6-25-216

Feasibility of Developing a Sustainable Multidisciplinary Senior Capstone Experience

Jacqulyn Baughman
Iowa State University, jacqulyn@iastate.edu

Gretchen A. Mosher
Iowa State University, gamosher@iastate.edu

Ann M. Gansemer-Topf
Iowa State University, anngt@iastate.edu

Tejas Dhadphale
Iowa State University, tejas@iastate.edu

Feasibility of Developing a Sustainable Multidisciplinary Senior Capstone Experience

Dr. Jacqulyn Baughman, Iowa State University

Dr. Jacqulyn Baughman Senior Lecturer, Mechanical Engineering Director of Graduate Education (DOGE), BRT Graduate Program Faculty-in-Charge, ADM Biorenewables Education Labs Iowa State University

Dr. Gretchen A. Mosher, Iowa State University

Dr. Gretchen Mosher is an assistant professor in the department of Agricultural and Biosystems Engineering at Iowa State University. Teaching responsibilities include undergraduate courses in total quality management and senior capstone. Research interests include human elements of safety and quality in food and agricultural systems and best practices for introducing new and complex information to learners.

Dr. Ann M Gansemer-Topf, Iowa State University

Ann Gansemer-Topf is an Assistant Professor in Higher Education and Student Affairs. She teaches courses in program evaluation and assessment, student affairs and higher education. Her research interests focus on examining the micro (student) and macro (institutional, state, federal) factors that impact student success and student learning. She has presented at several regional and national conferences and her research has been published in journals such as Research in Higher Education, Journal of the First-Year Experience and Students in Transition, Journal of Student Affairs Research and Practice, and Journal of Assessment and Institutional Effectiveness. She received her doctoral and master's degree from Iowa State University in Ames, Iowa and her bachelor's degree from Loras College in Dubuque, Iowa.

Tejas Dhadphale Ph.D., Iowa State University

Tejas Dhadphale is an Assistant Professor in Industrial Design at Iowa State University. He received his doctoral degree in Industrial Design from the Herberger Institute for Design and the Arts at Arizona State University. His research critically examines the role of design research in design education and practice. He has taught classes in design research methods, design thinking, multidisciplinary innovation, and human-centered design. Trained as a design researcher, he is passionate about developing new methods for investigating cross-disciplinary collaboration among faculty, students and academic units.

Feasibility of Developing a Sustainable Multidisciplinary Senior Capstone Experience

Abstract

Today's undergraduate engineering students will enter a workforce that requires a multidisciplinary approach to problem-solving. According to data from the National Science Foundation[1] and the National Academy of Engineering[2] a multidisciplinary problem-solving approach is increasingly a critical component of the nations' innovation infrastructure. Although both academic and industry professionals agree on the importance of providing students the opportunity to work on multidisciplinary teams, many institutions struggle to create these opportunities within their curriculum. This paper will examine the benefits and challenges of creating a multidisciplinary senior capstone course from the perspective of engineering faculty.

Introduction

Most engineering educators support the idea of a multidisciplinary capstone course in concept,[3, 4] but long-standing obstacles have limited the development and long-term success of such projects.[5, 6] Saunders[4] noted that work experience involving both engineers and non-engineers enhances the preparation as engineers and more broadly, as life-long learners[7]. The Accreditation Board for Engineering and Technology (ABET) has articulated the importance of being able to function on a multidisciplinary,[8] and the National Academy of Engineering's (NAE) Grand Challenges requires a multidisciplinary approach.[9] Curricular and knowledge differences across departments, a lack of standardization in working with industrial partners, and differences in faculty rewards and expectations limit the development of multidisciplinary capstone courses.[3,10] Although few question the importance of and need for multidisciplinary education, sustainable strategies for accomplishing these goals are limited. This paper will report the results of a feasibility study performed to examine the benefits and challenges of creating a multidisciplinary senior capstone course from the perspective of engineering faculty. From this study five overall themes emerged: 1.) multidisciplinary courses reflect real world, 2.) students are primary beneficiaries of multidisciplinary courses, 3.) current university structure and organization can create obstacles, 4.) senior capstone is a critical component in engineering education, and 5.) dedication of resources. The paper will conclude with recommendations for working with faculty to create a more multidisciplinary learning environment for students and initial thoughts on the next steps in the development process.

