Impacts of a Multidisciplinary Engineering Capstone Design Program from Early-Career Alumni Perspectives

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The Engineering Education Innovation Center at The Ohio State University offers students, through its Multidisciplinary Engineering Capstone Design Program, a broad range of opportunities for both engineering and non-engineering students to work directly with industry personnel on company-sponsored product and process design projects. The Center provides students an opportunity to apply their academics and professional and practical skills to real-world problems as a member of a multidisciplinary team. The program covers all aspects of the engineering design process and helps develop several critical professional skills. The program is continually developing to enrich the experience and better prepare the students for their careers. Most recent efforts included distributing a survey to program alumni that focused on the impacts of the program's learning objectives to prepare students for their professional careers and its impacts with Accreditation Board for Engineering and Technologies Criteria. This paper addresses the survey results on post-graduates ratings of learning objectives based on the importance to their professional career and preparedness through their academic experiences. Comparisons are made to similar survey ratings from a larger population from the College of Engineering alumni, providing insight into the impacts of the multidisciplinary program's structure relative to the College as a whole.

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Introduction

The Ohio State University (OSU) College of Engineering offers 14 undergraduate engineering programs through 10 engineering departments. Each program offers a capstone design experience, with project topics generated from faculty, research or industry.

Additionally, the Engineering Education Innovation Center (EEIC) Multidisciplinary Engineering Capstone Design Program at OSU offers a multidisciplinary capstone experience as an alternative to the discipline specific programs. The multidisciplinary program provides an opportunity for students from multiple disciplines to work together and with industry on sponsored projects. The program covers all aspects of the engineering design process and helps develop several critical professional skills including technical oral and written communication, professional working relationships, project and time management, ethics, and a broad understanding of relationship of business, engineering, and design elements.

The program is continually developing to enrich the experience and better prepare the students for their careers by looking at successes of other institutions and trends in engineering education[1,2], and through conducting internal studies. Most recent internal investigations for the program included distributing a survey to early-career post-graduates from the program. The survey focused on the impacts of the program's learning objectives to prepare students for their professional careers, and included first through fifth year graduates. The program survey questions were comparable to a larger alumni-based survey from the College of Engineering's Outcomes Assessment Committee in 2012 distributed to second and third year graduates. The Committee has been surveying alumni regarding Accreditation Board for Engineering and Technologies (ABET) Objectives and Outcomes since 1999, with their most recent survey including questions relevant to the specific program learning objectives.

The following paper discusses the structure of the Multidisciplinary Engineering Capstone Design Program and compares program specific survey results compared to key outcomes identified by the College's Outcomes Assessment Committee survey.

Program Structure

EEIC's Multidisciplinary Engineering Capstone Design Program offered at OSU began in 2009. The program is a two semester sequence that includes a pre-capstone seven week course followed by a semester and a half project. The projects are real-world applications to industry. The companies sponsor the projects both financially and with company personnel. The program

offers students projects from process and equipment improvements to new product development, and has included over 20 (both engineering and non-engineering) disciplines with approximately 450 students completing the program through the spring of 2013. All 14 undergraduate engineering programs have participated in the program. Non-engineering students, such as business, psychology, international studies, industrial design, and food science, are involved through an engineering sciences minor. The program has also involved Masters of Business Administration students in the role of project manager for the project team. Since 2009, the program has partnered with over 50 companies to complete over 70 projects.

Since the program is an option for the students, the capstone coordinators can be selective with participants in the program. The students go through a screening process and are required to submit a current resume, respond to questions, and schedule a face-to-face interview with one of the capstone coordinators.

The pre-capstone course (first seven weeks) focuses on teaching a design process in a lecture setting with teams of three or four students applying the process to a mini-design project. All of the assignments are directly related to the design process involving both written documents and oral presentations.

For a semester and a half, students are partnered with an industry sponsor to work on a real-world project. Teams of three to six students are formed based on their preference, discipline and project needs. The company assigns an employee (typically an engineer directly associated with the project) to the team to function as a liaison and technical expert. In addition, the program recruits a faculty or staff member to be a mentor to the student team. The students deliver multiple design reports and formal presentations to the program, advisors, and the industry sponsors throughout the process as part of their assessment. These assignments are graded both by the advisor and one of the project coordinators. Common rubrics are used to ensure consistency between graders.

The learning outcomes for the program are key element in preparing students for the professional careers after graduation. Table 1 lists these outcomes by name and corresponding definition.

