Introducing Healthcare Engineering into the Undergraduate and Graduate Industrial Engineering Curriculum

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Abstract – The need to change healthcare delivery has been in the forefront of public awareness and has culminated in the passage of a healthcare reform bill in 2010. Increasingly, advocates for improvement in healthcare delivery are recognizing the potential contributions of industrial engineering professionals. Therefore, for the past several years at Mercer University, we have modified the traditional industrial engineering curriculum to include course components that involve projects related to healthcare engineering. This paper discusses how we have used short course units in required courses, senior design projects and technical electives to help prepare our graduates for careers in the healthcare field.

Keywords: industrial engineering curriculum, healthcare, real-world clients, senior design projects

INTRODUCTION

The need to change healthcare delivery has been in the forefront of public awareness since the publication of the Institute of Medicine's glaring report on the prevalence of medical errors in the US healthcare system. [Institute of Medicine, 5,6] and has culminated in the passage of healthcare reform legislation in 2010. Advocates for improvement in healthcare delivery recognize that increased productivity, cost containment, and continuous quality improvement are essential components of the new approach. [Omachonu, 9]. Increasingly, methods from Six Sigma and lean manufacturing are being applied in the healthcare industry. [Graban, 4] Emphasis on cost containment, increased productivity, continuous quality improvement, and lean philosophy naturally leads to the potential contributions of industrial engineering to the delivery of healthcare [Crane, 2]. Therefore, for the past several years at Mercer University, we have modified the traditional industrial engineering curriculum to include course components that involve projects related to healthcare engineering.

MERCER'S INDUSTRIAL ENGINEERING AND INDUSTRIAL MANAGEMENT CURRICULUM

Mercer University offers an ABET-accredited BSE degree with specializations in the areas of biomechanical, electrical, environmental, industrial, and mechanical engineering. All BSE degree students enroll in a common core of general engineering courses as well as required or elective courses related to their specialization. The required courses in the industrial curriculum reflect a traditional industrial engineering (ISE) curriculum in four areas: manufacturing, operations research, human factors, and quality. The School of Engineering also offers a BS degree in industrial management (IDM). Students in this program take two required courses in their major (industrial management case studies and quality management). They complement their industrial management courses with required courses in industrial engineering, economics, accounting, management, marketing, and psychology. Due to our small class sizes and emphasis on applications of engineering, our students frequently have the opportunity to combine on-site projects with theoretical course content. Meetings with members of our National Engineering Advisory Board allow us to be current with the needs of companies who employ Mercer engineers. We routinely seek their guidance as we update and improve our curriculum. In response to industry demand, we have used short

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course units in required courses, senior design projects and technical electives to help prepare our graduates for changing opportunities in the healthcare field.

Short Course Units in Required Courses

For the past seven years, our industrial management students have been required to complete a senior-level course titled Industrial Management Case Studies. The 3-semester hour course meets twice weekly and has a seminar format. Originally, all of the case studies were based on lean principles applied in a manufacturing setting. However, during the spring 2006 offering, we were given an opportunity to include a real-world healthcare project. The project was initiated by an MD who was the director of quality at a hospital facility in the southeast. Students were asked to observe actual surgeries and recommend process improvements designed to reduce the incidence of retained objects (gauze sponges, needles, etc) as a result of surgical interventions. Students and faculty were required to participate in safety training and sign a confidentiality agreement before being allowed to enter the operating room. The time commitment for data gathering was approximately five hours a week (three hours travel and two hours on site) for three weeks. Data analysis and project presentations consumed four additional class meetings. Although one student was reluctant to go into the operating room to view actual surgeries, all students felt that the hospital project was a positive experience. We received positive feedback from our hospital contact; he subsequently made a commitment to serve as a client for a senior design project at the same facility.

During the same time period, Dr. Laura Moody, who teaches the senior-level capstone course to industrial engineering students, added the healthcare project to her course. In contrast to the industrial management course, where the same project was required of all students, the design of the industrial engineering course gave students the choice of several projects. A team of four students chose the healthcare option and observed at the healthcare facility alongside the industrial management students. Students in this course were required to deliver weekly progress reports and submit a written report at the end of the project.

