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# Developing Essential Business and Engineering Skills through Case Competitions

**Dr. Paul C. Lynch, Penn State University Erie, The Behrend College**

Paul C. Lynch received his Ph.D., M.S., and B.S. degrees in Industrial Engineering from the Pennsylvania State University. Dr. Lynch is a member of AFS, SME, IIE, and ASEE. Dr. Lynch's primary research interests are in metal casting, manufacturing systems, and engineering education. Dr. Lynch has been recognized by Alpha Pi Mu, IIE, and the Pennsylvania State University for his scholarship, teaching, and advising. He received the Outstanding Industrial Engineering Faculty Award in 2011, 2013, and 2015, the Penn State Industrial & Manufacturing Engineering Alumni Faculty Appreciation Award in 2013, and the Outstanding Advising Award in the College of Engineering in 2014 for his work in undergraduate education at Penn State. Dr. Lynch worked as a regional production engineer for Universal Forest Products prior to pursuing his graduate degrees. He is currently an Assistant Professor of Industrial Engineering in the School of Engineering at Penn State Erie, The Behrend College.

**Dr. James F. Kimpel, University of Pittsburgh**

Jim Kimpel joined the faculty of the Katz Graduate School of Business at the University of Pittsburgh in 2012 following a 27-year career in industry. His industry experience includes work in the fields of marine outfitting; software design and consulting; medical devices; and heavy equipment. Jim held operational positions in production supervision; master scheduling; materials management; and industrial engineering. In an IT capacity, he served as a software engineer; systems analyst; project manager; manager of programming, quality assurance, and architecture; director of IT governance and program management; and director of business service demand management. He leverages his industry experience to enhance classroom learning. In his three-year teaching career at the University of Pittsburgh he has won four "student choice" teaching awards from undergraduate and master's students alike. Jim holds a BS in Computer Systems and Mathematics from Grove City College, an MS in Mechanical & Aerospace Engineering from the University of Virginia, and a DSc in Information Systems and Communication from Robert Morris University.

**Dr. Karen M. Bursic, University of Pittsburgh**

Associate Professor and Undergraduate Program Director for Industrial Engineering at the University of Pittsburgh. She received her B.S., M.S., and Ph.D. degrees in Industrial Engineering from the University of Pittsburgh. Prior to joining the department she worked as a Senior Consultant for Ernst and Young and as an Industrial Engineer for General Motors Corporation. She teaches undergraduate courses in engineering economics, engineering management, and probability and statistics in Industrial Engineering as well as engineering computing in the freshman engineering program. Dr. Bursic's recent research has focused on improving Engineering Education and she has 20 years' experience and over 20 publications in this area. She has also done research and published work in the areas of Engineering and Project Management. She is a senior member of the Institute of Industrial Engineers and the American Society for Engineering Education (where she currently serves as the Chair of the Engineering Economy Division) and a registered Professional Engineer in the state of Pennsylvania.

# Developing Essential Business and Engineering Skills through Case Competitions


## *Abstract*

The intersection of business and engineering is being discussed now more than ever as companies are demanding that new hires graduating from baccalaureate engineering degree programs have a level of business expertise to complement their technical skill sets. Companies also expect business students to have an understanding of technical concepts to be effective working in teams composed of employees with both business and engineering backgrounds. With corporate investment and engineering project funding decisions more reliant upon company financial statements and stock price impact, now more than ever, it is crucial for engineers and business people to be able to share common skill sets to effectively evaluate project investment alternatives.

This paper discusses an integrated approach being taken at multiple universities to develop business and engineering competencies in industrial engineering and business students through case competitions. The paper will describe two different approaches and compare and contrast the business and engineering sponsored case competitions.