Table 1: Multidisciplinary Engineering Capstone Design Program's Learning Outcomes[3]

1. Perform Professionally:	Students individually exhibit integrity, accept responsibility, take initiative, and provide leadership necessary to ensure project success as part of a multi-discipline team.
2. Produce Quality Designs:	Students collectively produce designs that meet important authentic performance requirements while satisfying relevant societal and professional constraints.
3. Establish Team Relationships for Quality Performance:	Students establish relationships and implement practices with team members, advisors, and clients that support high performance and continuous improvement.
4. Manage Project Schedule and Resources:	Students plan, monitor, and manage project schedule, resources, and work assignments to ensure timely and within-budget completion.
5. Apply Knowledge, Research and Creativity:	Students utilize prior knowledge, independent research, published information, patents, and original ideas in addressing problems and generating solutions.
6. Make Decisions Using Broad-Based Criteria:	Students make design decisions based on design requirements, life-cycle considerations, resource availability, sustainability, and associated risks.
7. Use Contemporary Tools:	Students demonstrate effective use of contemporary tools for engineering and business analysis, fabrication, testing, and design communication.
8. Test and Defend Design Performance:	Students collectively test and defend performance of a multi-discipline design with respect to at least one primary design requirement.
9. Communicate for Project Success:	Students use formal and informal communications with team members, advisors, and clients to document and facilitate progress and to enhance impact of designs.
10. Pursue Needed Professional Development:	Students individually assess and pursue personal professional growth in concert with project requirements and personal career goals.

Survey Methods

The OSU College of Engineering (COE) Outcomes Assessment Committee has been surveying alumni regarding ABET Objectives and Outcomes since 1999. In 2012, the survey was sent out to second (2010) and third (2009) year alumni of the college. The survey included both college common and program specific outcomes. Of the 1,376 surveys sent out, the College received a response rate of 22.9% (n=315).

Similarly, in 2012 the Multidisciplinary Engineering Capstone Design Program (MDC) sent out a similar survey to the program's alumni. The MDC alumni survey was distributed to approximately 370 students

who have completed the multidisciplinary capstone experience. The program survey followed a similar process and structure as the College's survey and included the College's common outcomes section relating the surveyed alumni responses to ABET Criteria 3 preparedness and importance to their professional career. Of the 370 surveys sent out, the MDC program received a response rate of 19.4% (n=66) from the surveyed alumni.

When making direct comparisons, the MDC subgroup was part of the larger COE post-graduate class and may have responded to both surveys and respective questions, one-year apart. For the two graduating classes that the COE survey focused on, the MDC response rate for the 105 alumni that participated in the program specific survey was 22.8% (n=24).

The survey results will focus on comparing the MDC program survey results to the College's key outcomes identified from the alumni responses relating their academic preparation and the importance to their professional career. Both the larger COE alumni and MDC specific post-graduates responded with a rating of 1 through 5 for each category, 1 being either Not Important to one's professional career or Did Not Contribute in academic preparation and 5 being Extremely Important or Extremely Helpful respectively.

Results and Discussions

The results are divided into two categories that correspond to the general analysis conducted by the College's Outcome Assessment Committee. The categories include topics that the Committee identified and determined that the College reached a balance between the importance and preparation, and topics for continued or further consideration in program development across the College[4].

The College based this decision on comparisons made between the differences of the two ratings: the academic preparation and the importance to their professional career. A positive difference indicates that the students are adequately prepared to meet their identified career importance, and negative difference indicates that there is room to improve their academic preparation in order to meet the indicated importance.

For each topic list, the Multidisciplinary Engineering Capstone Design Program will be compared to the outcomes and results identified by the College. The results are discussed in a consistent manor with the College's published survey report that was released to the faculty and staff[4].

COE Balanced Topics

The College's Outcome Assessment Committee identified four topics the College appeared to have reached a balance between the importance and preparation. The results indicated that a "balance" topic was one in which the difference between the preparation and importance rating is on the order of ±0.30.

Three of the four topics corresponded to questions asked by the MDC survey, of which two can be directly related to the learning outcomes of the program, and the third a supplementary topic of the program. The three topics identified by the committee include:

1. Ability to: Design & conduct experiments
2. Ability to: ID & solve engineering problems
3. Ability to: Function in culturally and ethnically diverse environments

In passing, the fourth topic identified by the College as being balanced was the ability to apply knowledge of math.

