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The Development and Implementation of an Expanded Capstone Design Experience by Replacing an Internship Course

Abstract

The Industrial Engineering (IE) program at the authors' university receives continued feedback from industry, the IE Program Industry Advisory Board (IAB), and student evaluations. This feedback indicated the program needed to provide the senior-level students with a more realistic industry experience. Currently, the IE internship course, IE 471, and Industrial Systems Design (IE capstone course), IE 495, are in the IE program curriculum to introduce and provide the senior engineering student an insight into the industrial world. These two courses were evaluated according to the continuous improvement plan for the Accreditation Board for Engineering and Technology (ABET) and changes were recommended.

The IE 471 Internship is offered to give students an occupational experience in an industrial facility. Students and faculty have experienced several disappointing obstacles in executing this IE 471 internship course, including students being unable to convince industry to hire them for an internship course. The students in the authors' IE program are generally nontraditional students. They are generally older students with family and other responsibilities in addition to their education goals. They are generally working 40 hours per week to support the family and meeting a full-time student curriculum. These students are reluctant to give up their current employment and to work for one semester as an intern. These internships are at minimum wage without benefits for the student and his/her family. The student's current job may not be available when he/she returns after the internship. The disappointments the faculty experience stem from students requesting the faculty advisor to consider using their current job responsibilities as their internship. For example, the student may be working as a sales clerk at a cell phone retail store. This position would have no engineering problems or experience.

This paper focuses on the development and implementation of a replacement course for the IE 471 Internship course. Initially, introductory information on the authors' university and Industrial Engineering degree program are presented. Then, the approach in the past that the IE program has taken to implement the internship and the capstone courses is presented. Next, a description of the continuous improvement activities undertaken to make improvements in these courses is provided. This is followed by the description of the replacement course for the internship course, which includes a literature review justifying some of the new curriculum content. Also addressed is the modifications required of the IE 495 Industrial System Design course (IE capstone) so that the student is able to sequentially take these two courses during the their final academic year (fall and spring semesters). Completion of the two sequential courses with a participating industry partner gives the student a more consistent industry experience prior to entering an industrial engineering position.

Introduction

Since 1889, the authors' university, Texas A&M University-Commerce, has gone through many name changes before being incorporated into the Texas A&M University System in 1996. Texas
A&M University-Commerce is a regional university located in northeast Texas and enrolls approximately 9,000 combined undergraduate and graduate students. The university gains its reputation and a large portion of its alumni through its College of Education and College of Business and Technology, in which the Bachelor of Science degree program in Industrial Engineering (IE) is located.

The IE degree program is a growing albeit relatively new program with ABET accreditation. It was approved by the Texas A&M University System’s Board of Regents and Higher Education Coordinating Board and granted special items funding during the 2001 Session of the State Legislature. The original IE program plan projected that 30 students would begin their studies during the first year it was offered. To date, the program has graduated 24 students. All 24 are now employed in the IE discipline with very competitive salaries, representing such reputable companies as Raytheon, L-3 Communications, United Parcel Service, Siemens Energy & Automation, Inc., Campbell Soup, Vista-wall, and Kimberly Clark.

The core IE courses officially started being taught in the fall 2002 semester. During the prior years, the designated engineering faculty members from the College of Business and Technology began developing the degree plan. The curriculum development was constantly being reviewed with industrial advisors and university alumni from associated industries in the university's region and nearby metropolitan areas. The core goal and motivation of this group of faculty members and advisors/alumni was to develop a curriculum that first included a rigorous engineering education but one that was also closely associated with the best practices, experiences and applications of the real world business and industrial professionals for the industrial engineering student.

The prepared curriculum included two courses with industrial experiences providing the student to achieve hands-on actual engineering experience and practice. The two courses selected to present this real engineering application to the student were:

1. **IE 471, Engineering Internship**, three semester hours course----- Occupational experience in an industrial facility. Work experience is cooperatively planned by the department and employer to fulfill the student’s objectives. Weekly conferences, assignments and reports required. Application for internship course must be made 30 days before registration (contact department office for applications). Prerequisite: IE major, junior standing and consent of professor.

2. **IE 495, Industrial Systems Design**, three semester hours course---- Capstone design, flexible manufacturing systems and manufacturing integration; integrates knowledge gained from all required industrial engineering courses in a system design project; for students in their final semester of undergraduate studies. Prerequisites: IE major, senior classification (final semester of undergraduate studies), and consent of professor.

**History of IE 471, Engineering Internship**

At the onset of the program, it was planned that each student who was ready for the IE 471 experience would be responsible for seeking their own internship. The students were given a listing of possible sponsors to contact for an internship. The listing was derived from sponsorships of internships for the school’s industrial technology program and other industrial
partners that had suggested they would sponsor IE internships once the future new program reached that point.