Capstone as Part of Engineering Education

The requirements of a 21st-century engineer are considerable: engineers must not only be technically competent, but globally sophisticated, culturally aware, innovative, and flexible.[11] In order to function effectively in a complex, diverse environment, graduates must be able to synthesize their disciplinary knowledge with relevant contributions from other fields.[5] Sheppard[12] forwards a new paradigm for engineering education to: i) respond to the incredible pace of intellectual change by synthesizing information from many disciplinary fields; ii) develop and implement new technologies; iii) holistically approach client social needs and priorities, effectively link social, economic, environmental, legal, and political considerations with technological sound design and innovation, and iv) reflect in its diversity, quality, and rigor the characteristics necessary to serve a 21st-century nation and world. Capstone projects are widely acknowledged as important components in engineering, engineering technology, design, and business undergraduate education.[2,6,15]

Much has been written on the topic, particularly on capstone courses in engineering.[6, 17] Some researchers have focused on capstone programming and structure.[13, 17, 18] Others have emphasized multidisciplinary collaborations.[10, 19, 20] A smaller amount of research has addressed the assessment of student knowledge patterns in multidisciplinary environments.[4, 21, 22] However, little research has examined the role of faculty and their beliefs on the success factors, as well as, time commitments for capstone courses.[23, 24] This is especially true when the topic is narrowed to the development and sustainability of multidisciplinary capstone programs.

Multidisciplinary Capstone

There is wide agreement on the need for a multidisciplinary preparation of students, [16] yet strategies for doing so are limited. Long-standing obstacles have limited the development and long-term success of multidisciplinary capstone programs, even given the support by engineering faculty.[3, 6, 27] Challenges can be broadly categorized as curricular and knowledge differences across departments, a lack of standardization in working with industrial partners, and differences in faculty rewards and expectations.[3, 10]

Small-scale models of multidisciplinary capstone courses have been piloted, but have depended heavily upon on the network and contacts of individual instructors, and consequently have been difficult to sustain over time.[16,28] Hotaling[14] found that students who completed their multidisciplinary capstone design course produced higher quality engineering solutions, as evaluated by external industry professionals. Student impacts, however, are only one part of a sustainable multidisciplinary capstone program. Saunders[4] note that work experience involving both engineers and non-engineers enhances the preparation as engineers and more broadly, as life-long learners.[7] Industry projects provide one way to do this, but challenges include the inability of industrial and academic practitioners to speak the same "language".[18, 19]

Engineering graduates are expected to work in team-based projects.[30, 31] Multidisciplinary capstone courses provide a unique opportunity for students to work with their peers from other disciplines, mirroring the experiences they will confront in the workplace.[32]

Definitions in the literature exist for terms such as multidisciplinary, cross-disciplinary, transdisciplinary, and interdisciplinary; [21, 3] Lattuca, Knight, and Bergom[34] define "Multidisciplinary" as an effort to bring together the tools, viewpoints and understandings of two or more disciplines to explain or solve a problem while separating the thoughts of each discipline. This differs from an interdisciplinary approach, which integrates knowledge from multiple disciplines, with the goal of synthesizing differences into a new understanding or even a new disciplinary field.[10, 34] These types of teams have previously been defined as multidisciplinary teams.[10, 35, 36] In this paper, we will use the term "multidisciplinary" to describe capstone courses with students from two or more disciplinary fields.

Key Departmental Roles

A senior capstone course is required of all students in the College of Engineering, however most are departmental and program-specific and do not provide students with an experience of working in multidisciplinary collaborative teams. Because faculty play a key role in the success of capstone courses, in the Summer of 2015 a feasibility study was conducted with department chairs and faculty members within the College of Engineering to better understand the current structure of the capstone courses in each of the departments, and assess the potential obstacles and benefits of offering a multi-disciplinary senior capstone course.

Methods

We employed qualitative research methods to better understand the current structure of College of Engineering capstone courses and potential obstacles and benefits of a multidisciplinary capstone course. Specifically, we collected data through 16 semi-structured interviews. Interviews were appropriate for this study because they allowed for in-depth collection and examination of data.[37] Before beginning data collection, we applied for and received approval from the University's Institutional Review Board.