Table 2 shows the survey results corresponding to the topic numbers listed above for the College and the MDC specific alumni.

Table 2: COE Balanced Topic List

Topic No.	COE			MDC		
	Imp.	Prep.	Diff.	Imp.	Prep.	Diff.
1	3.36	3.22	-0.14	2.96	3.00	0.04
2	4.03	3.73	-0.30	3.79	3.88	0.09
3	3.62	3.68	0.06	3.50	2.58	-0.92

It is positive to see that the MDC survey results demonstrate that the program is consistent with the College with respect to the two topics, and in fact shows a positive difference. Results indicate that the program is providing additional academic preparation with respect to the MDC program, while contributing positively with respect to the alumni's perspective of their importance College-wide.

Even though providing academic preparation with respect to the ability to function in a culturally and ethnically diverse environment is not directly related to program's learning outcomes, it has room for improvement in future program development, indicated by the MDC survey responses.

COE Topics for Continued Development

The College's Outcome Assessment Committee identified seven topics that the College recognizes room for continued development. Topics for "continued development" was one in which the difference between the preparation and importance rating was greater than ±0.30.

Six of the seven topics corresponded to questions asked by the MDC survey, of which four can be directly related to the learning outcomes of the program, and the

other two are supplementary topics of the program. The six topics identified by the College include:

1. Ability to: Function on multi-disciplinary teams
2. Ability to: Communicate effectively in writing: letters, technical reports, etc.
3. Ability to: Communicate effectively orally: informal & prepared talks
4. Ability to: Manage an engineering project
5. Ability to: Analyze & interpret data
6. Ability to: Use computing technology

In passing, the seventh topic identified by the College as having room for development was the ability to apply knowledge of chemistry.

The first four topics listed above have direct correspondence to the MDC program learning outcomes, while the last two topics could be viewed as important to any capstone experience; they are not specifically emphasized within the multidisciplinary capstone program's curriculum material.

Table 3 shows the survey results corresponding to the topic numbers listed above for the College and the MDC specific alumni.

Table 3: COE Topics List for Continued Development

Topic No.	COE			MDC		
	Imp.	Prep.	Diff.	Imp.	Prep.	Diff.
1	4.17	3.62	-0.55	4.00	4.08	0.08
2	4.25	3.67	-0.58	4.08	3.75	-0.33
3	4.42	3.58	-0.84	4.33	4.13	-0.20
4	3.85	3.27	-0.58	3.92	3.79	-0.13
5	4.39	3.75	-0.64	3.96	2.96	-1.00
6	4.42	3.77	-0.65	4.17	3.21	-0.96

The first four topics identified in comparison, is actually "balanced" using the College committee's definition by the Multidisciplinary Engineering Capstone Design Program.

Considering that one of the main objectives of the multidisciplinary program is to provide students with the opportunity to function specifically on multidisciplinary teams, these results are positive for the program in providing improvement with academic preparation compared to the general alumni responses within the College.

With respect to ability to effectively communicate and manage an engineering project, the program provides a significant amount of opportunities to present to the program and their respective industry-sponsors with frequent feedback by both. Additionally, the program requires student-teams to hold formal weekly update meetings with the industry liaison and faculty adviser, further contributing toward developing communications and project management skills.

The program acknowledges the need to further emphasize, where possible, the ability to analyze and interpret data and use computing technology as part of the College's recognition for topics that have room for continued development.

Concluding Remarks

A detailed overview of a Multidisciplinary Engineering Capstone Design Program and its learning outcomes was discussed. Results of survey responses from early-career impacts of the program on post-graduate professional careers, which are used for continued development efforts of the program, were discussed.

The program was compared to similar survey results and analysis from the College of Engineering's Outcome Assessment Committee study of the College as a whole. Comparisons of alumni responses were made between College-identified balanced topics and topics for continued development. Comparison results were identified, differentiating the impacts that the Multidisciplinary Engineering Capstone Design Program has on academic preparation to early-career post-graduates.

While the survey results show positive results providing academic preparation with several ABET Objectives and Outcomes that include functioning on multidisciplinary teams and the ability to communicate effectively in writing and with informal and prepared talks, the instructional staff continues to monitor feedback from industry, trends in engineering education, successes at other institutions, and anecdotal feedback from graduating seniors for continuous improvement.

References

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