## *Motivation and Background*

### *The Pennsylvania State University (Industrial Engineering Program) Motivation*

The motivation for bringing business concepts into the engineering classroom and for bringing real world case competitions is a result of the expectations of corporate employers in this new economy. At Penn State, making curriculum changes to the current engineering economy course came directly from suggestions made by corporate executives serving on multiple engineering advisory boards for the industrial engineering department. Input from the industrial engineering advisory boards noted that industrial engineering graduates needed to graduate with a more thorough understanding of the link between engineering economic decisions and business planning, financial statements, and financial accounting. It is crucial for industrial engineering students to learn not only how to provide a definitive argument explaining the conclusion of their engineering decision (both from a qualitative and quantitative perspective) but also how to take this one step further to be able to understand and explain how their decision will impact company financial statements (i.e., the bottom line of the company). At Penn State, industrial engineering students are only exposed to a semester of financial accounting and financial statements if they choose to complete a minor in business/liberal arts.

An overhaul of the engineering economy course in the industrial engineering program was completed. However, simply adding additional lecture material in the engineering economy course to cover the link between engineering economic decisions and business planning, financial statements, financial accounting, and stock value was only one part of addressing the needs of the companies hiring industrial engineering students from this university. The advisory boards and the course instructor that presenting a real world company problem would force the students to apply engineering economy tools learned in the course and to justify their engineering

decisions would allow the students to gain real world training in this area. The team competition component was expected to add another element of motivation for the study and to provide a real world competitive business environment[1].

### *University of Pittsburgh (Center for Supply Chain Management Program) Motivation*

The strategic intent of the Business School from the University of Pittsburgh, within the scope of this paper is the integration of theory and practice. This strategy is realized through four guiding principles: experience-based learning, collaboration, innovation, and globalization. The principles are embodied in the University's Center for Supply Chain Management (SCM) which conducts research projects, educational programs, and outreach activities in close collaboration with corporate partners, professional organizations, and other schools within the University.

The Center for SCM has sponsored several working sessions with industry. Recurring themes from the working sessions are the need for students who are able to employ systems thinking and critical thinking, in a team setting, to analyze processes and data, to arrive at data-driven recommendations, and then communicate the analysis and recommended way forward effectively. One of several ways these industry needs are met is through the "Race to the Case" competition.

The Swanson School of Engineering at Pitt also recognizes the critical need to provide students with experienced-based learning opportunities. The instructor for the engineering economy course (housed in the department of industrial engineering (IE)) has incorporated numerous active learning pedagogies, including case studies and model-eliciting activities, within the course over many years. The instructor saw the "Race to the Case" competition as an additional opportunity to provide IE students with an opportunity to apply engineering economy and other industrial engineering skills to a real world problem.

The Race to the Case, represented by Figure 1, is an annual case competition, sponsored by the Center for SCM in collaboration with the Engineering School and run primarily by the students themselves, where engineering and business students collaborate to analyze the data presented in a SCM focused case study, and then propose actions that resolve the case in a manner that balances delivery, quality, cost, and flexibility. Cases are chosen that require both engineering expertise and business acumen to successfully analyze their data and synthesize recommendations. The 2015 case focused on the impact of 3D Printing (additive manufacturing) on SCM in China; integrating theory and practice through experience-based learning, collaboration, innovation, and globalization.


**Figure 1:** Logo for the Race to the Case Competition Developed and Hosted by The University of Pittsburgh.

***Background from Prior Literature***

A challenge instructors often face is how to make abstract concepts concrete for their students. Drawing on experiential-learning theory (ELT), Baker, Jenson, and Kolb[2] recommend a procedure that moves students through a four-stage process of: experiencing, reflecting, abstracting, and acting. The incorporation of case studies in the classroom is one method of simulating experiencing, reflecting, abstracting, and recommending actions based on the real world scenario depicted by the case. Additionally, engineering education literature has continuously shown that projects with industry can be helpful for undergraduate and graduate students, even the processes of soliciting, administering, and managing industry projects that reinforce academic topics in engineering, technology, manufacturing, project management, lean, and six sigma[3-7]. Other topics that are reinforced include professionalism (through interaction with industry), teamwork, and leadership[8]. Formally, these projects are also often assessed as students work to meet the established learning outcomes[9].