Students early on expressed concerns and problems in landing these required internships. The faculty coordinator for the internship course expressed his concern as to how the student did not show much motivation to campaign for these internships. The faculty coordinator started referring the students to his industrial contacts.

The students had marginal success in capturing internships even with these referred sponsors. It then became apparent there was more to this lack of sponsorship than initially was recognized. It appeared the students were not as interested in working their class schedules with the agreed sponsors. The core IE course curriculum was modified to allow the students take IE 471 during the summer sessions. This approach appeared to make sense since at this time there is minimal demand for IE courses to be offered during the summer sessions. Thus, no engineering courses are offered during the summer. The senior IE students ready for internship should have no class scheduling conflicts with IE courses offering during the summer sessions.

Another obstacle in executing the IE 471 internship course surfaced. The students in the IE program at the authors' university are generally nontraditional students. They are generally older students with family and other responsibilities in addition to their education goals. They are generally working 40 hours per week to support the family and meeting a full-time student curriculum. These students are reluctant to give up their current employment and to work for one semester or a summer as an intern. These internships are at minimum wage without benefits for the student and his/her family. The student’s current job may not be available when they return after their internship. The disappointments the faculty experience stem from students requesting the faculty advisor to consider using their current job responsibilities as their internship. For example, the student may be working as a sales clerk at a cell phone retail store. This position would have no engineering problems or experience.

**History of IE 495, Industrial Capstone Design (IE Capstone)**

As stated earlier, from the outset, the faculty members and the industrial advisors expected the curriculum would have a senior semester capstone design project course. Research showed that many schools have established and been successful with this curriculum approach.

For example, consider the history and success of the senior capstone design course at Harvey Mudd College founded in the 1950s. The original curriculum at Harvey Mudd College was focused on mathematics and engineering analysis and lacked real-world engineering in practice and occupational experience in an industrial facility. In 1963, The Harvey Mudd Engineering Clinic Program was conceived as a way to address these shortfalls. This program has been successful and in operation for more than 40 years. The course is designed for teams made up of four or five student members each. The teams are responsible for developing project plans and technical proposals in concert with the project sponsor. The student teams are fully responsible for executing the project and submitting the deliverables. The faculty advisor becomes the coach and evaluator.
Other IE programs offered in the same state as the authors' university have a senior design course. The following are course descriptions as provided in their respective catalogs:

- University 1 defines their senior design course as Manufacturing Systems Design. This course emphasizes the analysis and design of manufacturing systems. The course uses the team concept with four students per team. As a team, the four students apply their engineering skills to a design project, under the guidance and advice of faculty members and industrial sponsors.

- University 2 has a senior design project course. An individual student is expected to complete an individual industrial engineering design project (not team oriented).

- University 3 has an industrial engineering capstone design course. The course description suggests this is an open-ended design experience through planning and design of an enterprise. The individual student selects a product; determines the necessary processes, equipment, capacities routings and personnel required; develops supporting material handling, inventory, and quality systems; and designs the fully integrated enterprise including facilities layout with estimated cost of operation. This senior project course was specified to be a three semester hour course.

At the authors' university, the current curriculum provides for conducting a one four semester hour IE 495 Industrial Capstone Design course. During a semester (15 weeks duration), each student team in the capstone course had the following course deliverables:

- proposal preparation and presentation to the industry client and faculty advisors, and
- the execution of the proposed engineering project during the same semester

Individual project deliverables included a mid-semester design review, a project status reporting/control, a final design presentation, and a final written report. For the preparation of these deliverables, a very short time period remained within the semester to adequately conduct the execution of the project: analysis, design and a validation phase of the final product or process. The inadequate time provided to accomplish each task resulted in a stressful experience for both the students and the professors. During these project times, the supervising professor observed how the students dropped applying their analytical thought process to the project. The students literally jumped into a panic flow to complete the deliverables without performing systematic engineering tradeoffs and analyses. This is a critical learning period for students and ultimately they are the ones that are hurt when the applications and processes are not fleshed out and acted upon thoroughly.

A prime example of this occurred during the Spring 2006 semester. The industry sponsor for the IE Capstone Design course was a third party logistics company that had a strong presence in the region. The student team was tasked to perform analysis of the sponsor’s warehouse management and logistics system (WMS) at the lowest level and offer process improvement ideas inline with the sponsor’s key performance indicators and customer requirements. The spring semester began January 16, 2006 and closed on May 3, 2006. The sponsor’s management presented the team the statement of work on January 30, 2006. The team prepared and presented its technical proposal to the sponsor’s management on February 8, 2006 with a project go-ahead immediately following this event. The team’s next milestone was the completion of the system analysis and the requirements for the WMS to support a System Operations Requirement Review (SORR) on March 29, 2006. Following the successful SORR, the team and sponsor decided to
narrow the scope of work to a single facet of the sponsor’s operation. With only four weeks remaining, the reduced work was going to be difficult to achieve. This put the team into a very awkward position because without completing the reduced work, the sponsor would not have much value added from the students’ efforts.