Participants

We used purposeful criterion and snowball sampling techniques to identify participants.[38] Members of the Iowa State University College of Engineering ABET/SLTF team and department chairs from each of the engineering departments were sent an email inviting them to participate in an interview focusing on their perceptions of multidisciplinary senior capstone courses. This group was selected because they had some knowledge of the senior capstone courses and were responsible for ensuring that engineering curricula were designed to fulfill the ABET accreditation requirements. Those selected also had the ability to suggest and implement curricular changes. In some instances, department chairs recommended that we interview faculty who coordinated capstone courses for their departments. Table 1 provides an overview of the current structure of (i.e. number of semesters and credits) of the current senior capstone course by department.

Table 1. Overview of Senior Capstone Courses by Engineering Department

Department	Course Structure	Spring 2016 Enrollment	Number of Faculty
Aerospace	2 semesters	1st semester: 50 2nd semester: 82	1 2
Agriculture & Biosystems	2 semesters	1st semester: 20 2nd semester: 38	1 1
Chemical & Biological	1 semester	1st semester: 87	1
Civil, Construction, & Environmental	1 semester (civil, environ) 2 semesters (construction)	1st semester: 96 (civil/environ.) 1st semester: 33 2nd semester: 35	6 6 1
Electrical & Computer	2 semesters (electrical, computer, and software)	1st semester: 81 (electrical) 2nd semester: NA (electrical)	1 1
		1st semester: NA (computer) 2nd semester: 133 (computer)	1 1

		1st semester: 19 (software) 2nd semester: 37 (software)	1 1
Industrial and Manufacturing Systems	1 semester	1st semester: 61	1
Materials Science	2 semesters	1st semester: 11 2nd semester: 50	3 2
Mechanical Engineering	1 semester (3 disciplinary courses, 1 multidisciplinary course)	1st semester: 206 (combined disciplinary courses)	12
		1st semester: 41 (multidisciplinary)	4

Data Collection and Analysis

We collected data using a topical individual interview.[39] We used a semi-structured protocol, [37] allowing for follow-up questions to probe responses to a list of prescribed open-ended questions. During interviews, we asked participants their perceptions of the benefits and challenges of a multidisciplinary capstone and any recommendations they would have for creating a successful multidisciplinary course.

We audiotaped and transcribed interviews and used inductive coding procedures[38, 40] to analyze the data, reviewing each transcript separately and coding data into specific categories. To ensure credibility, at least two researchers reviewed the transcriptions.[41] We also engaged in member checking by sending a draft of the report back to participants for their suggestions.[42]

Findings

Sixteen people representing the Departments of Aerospace Engineering, Agricultural and Biosystems Engineering, Chemical and Biological Engineering, Electrical and Computer Engineering, Industrial and Manufacturing Systems Engineering, Materials Science and Engineering, and Mechanical Engineering at Iowa State University were interviewed. Of the eight departments in the College of Engineering, representatives from seven departments participated in the interviews. The results of this feasibility study provided insights into the challenges and benefits of offering a multidisciplinary, as well as a list of considerations in developing a course. From the faculty interviews, five overall themes emerged: 1.) multidisciplinary courses reflect real world, 2.) students are primary beneficiaries of multidisciplinary courses, 3.) current university structure and organization can create obstacles, 4.) senior capstone is a critical component in engineering education, and 4.) dedication of resources.

Multidisciplinary courses reflect industry projects

Participants agreed that a multidisciplinary studio reflects what students will encounter in industry. Most participants believed that providing students with a multidisciplinary experience - giving them the opportunity to take risks outside of their discipline and work with people different than them - is extremely valuable. Others suggested that students will gain multidisciplinary experience in industry very quickly and therefore, it is not as critical to provide this exposure within the curriculum.

Students are primary beneficiaries of multidisciplinary courses
A few participants mentioned that the university's reputation would be enhanced if it chooses to focus on multidisciplinary capstones. Others mentioned that industry would benefit by having students experienced in multidisciplinary relations. A few participants who had prior experience in multidisciplinary courses mentioned they enjoyed the experience. However, no benefits for faculty and staff were specifically mentioned.

University infrastructure and organization cannot support multidisciplinary capstone
The current structure and organization of courses, departments and the institution is a significant obstacle in offering multidisciplinary capstone course. Departments vary in terms of the length and technical components of and funding for their capstone courses. Current reward structures, specifically those related to promotion and tenure may be difficult for those developing and teaching multidisciplinary courses.