Another benefit of incorporating industry projects within engineering economy courses is that academic materials such as course lectures and notes have excellent coverage of project economic analysis, but these academic materials lack the hands-on use of economic analysis within a design that a project with industry can provide[10]. In a broader context, within the K-16 realm, there has been a push to increase the mathematical competency of students, particularly financial literacy. Within the book, Mathematics and Democracy: The Case for Quantitative Literacy[11], the findings and suggestions are aligned with National Academy of Engineering recommendations[12]; that an individual will need to have a basic understanding of decision making to make competent financial decisions in order to survive in the 21st century society. Engineering economics takes this level of understanding to a higher ceiling by including competent financial decisions for a company or organization with respect to projects and designs.

The importance of economically quantifying projects has been shown in prior literature, as the economic and social well-being progress is a direct consequence of technical change and its application in the modern world. Solow[13] originally estimated that technological and engineering advances led to 80% of the economic growth and development of a society . Furthermore,

incorporating economic decision considerations within the design process is what sets engineers apart from other specialists with respect to financial decisions. Basically, understanding the economic characteristics of a technology or a design and its costs is what distinguishes engineering economics from other branches of economics, accounting, and finance[14]. Also, engineers are equipped to analyze a project, technology, and design with respect to sustainability and environmental factors.

### *Introduction to the Competitions*

### *Penn State Industrial Engineering Program*

At Penn State, 116 industrial engineering students competed in a case competition sponsored by a major U.S. retailer as part of their junior engineering economy course. The problem given to the students was a real world challenge currently being addressed by the U.S. retailer. The case competition was carried out in an effort to complement an evolving engineering economy curriculum with increased emphasis on business concepts rooted in finance and financial accounting, namely financial statement analysis. The first place team was awarded $1,500, second place $1,000, and third place $500.

A well-known, large U.S. retailer worked with the instructor of the engineering economy course at Penn State to put together the case study problem and charter. This was the first large case study competition of its kind for this retailer. The company wanted junior level industrial engineering students to study and propose changes to their current regional distribution center (RDC) recycling program. Teams had five weeks to work on the case study and submit a final report. They were asked to submit a maximum 10 page report. The final report consisted of four sections: an executive summary, which outlined the team's solution and cost justification; a results and discussion section, where the students explained their approach to the problem; proposed changes/solution where the students explained their changes and the solution for the RDC recycling program; and a cost analysis and economic justification section, where the students had to sell their ideas to the U.S. retailer's engineering and management team. Of the ten pages in the report, the first five pages were dedicated to the four sections explained above. The final five pages provided space for supporting appendices.

The case study competition grade was worth 3.33% of the overall course grade in the engineering economy course. After a university team completed their assessment of the case studies, all 29 case studies and a top ten team list (in no particular order) was passed on to the retailer's employees. The U.S. retailer's team graded all 29 case studies. After grading was complete, they returned the top five to the course instructor.

The top five teams were instructed to put together seven-minute sales pitch presentations to be delivered to the U.S. retailer's team one week after the top five teams were named (Figure 2). Their presentations were limited to eight total slides including proposed changes/solutions, cost analysis/ economic justification and an implementation plan. After each presentation, the teams were subject to a three-minute question and answer session. Eight corporate representatives from the U.S. retailer's team judged the presentations. The top three teams were announced, and all five teams were recognized at an awards reception sponsored by the U.S. retailer immediately following the final presentations.


**Figure 2:** A case study team answers questions from the company sponsor in the final round of the Engineering Economy Case competition.

***University of Pittsburgh Center for Supply Chain Management***

The second competition brought together 36 industrial engineering and business students from Pitt, Penn State, and West Virginia University. The competition was developed and sponsored by the Center for SCM in collaboration with the Engineering School at Pitt. The basis for the competition was a Harvard Business School (HBS) case. Each school involved had three teams in the competition. Nine teams comprised of two business students and two engineering students literally raced through three one-hour rounds of competition. The first place team was awarded $3,000, second place $1,500, and third place $500.