**Continuous Improvement Activities**

At the start of the IE program, a three-tier assessment model as shown in Figure 1 was created to monitor the status of program outcomes. Program Educational Outcomes (PEOs), Industrial Engineering Education Program Outcomes (IEPOs), and Industrial Educational Core Competencies (IECCs) are defined, assessed, evaluated, and modified to ensure continuous process improvements within the program. To implement this model a variety of assessment tools were required at each step. These assessment tools included student, faculty and employer surveys, in-class evaluations as well as peer-to-peer evaluations and other related feedback vehicles.\(^2\,^3\) The authors used this assessment model to address the previously mentioned issues with IE 471 and IE 495.

**Figure 1. Industrial Engineering Assessment Model at the Authors’ University**
Armed with an intimate understanding of the operational issues and concerns that faced the faculty during the early years of Industrial Engineering program, the faculty presented their concerns about the IE 471 Internship course to the Industry Advisory Board (IAB). The IAB encouraged faculty members to reexamine and reevaluate the IE program and decide how to improve the program's curriculum. The resulting effort undertaken by the IE faculty curriculum committee determined that creating an effective alternate path for an improved industrial experience would be beneficial to the success of the program, faculty and most of all the students. Taking this new approach allowed the current internship requirement to be eliminated. Once the prohibitive obstacles facing the IE students and faculty advisors with the internship requirement are removed, the number of IE majors should increase, which in turn will enable the IE program to realize an improvement in student retention.

**New Senior Design Course Sequence**

After considering various options, the IE curriculum faculty committee with the approval of the Industry Advisory Board made the decision to convert the IE 471 Internship Course into a Predevelopment Capstone Course. The new IE 471 course is a three (3) semester hour course offered to senior IE students during their fall semester prior to a spring graduation. IE 471 is a prerequisite for the IE 495 Industrial Capstone Design course offered during the final spring semester for the spring graduates.

To determine content for the new IE 471 course, a literature review was conducted to assess and evaluate current trends considered to be critical for maintaining an effective engineering education. There were two major areas in engineering education that seemed to be consistent within the literature. First, it is critical that engineering programs include and/or emphasize equipping the students with knowledge, skills and experience in areas of leadership and management. Findings in “Educating the Engineer 2020, Adapting Engineering Education to the New Century” reveal that it is vital to equip students with knowledge, skills, and experiences in the area of leadership and management. Recommendations were that an engineering education should include courses of leadership and management. Schools such as Purdue and Penn State offer courses in Leadership Studies.  

Also, findings of institutions conducting a National Science Foundation (NSF) grant for “Educating the Engineer 2020” recommended that an engineering curriculum should have the capability to equip student with knowledge, skills and experience in the area of leadership and management. Recognizing the importance of this recommendation, the revised IE 471 will have a component of leadership and team dynamics training. A key deliverable of this new course will be for the students to demonstrate and experience the positive effects of team dynamics.

Consequently, the plan called for IE 471 to accomplish dual objectives: 1) to deliver a face to face course directed towards leadership, team dynamics training, and management in engineering discipline, and 2) to prepare as a deliverable, a proposal for the industrial system design engineering project to be executed in the IE 495 Industrial Capstone Design course the following spring semester. Having the IE 471 class the previous semester to properly prepare a proposal
for the project should allow the teams more time to actually conduct the project and sufficient
time for preparation of the deliverables in the IE 495 Capstone Design course. Also, the IE 495
course structure now can be modified to allow for more of the previously mentioned value-added
engineering efforts (e.g., systematic engineering tradeoffs and analyses) to be realized during the
students' final semester.

Conclusion

This paper presented the development and implementation of an expanded capstone design
experience by replacing an internship course. The original internship course was replaced with a
fall semester introductory senior design course, consequently expanding the senior design
experience to a full academic year. It is anticipated that this change will address concerns about
the internship course and the Industrial Engineering program providing students with a more
realistic industry experience.

The assessment model in Figure 1 showed the critical elements of the authors' program
assessment model as Program Educational Outcomes (PEOs), Industrial Engineering Educational
Program Outcomes (IEPOs), and Industrial Engineering Core Competencies (IECCs). The
IEPOs and IECCs will be defined, assessed, and evaluated for the new IE 471 and modified IE
495 courses to insure continuous process improvements within the program. The faculty will
assess these elements using assessment tools including surveys, in-class evaluations, peer-to-peer
evaluations, employer surveys and other related feedback values. The faculty with the various
stakeholders will then make an overall assessment of the program with these modifications.

After careful review of the experiences gained and the constructive feedback from the students
and faculty over the course of this program, it is the recommendation of the faculty that these
changes in curriculum are critical and timely to the success of the IE students and ultimately the
IE program.

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