Senior capstone is a critical disciplinary component of engineering education
Senior capstone design courses are considered some of the most important courses students will take. These courses are expected to support ABET requirements, demonstrate a student's technical and non-technical skills, and provide students with key skills prior to graduation. Therefore, many departments are not supportive of the idea of using multidisciplinary courses to substitute for their current design courses. Departments felt that they would be losing a significant amount of control over their curriculum and as a result, students will not receive the appropriate amount of disciplinary content nor would the quality of their exposure to disciplinary content in a multidisciplinary capstone be acceptable.

Dedication of resources
Successful multidisciplinary work takes a dedication of resources: time, money, people, and support. The management of industry, student, and faculty stakeholders requires people willing to champion not only the initial development but also provide a sustainable structure that would allow the project to continue even if the coordinating faculty leave the university. The alignment of rewards (or lack thereof) in relation to the time and energy needed were also major concerns of the departmental representatives.

Discussion

Our findings mirror the benefits and challenges largely suggested by the first National Capstone Design Conference, which found that although there is a movement toward greater use of multi-disciplined teams, they are difficult to establish without an overarching university-wide structure to make it happen.[43] This study indicates that most faculty do favor a multidisciplinary capstone course, and highly beneficial for students as a capstone experience. However, the current university structure creates obstacles to the development and administration of a multidisciplinary capstone course due to the diversity in the way capstone courses are administered across the campus community. Additionally, the faculty interviewed for this project felt that the existing promotion and tenure processes at most universities do not currently support the participation of junior-level faculty in this type of a course.

The senior capstone design course in engineering is considered to be one of the critical courses students will take in their journey towards the attainment of an engineering degree as a key piece in career development. However, not all departments support the idea of a multidisciplinary capstone because they fear it will negatively impact their ability to meet their department's specific curricular needs, and ensure ABET requirements are met. The administration and facilitation of a multidisciplinary capstone takes significant resource dedication, and a sustainable structure would need to be built the appropriate infrastructure to ensure future success.

Implications and Recommendations

Multidisciplinary capstone has much support across campus, as it reflects experiences students will encounter in industry. However, the resources needed, including faculty, time, funding, and other support have yet to be clearly defined. Designing a multidisciplinary capstone experience that meets stakeholder needs remains a challenge within the current university structure. With both industry and accreditation entities putting pressure on academic programs to offer a multidisciplinary approach, the impetus to design a multidisciplinary structure continues to grow, in order to prepare students for their impending professional career.

Faculty members mentioned ABET requirements as a disincentive to pursue multidisciplinary capstones. This concern seems to reflect an assumption that ABET does not value multidisciplinary work or that it cannot be achieved unless other criteria are not met. A primary purpose of ABET is to ensure engineers are receiving the skills and competencies needed to be successful engineers. With this purpose in mind, engaging ABET representatives in discussions around multidisciplinary capstones and how they may fit within ABET criteria may be useful – both for the university as well as for the ABET organization.

Therefore, industry-university collaboration may be needed to develop an effective and sustainable multidisciplinary capstone. This collaboration could be facilitated by having professionals from academic and industry work together to best understand and articulate what is needed from the senior capstone course in terms of multidisciplinary content and skills, and the best manner to provide needed multidisciplinary experience to students. Additionally, this collaboration could bring forth a recommended structure for the multidisciplinary capstone course.

A significant amount has been written on the challenges with developing a sustainable multidisciplinary capstone. However, the value of this study is its focus on administrator and faculty perspectives. This approach provides valuable information from those most likely to develop and implement these courses. Additionally, future research should focus on the perceptions of non-engineering faculty within the university, as it will likely be faculty from these disciplines who add some of the multidisciplinary content to engineering courses. For this reason, understanding the benefits and challenges from this group of stakeholders is critical in developing an effective and sustainable multidisciplinary capstone course.