During round one and round two, the students answered a series of qualitative and quantitative questions based on the HBS case which focused on the impact of 3D Printing (additive manufacturing) on SCM in China. Students then physically raced from one location to another (spread across the University's campus) to submit the required information (Figure 3). The first three teams to complete round one and round two had three, two, or one bonus point added to their respective scores (with each bonus point worth 2.5% of the final score). Conversely, any team that did not complete round one or two in the allotted time was penalized one point for each minute their submission was past due, up to five minutes total. This dynamic caused the teams to tradeoff delivery speed with quality of response.

Each round was judged by a panel of judges consisting of five corporate and five faculty judges. Specifically, each team response was blindly evaluated independently by two judges according to a predefined grading rubric. The team's score was the average of the two judge's scores. However, if the two judges scores deviated by more than 5 points (12.5%), a third judge independently evaluated the team's response and the three scores were averaged.

**Figure 3:** Engineering and Business students "Race to the Case" between case study competition rounds during the Industrial Engineering and Supply Chain case competition.

A networking session was held as part of a buffet lunch that was served between round two and round three. This afforded an opportunity for the students to interact with one another, and with the corporate judges. Further, given the subject of the case was 3D Printing, a 3D printer was setup to print 3D Race to the Case logos during the meal. Students enjoyed the physical manifestation of the case study subject; and the complete logos were highly desired as souvenirs of the competition (Figure 4).

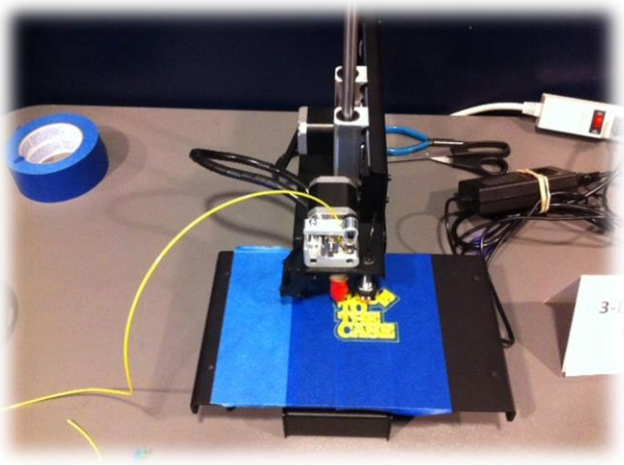

**Figure 4:** A 3D Printer produces "Race to the Case" logos during the Supply Chain case competition where 3D printing was the competition topic.

Thirty minutes into the lunch the three teams with the largest combined average round one and round two scores were announced. Only these three top scoring teams advanced to the third, and final, round of competition.

The three advancing teams were given additional data not included in the case, a new challenge problem, but only 30 minutes to prepare a final ten-minute presentation. Chosen at random, each finalist team delivered their ten-minute presentation to a mock board of directors comprised solely of corporate judges. Following the presentation, each team was questioned by the board. One member of the board was designated to aggressively challenge the team's proposal so the judges could observe how the students responded to pressure.

At the conclusion of all three presentations, the judges were sequestered to identify the first, second, and third place teams. Each judge independently ranked the teams based on a predefined rubric, and then each judge's rankings were noted on a white board. The judges deliberated until a consensus was reached. The final evaluation was completed in 20 minutes, and then the top three teams were named and awarded their prizes.

### *Discussion and Results of the Competitions*

### *Penn State Industrial Engineering Program*

The results of the company case competition were overwhelmingly positive. 95.5% of the participants felt as though the case study experience added value to the engineering economy course. When compared to completing an assignment solely for a grade, 79.1% of the students felt as though the competition component of the study motivated them to try harder on the assignment. In fact, over 91.0% of the students said they would like to see similar case study experiences in more of their industrial engineering courses. 99.1% of the students felt as though they had a better understanding of how they would conduct an industrial engineering study and sell their work to upper level management using an engineering economic/financial justification. On a Likert scale from 1 to 5, with 5 being extremely satisfying, the overall case study learning experience from the student perspective averaged 4.1.