Sometimes the short course units are initiated by an individual student. For example, every student enrolled in the industrial management case studies course must develop a case study based on a real-world company. Several years ago, a student who had obtained a part time job at a local hospital wrote his case study based on data collected on-the-job. Although the data was modified for proprietary reasons, the case study helped other students in the class understand some aspects of the application of industrial engineering principles in a healthcare environment. The student was subsequently hired full-time at the same facility.

Currently, we are conducting a short course unit in the quality management course in which students are conducting a qualitative analysis of an open response survey that was designed by a real-world client. The project has consumed approximately four weeks of course time and is in progress. The data source is quite rich and will provide opportunities for further analysis in subsequent terms.

Senior Design Projects Chosen by Students

All BSE graduates must complete a two-semester senior design course as part of the common core. Prior to enrolling in senior design, students form their own teams of three or four students and propose a project. The project descriptions are reviewed for scope and technical content before approval. Once approved, students are allowed to enroll in senior design the next term and begin their project. Typically, the first semester emphasizes the design phase and the second semester encompasses the implementation phase. Although the students receive course credit, typically the students are not paid for their work.

As mentioned earlier, the success with the implementation of a short course unit resulted in a commitment to conduct a senior design project at the same facility. The design team consisted of industrial management and industrial engineering students who participated in the short course project the prior term. At first, the team was focused on using their engineering skills to develop an electronic simulation device that would signal the user when an object was retained in the “body cavity”. As the project evolved, it was determined that the client needed a low-tech simulator to aid in-service nurses training. The resulting deliverable was a bean bag filled with Styrofoam peanuts and various small objects (gauze sponges, needles, etc) that are typically the subject of retained object

incidents. The client was pleased with the final design because of its portability and low cost to replicate. The final design presentation included videotapes of the product being used by doctors and nurses at the healthcare facility.

More recently, a senior design team is working on improving an inventory management system for the facilities department of a local hospital. It is interesting to note that the client for the project is one of our own graduates who obtained a position as a management engineer at the facility three years ago. The students are currently completing the design phase and will proceed with the implementation phase next month.

Semester-Long Technical Elective Courses

During the past several years, we have increased the emphasis on healthcare engineering by offering two semester-long technical elective courses with significant healthcare engineering content. During the fall of 2008, the industrial engineering department offered its first semester-long course related to healthcare. The course, Process Improvement in Healthcare, was offered as an industrial engineering technical elective (ISE 491) and was taught by the author of this paper. The two required textbooks focused on operations research [Ozcan, 10] and lean principles [Tapping et al, 12]. The course objectives were as follows:

Upon successful completion of this course, students should be able to:

1. Describe the history of healthcare quality in the U.S.
2. Apply quantitative methods to improve quality of care, efficiency and patient safety
3. Apply tools for the elimination of waste in hospitals, clinics and other healthcare facilities
4. Combine best practices from Six Sigma and Lean Manufacturing to improve operations in at least one Georgia healthcare facility

The course prerequisites included engineering statistics and statistical process control. In addition to the typical lectures and class discussions, the ISE 491 course included case studies including analysis of data obtained from Georgia healthcare facilities. The emphases in this course included exposure to healthcare management terminology and understanding how industrial engineering principles are currently being implemented in healthcare settings. I supplemented the course texts with several lectures on non-parametric statistics which is an area not typically included in engineering statistics. I found two medical statistics texts [Riffenburgh, 11] [Munro, 8] that were especially helpful sources for applications. All students were required to complete a “real-world” project. For the main project, students were asked to conduct a process improvement / time study project at a hospital located 1.5 hours from campus. Students involved in this project were required to participate in safety training and pass a policies and procedures compliance test before being issued a badge. Students who could not travel were allowed to complete an alternate project in which they helped a local hospital analyze data from a call light project that had been conducted by the hospital the previous year. Since weekly oral briefings were required, all members of the class were exposed to operations in two Georgia healthcare facilities. Although there were some logistic difficulties associated with the long distance project, I believe the course met its ultimate goal of expanding the ISE/IDM curriculum to include expertise in healthcare process improvement.