The results from this study illustrate the perspective of the engineering faculty at a Midwest research-intensive institution on the need for and benefits of a multidisciplinary capstone experience. Engineering faculty were supportive of the idea in concept. However, the group also recognized major obstacles in place that have prevented the development of such a capstone model, including university infrastructure, faculty instructional time, and promotion and tenure expectations. Although the development, creation, and implementation of a multidisciplinary capstone program is a challenging task, the benefits of implementing a sustainable and successful capstone course were also expressed as opportunities to provide critical learning experiences for our students.

References

1. National Science Foundation. (2014). *Investing in science, engineering, and education for the nation's future*. *Strategic Plan for 2014-2018*. Downloaded October 16, 2015 from: www.nsf.gov
2. National Academy of Engineering. (2008). *Grand challenges for engineering*. Downloaded August 30, 2015 from: www.engineeringchallenges.org
3. Besterfield-Sacre, M., Cox, M.F., Borrego, M., Beddoes, K., and Zhu, J. (2014). Changing engineering education: Views of U.S. faculty, chairs, and deans. *Journal of Engineer in Education*, 103(2), 193-219.
4. Saunders, K. Brumm, T., Brooke, C., Mickelson, S., and Freeman, S. (2009). Assessing student work to support curriculum development: An engineering case study. *Journal of Learning Communities Research*, 3(3), Dec 2008/Jan 2009, 47-62.
5. Richter, D.M. and Paretti, M.C. (2009). Identifying barriers to and outcomes of interdisciplinarity in the engineering classroom. *European Journal of Engineering Education*, 34(1), 29-45.
6. Seidel, V.P. and Fixson, S.K. (2013). Adopting design thinking in novice multidisciplinary teams: The application and limits of design methods and reflexive practices. *Journal of Product Innovation and Management*, 30(S1), 19-33.
7. Adams, R.S. and Felder, R.M. (2008). Reframing professional development: A systems approach to preparing engineering educators to educate tomorrow's engineers. *Journal of Engineering Education*, 97(3), 239-240.
8. ABET. (2015). *Accreditation criteria and supporting docs*. Downloaded on October 1, 2015 from: http://www.abet.org/accreditation/accreditation-criteria/.
9. Augustine, N. (2007). *The nature of challenges*. Downloaded on October 23, 2015 from: http://www.engineeringchallenges.org/14373/GrandChallengesBlog/Augustine.aspx.
10. Borrego, M. and Newswander, L.K. (2008). Characteristics of successful cross-disciplinary engineering education collaborations. *Journal of Engineering Education*, 97(2), 123-134.
11. Continental AG (2006). "*In Search of Global Engineering Excellence: Educating the Next Generation of Engineers for the Global Workplace*". Hanover, Germany, Continental AG, 2006. Available at http://www.conti-online.com.
12. Sheppard, S. D., Pellegrino, J. W., and Olds, B. M. (2008). On becoming a 21st century engineer. *Journal of Engineering Education*, *97*(3), 231-234.
13. Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., and Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, 94(1), 103–120.
14. Hotaling, N. (2012). "A quantitative analysis of the effects of a multidisciplinary engineering capstone design course." *Journal of Engineering Education*, 101(4), 630-656.
15. Davis, D., Trevisan, M., Gerlick, R., Davis, H., McCormack, J., Beyerlein, S., Thompson, P. Howe, S., Leiffer, P., and Brackin, P. (2009). Assessing team member citizenship in capstone engineering design courses. *International Journal of Engineering Education*, 26(4), 771-783.
16. Howe, S. and Willbarger, J. (2006). *Current practices in engineering capstone education: Further results from a 2005 nationwide study.* American Society of Engineering Education Frontiers in Education Conference, Paper 1-4244-0257-3/06, presented October 2006.
17. Paretti, M., Layton, R., Laguette, S., and Speegle, G. (2011). Managing and mentoring capstone design teams: Considerations and practices for faculty. *International Journal of Engineering Education*, 27(6), 1192 – 1205.
18. Kauffman, P. and Dixon G. (2011). Vetting industry based capstone projects considering outcome assessment goals. *International Journal of Engineering Education*, 27(6), 1231-1237.