The competition was judged by eight corporate employees from the large U.S. retailer. The case competition paid huge dividends for the sponsor. On a Likert scale from 1 to 5, with 5 being extremely satisfying, the overall case study experience from the retailer perspective averaged 4.8. Before completing the company case study experience, only 22.7% of the students (25 out of 110) said they had a good understanding of the work industrial engineers did for the U.S. retailer sponsoring the case study competition. After completing the case study experience, 92.7% of the students (102 out of 110) said they now have a good understanding of the work industrial engineers do for the case study sponsor. Prior to completing the case study experience, 35.5% (39 out of 110) of the students responded 'Yes' they would have considered an internship or full time position with the U.S. retailer sponsoring the case study competition. 47.3% said 'Maybe' they would have considered an internship or full time position while only 17.3% responded 'No.' After completing the case study experience, 54.5% (60 out of 110) responded 'Yes' they would consider an internship or full time position with the sponsor. 40.9% said 'Maybe' they would consider an internship or full time position while only 4.5% responded 'No.'

### *University of Pittsburgh Center for Supply Chain Management*

The feedback received from the "Race to the Case" experience was overwhelmingly positive. On a Likert scale from 1 to 5, with 5 being extremely satisfying, the overall case study learning

experience from the student perspective averaged 4.6. 100% of the participants said the case competition experience added value to their education and 100% also said they would like to see similar case study experiences in the remainder of their educational experience. When compared to completing an assignment solely for a grade in a class, 94.4% of the students said the competition motivated them to try harder. 91.7% of the students said that after completing this case study competition, they felt as though they now had a better understanding of how they would conduct a business or engineering study and sell their work to upper level management. 94.4% of the students said that going forward they felt as though they had a better understanding of how to assess the capabilities and impact of an emerging technology on SCM as a result of their participation in this Race to the Case competition.

***Student Comparison of the Two Case Competition Approaches***

There were two students from Penn State that took part in both competitions. Independently, the two students were asked for feedback on both approaches by means of an open ended questionnaire. One female and one male student competed in both competitions. They were both industrial engineering students from Penn State. One student was minoring in Six Sigma Quality and the second was minoring in Engineering Entrepreneurship.

*Motivation*

The students felt as though both of the case competitions were great experiences and they learned a great deal from both competitions. Both of the students indicated they were motivated to learn and work harder on the engineering economy company sponsored case competition. The stated reasons for this surrounded the case competition being a real life problem and it was used as part of their final course grade (3.33%). They also noted there were few constraints in the engineering economy case competition, ultimately allowing the students to "think big." They felt as though the Race to the Case experience was limited to extracting information from the HBS case. They felt the HBS competition was more about backing up principles with examples rather than developing creative solutions. Lastly, they felt as though the opportunity to present their ideas directly to the case study sponsor, which could be a future employer, was a major motivator in the engineering economy competition.

Both students said they would like to see similar case study experiences in the remainder of their educational experience. Both felt as though they now (i.e. after completing the Race to the Case) have a better understanding how they would conduct a business or industrial engineering study and sell their work to upper level management. They indicated they both felt the same way after completing the engineering economy company sponsored case as well.

*Combining Engineering Students with Business Students*

For both engineering students, the Race to the Case was their first opportunity working with business students to solve a real life problem. They agreed this was a great experience since they know they will be working across disciplines to solve similar problems in their careers. One of the students noted the Race to the Case overnight stay gave them time to collaborate and learn about each other's disciplines and the student felt as though there was a clear contribution from

students in the two disciplines on the team which proved to be necessary to providing a solution for the HBS case.

*Competition with Rival Schools*

Both students said they really enjoyed competing against students from other schools in the Race to the Case competition. One student noted that this was perhaps the most exciting and motivating element of the Race to the Case. The student felt as though the competition fueled by competing against students from rival schools was a driving force for creativity that led to unique solutions, much the same way that competing businesses do battle in today's competitive business environment. One student noted that pressure was felt by their team throughout the competition to bring home a victory for their home school since it was a competition against rival schools.

