match between the classes, the students are not penalized for working on a collaborative team as they may have been in prior years.

The increased proportion of awards earned by interdisciplinary teams implies that these teams have been more successful at accomplishing their tasks than their single-discipline counterparts. In the 2009-2010 and 2010-2011* academic years, the interdisciplinary teams (~30% of the total teams) accounted for over 60% of the awards given to teams (Figure 2). (*2010-2011 winners have not all been determined) Some of these awards are local, Rice -based design awards. Such awards are judged by professional engineers for quality of design solution based on design goals, in competitions that were open to all teams across the School of Engineering. Other national awards such as the ASME iShow award were also counted in the total.

DISCUSSION AND CONCLUSIONS

While the results we present appear to support the idea that interdisciplinary teams demonstrate greater success in their design projects, there are a number of serious questions that still need to be addressed. These include: (1) Are stronger students more likely to participate on interdisciplinary teams thus accounting for the differences in awards?, and (2) Are measures other than awards earned, such as quality of design solution, more appropriate measures of team performance? As part of this work in progress, we are quantifying these potentially confounding factors and measuring team outcomes more precisely and completely for teams over a three year period. We plan to continue to track these students after graduation through questionnaires to better understand the longer term benefits, if any, they enjoyed from working on interdisciplinary teams.

REFERENCES

[1] Engineering Accreditation Commission, Criteria for Accrediting Engineering Programs: Effective for Evaluations During the 2011-2012 Accreditation Cycle. ABET, Inc, 2010.

[2] K. A. Jehn, G. B. Northcraft, and M. Neale, “Why Differences Make a Difference: a Field Study of Diversity, Conflict and Performance in Workgroups,” Administrative Science Quarterly, vol. 44, no. 4, p. 741–763, 1999.

[3] P. L. Hirsch et al., “Engineering design and communication: the case for interdisciplinary collaboration,” International Journal of Engineering Education, vol. 17, no. 4/5, p. 343–348, 2001.

[4] R. C. Knox, D. A. Sabatini, R. L. Sack, R. D. Haskins, L. W. Roach, and S. W. Fairbairn, “A practitioner-educator partnership for teaching engineering design,” JOURNAL OF ENGINEERING EDUCATION-WASHINGTON-, vol. 84, p. 5–12, 1995.

[5] J. Jacoby, A. T. Moser, T. Bonifield, S. Botts, and P. D. Daniels, “An undergraduate interdisciplinary environmental assessment project in partnership with the U.S. Public Health Service,” in Frontiers in Education Conference, 1996. FIE \uc0\u8217{}96. 26th Annual Conference., Proceedings of, 1996, vol. 3, pp. 1453-1456 vol.3.

[6] D. R. Sommers and G. Engbretson, “Teaching ‘Real-World’ Design in the Classroom,” in Meeting the Growing Demand for Engineers and Their Educators 2010-2020 International Summit, 2007 IEEE, 2007, vol. 50, pp. 1-8.

AUTHOR INFORMATION

Z. Maria Oden, Professor in the Practice - Engineering Education and Bioengineering; Director, Oshman Engineering Design Kitchen, Rice University, moden@rice.edu
Marcia K. O’Malley, Associate Professor, Mechanical Engineering and Materials Science; Associate Professor, Computer Science, Rice University, omalleym@rice.edu
Gary L. Woods, Professor in the Practice, Electrical and Computational Engineering, gary.woods.rice.edu
Tracy M. Volz, Senior Lecturer, Professional Communications, Brown School of Engineering, Rice University, tmvolz@rice.edu