19. Adams, R.S., Beltz, N., Llewellyn, M., and Wilson, D. (2010). Exploring student differences in formulating cross-disciplinary sustainability problems. *International Journal of Engineering Education*, 26(2), 324-338.
20. Borrego, M., Foster, M.J., and Froyd, J.E. (2014). Systematic literature reviews in engineering education and other developing interdisciplinary fields. *Journal of Engineering Education*, 103(1), 45-76.
21. Lattuca, L.R., Voigt, L.J., and Fath, K.Q. (2004). Does interdisciplinarity promote learning? Theoretical support and researchable questions. *The Review of Higher Education*, 28(1), 23-48.
22. McKenzie, L.J., Trevisan, M.S., Davis, D.C., and Beyerlein, S.W. (2004). *Capstone design courses and assessment: A national study.* Paper presented at the American Society of Engineering Education Annual Conference and Exposition, June 2004.
23. Stanford, S., M., Benson, L. C., Alluri, P., Martin, W. D., Klotz, L. E., Ogle, J. H., and Schiff, S. (2012). Evaluating student and faculty outcomes for a real-world capstone project with sustainability considerations. *Journal of Professional Issues in Engineering Education and Practice*, *139*(2), 123-133.
24. Rasul, M. G., Lawson, J., Howard, P., and Martin, F. (2014). Learning and Teaching of Capstone Final Year Engineering Projects: An Australian Study.
25. Pembridge, James J., and Marie C. Paretti. "An examination of mentoring functions in the capstone course." *American Society for Engineering Education*. American Society for Engineering Education, 2011.
26. National Academy of Engineering. (2008). Grand challenges for engineering. Downloaded August 30, 2015 from: www.engineeringchallenges.org
27. Parfitt, M. Kevin, Robert J. Holland, and Ryan L. Solnosky. "Results of a Pilot Multidisciplinary BIM-Enhanced integrated Project Delivery Capstone Engineering Design Course in Architectural Engineering." *2013 Architectural Engineering Institute National Conference*. 2013.
28. Anderson, David, and Claudio Mourgues. (2013). "Industry participation in construction capstone courses: A company's experience." *Practice Periodical on Structural Design and Construction* 19(1), 73-76.
29. Friesen, M., and Taylor, L. K. (2007). Perceptions and experiences of industry co-operators in project-based design courses. *International Journal of Engineering Education*, *23*(1), 114-119.
30. Natishan, M.E., Schmidt, L.C. and Mead, P. (2009). Student focus group results on student team performance issues. *Journal of Engineering Education*, 89(3), 269-272.
31. Willey, K. and Freeman, M. (2006). Improving teamwork and engagement: the case for self and peer assessment. *Australasian Journal of Engineering Education*., 2(10), 1-19.
32. Behdinan, K., Pop-Iliev, R., and Foster, J. (2015). What constitutes a multidisciplinary capstone design course? Best practices, successes and challenges. *Proceedings of the Canadian Engineering Education Association*.
33. Boix Mansilla, V. (2005). Assessing student work at disciplinary crossroads. *Change*, 37(1), 14-21.
34. Lattuca, L.R., Knight, D., and Bergom, I. (2013). Developing a measure of interdisciplinary competence. *International Journal of Engineering Education*, 29(3), 726-239.
35. Committee on Facilitating Interdisciplinary Research. (2005). *Facilitating interdisciplinary research.* Washington, D.C.: National Academies Press.
36. Lattuca, L.R. (2001). *Creating Interdisciplinarity: Interdisciplinary Research and Teaching among College and University Faculty*. (2001). Nashville, TN: Vanderbilt University Press
37. Creswell, J.W. (2007). *Qualitative inquiry and research design: Choosing among five approaches.* Thousand Oaks, CA: Sage Publication.
38. Miles, M.G. and Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd. Ed.). Thousand Oaks, CA: Sage.
39. Rubin, H. J., and Rubin, I.S. (2012). *Qualitative interviewing: The art of hearing data* (3rd Ed.). Los Angeles, CA: Sage.
40. Seidman, I. (1998). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (2nd Ed.). New York, NY: Teachers College Press.
41. Merriam, S. B. (1998). *Qualitative research and case study applications in education: Revised and expanded from case study research in education.* San Francisco, CA: Jossey-Bass.
42. Guba, E. G. and Lincoln, Y. S. (1998). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.). *The landscape of qualitative research: Theories and issues* (pp. 195–220). Thousand Oaks, CA: Sage.
43. Zable, J. (2010). Guest Editorial: 2007 National Capstone Design Conference. *Advances in Engineering Education*, 2(1), 1–4.