*Skills Learned and Honed*

Both students commented on the skills they took away from each of the competitions. The engineering economy course forced the students to combine skills learned in a number of their industrial engineering courses to come up with a solution for the company case problem. They noted that at the end of the day, the ultimate goal of both of these competition projects is to save the company money. They noted that they now know how important it is to use engineering economic principles to calculate costs and benefits. The students noted that they learned a great deal about giving final presentations to company representatives. One student observed the value in learning how to create and organize a presentation pitch that would be compelling to a panel of company professionals.

In the Race to the Case competition, both students commented that they learned how to think on their feet and how to work together as a team. One student stated how important it was to be able to deliver ideas succinctly to teammates who may not otherwise understand engineering terms. One student said the need to work effectively and efficiently together as a team was a skill they would have to use in their future careers. The strict time limits honed time management and project management skills while listening carefully to everyone's ideas and leveraging each team member's strengths to produce their best work.

*Like/ Dislikes of Engineering Economy Case Competition*

The students noted that the real life problem presented directly from the sponsoring company was the main aspect they liked about the engineering economy case competition. They both enjoyed the fact that their solutions would be taken into consideration for a solution to this real life problem and felt as though an on-site visit of a distribution center would have added more value to the competition since none of their teammates had ever visited a distribution center. One of the students said the team wished they could have had more given information in the problem statement to help their understanding of the actual problem "less fuzzy."

*Like/ Dislikes of Race to the Case Competition*

Both of the students commented that the final presentation in front of the panel of judges was a great learning experience. One of the students liked the entire schedule of events. They liked arriving the night before and being able to get acquainted with their team after the case was given to the students. A student also noted the short amount of time for each round made it very exciting. One student really liked being able to work with business students to understand their thought process, which may have been very different from their thought process. Both students felt as though the questions asked during the competition were very limiting. They felt as though they were extracting information from the case rather than being creative and trying to solve a problem. They would have liked to see more math and questions that required more critical thinking.

***Overall Comparison and Contrast of the Two Approaches***

Both Penn State and Pitt leveraged case studies for experience-based learning. The cases provided an opportunity for students to integrate theory and practice. Students experienced a near real world scenario through the case. Reflection on the data of the case allows for the abstraction of key principles that led to recommended actions. Cases rarely have one "right answer," or way forward, which fosters critical thinking.

An emphasis on the amalgamation of engineering and business knowledge was a tenant of both Universities' adoption of case study competitions. The ability to collaborate cross-functionally is a key systems thinking skill noted as necessary through both Universities interaction with their respective corporate partner network. In both instances, students reacted favorably to, and were motivated by, structuring the cases as a competition with financial incentives for superior results.

At Penn State the participant population consisted of engineering students from the University. The case competition was a required component of an engineering economy course. An industry partner provided a real world problem for which teams of students proposed solutions in the form of a ten-page report. The five top scoring teams delivered live presentations to a leadership team from the industry partner. The leadership identified the three best proposals.

At Pitt the participant population consisted of cross-functional teams comprises of two engineering students and two business students. The case competition was an optional, extra-curricular activity. Three teams from Penn State, three teams from Pitt (the host), and three teams from West Virginia competed in the Race to the Case. The subject of the competition was a HBS case. The five faculty judges were from Pitt. The corporate judges were from local industries.

### *Overall Suggestions for Improvement*

### *Penn State Industrial Engineering Program*

When students were asked an open ended question to give areas for improvement for the company sponsored case study in their engineering economy course, it was evident the most common response was for the problem statement and charter to contain more detailed information. The real world problem may have been the first time students were working on a real world problem without an answer in the textbook. The students also felt as though more question and answer time, along with face time with the sponsor would have made the case study experience even better. The students would have liked to tour a distribution facility to get a feel for the processes carried out in the facility they were asked to make more efficient. Finally, the students said they would have liked to make fewer assumptions and have more data at their disposal.