During the fall of 2010, the author taught a course titled Reliability and Quality Assurance. The course was offered in a combined undergraduate/graduate format and taught at night to accommodate the schedules of the graduate students who are employed during the day. For the graduate course (ETM 591), the two required textbooks included one devoted to the applications of reliability engineering [Benbow and Broome, 1] and one that emphasized the application of reliability to the healthcare field.[Dhillon, 2]. For the undergraduate course (ISE 427), the only required text was the applications of reliability engineering book. Unlike the short course unit approach, this effort to add a healthcare focus to the curriculum did not include on-site projects. Since fourteen of the students enrolled in the course were employed full-time in various locations throughout the middle Georgia area, the author believed the logistical challenges outweighed the potential benefits of a real-world project. Nevertheless, through presentations made by the graduate students, all students in the class became aware of some of the challenges and successful efforts to improve the quality and reliability of our healthcare system.

CONCLUSION

This paper detailed how we have used short course units in required courses, senior design projects and semester-long technical electives to help prepare our graduates for careers in the healthcare field. Hospital administrators are aware that our senior design projects provide an opportunity for employers to assess how well a student would fit in to the company [Crane, 2]. As an example, one of our industrial engineering students who completed a senior design project at a local hospital more than ten years ago has been employed in the healthcare industry ever since. Recently, she was asked to serve on our National Engineering Advisory Board. As was mentioned earlier, another student was offered full-time employment with a local hospital after completing a senior design project with the hospital. That graduate is now the client for a current senior design project. Although we have a long history of senior design projects with local healthcare facilities, the incidence of projects is increasing. As more of our students obtain internships or full employment in the healthcare field, the interest in healthcare engineering coursework is increasing. We intend to convert the Process Improvement in Healthcare course from a special topics course to a regularly-offered technical elective in the near future. Due to logistical considerations, we will probably limit the on-site projects that require travel outside of Macon. However, as technology is advancing, we are in the process of developing partnerships that will allow us to gain remote access to healthcare facilities outside of our local area. We believe this will broaden the student experience as well as provide a service to the healthcare community.

REFERENCES

[1] Benbow, D.W. and H.W. Broome , *The Certified Reliability Engineer Handbook*. ASQ Quality Press, Milwaukee, WI , 2008.

[2] Crane, A. B. *Management Engineering: A Scientific Approach to Pinpointing a Hospital's Problems*. Hospitals & Health Networks, Apr 2007, 81 (4)

[3] Dhillon, B.S., *Reliability Technology, Human Error, and Quality in Healthcare*. CRC Press, Boca Raton, FL., 2009.

[4] Graban, M. *Lean Hospitals: Improving Quality, Patient Safety, and Employee Satisfaction*. CRC Press, Boca Raton, FL. 2009.

[5] Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. National Academies Press, Washington, DC, 2001.

[6] Institute of Medicine. *To Err is Human: Building a Safer Health System*. National Academies Press, Washington, DC, 1999.

[7] Langabeer, J. R. *Health Care Operations Management*. Jones and Barlett, Sudbury, MA, 2008.

[8] Munro, B. H.. *Statistical Methods in Healthcare*. 5th ed. Lippincott Williams & Wilkins, Philadelphia, PA, 2005.

[9] Omachonu, V. K. *Healthcare Performance Improvement*. IIE Engineering and Management Press, Norcross, GA, 1999.

[10] Ozcan, Y. *Quantitative Methods in Health Care Management* 2nd ed, Josey-Bass, San Francisco, CA, 2009.

[11] Riffenburgh, R. H. *Statistics in Medicine*. 2nd ed. Elsevier, Boston, MA, 2006

[12] Tapping, D., S. Kozlowski, L. Archbold, and T. Sperl. *Value Stream Management for Lean Healthcare*. MCS Media. 2009.

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