The case study sponsor would have liked to see more information presented at the final presentation session. They also felt as though more question and answer time with the students would have improved the case study experience. They suggested having the final presentations at night (outside of class time) to allow more time for the presentation, and more time for questions and answers. They also noted giving more feedback to the students may have helped to improve the experience and they would have liked to have all of the students tour one of their distribution centers while they were working on the case competition.

### *University of Pittsburgh Center for Supply Chain Management*

Following the conclusion of the Race to the Case, faculty representatives from the Center for SCM, and the student leadership team who played a key role in the planning and execution of the competition met to debrief. A key observation was once three teams left the starting location to race to the submission location, the remaining six teams did not rush to submit their response given only the first three teams were awarded a bonus point. A recommended change was to award bonus points to more than the first three teams as a way to pressure the remaining teams to decide the tradeoff between delivery speed and submission quality.

The HBS case provided a near real world experiential-learning activity for the case participants. While providing value to the students, the resulting recommendations had no impact on the real world. Going forward, Pitt would like to find sponsors for the competition from the corporate executive board of the Center for SCM similar to the approach taken in the engineering economy competition. The sponsor would come with a real problem as the subject of the competition, would provide corporate judges to evaluate team submission, and would benefit by applying the best recommendations to resolve their problem. This closed-loop approach to the Race to the Case would fully realize the strategic intent of the Business School at Pitt as well as the desire of the IE program to integrate theory and practice through experience-based learning, collaboration, innovation, and globalization.

## *Conclusions and Future Work*

The goal of both of these case competitions was to give engineering and business students an educative opportunity to solve a real world business and engineering problem in a setting that more closely mimicked the competition, expectations, and scrutiny of the corporate landscape than the traditional engineering and business classroom. For both competitions, the goal was for engineering and business students to find value and appreciation and to understand where the engineering and business principles will be needed to solve similar problems after graduation. The results from this study indicate that each of these goals was successfully met. There were additional advantages shown in these studies, including an appreciation of the students and company representatives for each other and the increased interest in career opportunities with the corporate sponsor. Not only have students networked across disciplines and across schools but also faculty across schools have now developed a working relationship to share ideas, publish, and work on future business and engineering case competitions together.

The feedback collected for these two very different competitions showed the same results; when given the opportunity to compete on solving a real world problem, students embrace the challenge. Students can learn to analyze, process, report, and communicate proposed solutions to real world business and engineering problems when a well-designed case competition opportunity is presented.

The competitive approach and the integration of company representatives into the competitions had additional advantages over a general case study experience. Both competitions gave the students exposure to actual company personnel and real world company projects (or something very similar). This exposure can expand the students' professional network, and possibly lead to employment with the companies taking part in the competition. In addition, the academic institutions have a great opportunity to network with the companies and bring in additional real world case studies for their students while also having a possibility to bring on corporate sponsors for the departments and colleges involved. In addition to the educational benefits for the students, 12 of the students in each of the case competitions were able to obtain funding from their work on the project.

This study does lead to questions of further inquiry:

- Can an optimal case competition be designed that incorporates "The Likes" (Competition, Rival Schools, Real Life Problem, Time Constraints, Business and Engineering Students, Multiple Days) from both case competitions while diminishing the "Dislikes" (Not Enough Math and Critical Thinking, Not a Real Life Problem, Not Enough Information Provided, No Tour or video of the Program at Hand) from both case competitions?
- Can a similar, successful case competition model be instituted into the engineering economy and supply chain management curriculum across the country?
- Can both case study competition models be repeated in the course and in the Race to the Case and continue to produce the same level of student achievement, student appreciation, student motivation, and sponsor appreciation?

- Can a national group such as the National Organization for Business and Engineering (NOBE) embrace this business and engineering case competition concept, and take the concept to network with corporate partners and apply it across its member institutions?

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