

# **AC 2007-2160: AN EXPERIENCE IN THE DEVELOPMENT OF A COURSE IN HEALTH SYSTEMS ENGINEERING**

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# **An Experience in the Development of a Course in Health Systems Engineering**

## **Abstract**

The healthcare industry is increasingly adopting several Industrial and Systems Engineering (ISE) techniques and methodologies, such as continuous improvement, supply chain management, and total quality management, to ensure customer satisfaction. Best practices are being developed and aggressively disseminated within organizations. In addition, healthcare systems are targeting the optimal utilization of resources while concurrently streamlining procedures to achieve cost effectiveness. ISE concepts have been (and continue to be) effectively used in the healthcare arena.

The healthcare industry in the United States has partnered with academia to work on solutions to issues in numerous areas of which Industrial and Systems Engineering forms only a tiny fraction. It is evident that there is a huge potential for the healthcare industry and the universities to strengthen their collaboration to apply ISE concepts in the healthcare arena. Also, there seems to be a need for ISE professionals with background knowledge of the healthcare industry.

This paper describes our efforts in the development of a comprehensive graduate level course that will educate the students about the issues in the healthcare industry as applied to the ISE field. The course would also provide a summary of the potential ISE tools that could be used as learnt by the students through other courses within the department such as probability and statistics, simulation and modeling, quality, and supply chain management.

First, a comprehensive search on the related courses that were taught across universities in the United States was performed. It was observed that only a handful of universities included some coursework in the field of health systems engineering within ISE departments. The authors had already been closely working with a leading group of hospitals in the area to identify solutions so specific ISE related issues within their emergency departments, operating rooms, and their radiology department. An understanding of the field of telemedicine was also gained from another research team working at the university. This research work and the interaction with the staff at the hospital and the university allowed the team to gain 'first-hand' knowledge of the typical ISE issues in the healthcare industry. Knowledge of specific solution methodologies was also gained, which could serve as great case studies for the students. In addition, a comprehensive literature review was done to identify the work done within the areas of Total Quality Management (or TQM), Supply Chain Management (SCM), and simulation as applied to the healthcare industry. Based on all the above work, three courses were proposed in the field of health systems engineering which included, Healthcare Information Systems, Quality in Healthcare, and Healthcare Systems. A plan to develop a specialization in health systems engineering within the department was developed. After a comprehensive search and review, a textbook was selected, and several were identified for reference. Subsequently, a graduate course - Industrial and Systems Engineering in

Healthcare – was introduced. This course includes an introduction to the issues in the healthcare industry in the United States. It enables students to understand the application of simulation, TQM, and Six Sigma tools. An overview of SCM and outsourcing in the healthcare industry has also been provided. This course has been received very well by the graduate students.

## **Introduction**

The annual spending of the United States on healthcare continues to rise each year and is expected to reach \$3.1 trillion by 2012, which is almost 150% of the total spending in the year 2000 (\$1.3 trillion)<sup>1</sup>. This projected spending is estimated to account for up to 17% of the Gross Domestic Production (GDP) by 2012, up from 13.2% in 2000<sup>2</sup>. In other words, the average spending on healthcare per American is projected to double from \$4,373 in 2000 to \$9,216 in 2012. Hospitals are the single largest segment of the total expenditure on healthcare and will account for about 27% of total projected healthcare expenditure by 2012<sup>3</sup>. Consequently, the healthcare arena is an extremely critical segment of the US economy, and hospitals are perhaps the single most important part of this sector.

In 1999, approximately a third of the hospitals in the USA functioned on negative operating margins; this trend continues to rise<sup>4</sup>. Consequently, in recent years, hospitals have been devising strategies to effectively reduce operating costs without sacrificing the quality of their service.

Recent surveys conducted, by the Kaiser Family Foundation (KFF) and the Agency for Health Care Research and Quality (AHRQ), show that medical errors and malpractice suits against hospitals are leading performance measures (71%) that determine the quality of healthcare provided by the hospitals<sup>5</sup>. Increased public awareness has fuelled the demand for quality care in concurrence with cost competitiveness. This has augmented the need for efficient management and utilization of the resources of the hospitals. Consequently, several Industrial and Systems Engineering (ISE) concepts are being used in the healthcare arena to maximize efficiency and productivity through streamlining and key health and medical-care activities. This involves the use of quantitative and qualitative techniques to identify the efficient utilization of space, time, and resources without compromising the quality of care. ISE concepts and tools can be applied to a variety of set-ups such as operating rooms, emergency rooms, ancillary activities, blood centers, and purchasing/procurement departments.

Clearly, there is an active need of professionals with a background in ISE within the healthcare domain. However, very few ISE departments across universities in the United States have dedicated teaching programs that are catered toward the healthcare industry. Our efforts in the development of coursework in health systems engineering has been outlined in the following sections.

## **Research in Health Systems Engineering**

Our research in Health Systems Engineering began with an exhaustive survey of the available literature with an objective to educate ourselves about the healthcare industry in the United States. Also, potential areas of concern that could be addressed through ISE concepts were studied. The research team involved two graduate students, one project coordinator, and a senior professor. A compilation of some of the key findings from the literature survey was published<sup>6</sup>.

Soon a collaborative research endeavor with a leading group of hospitals was initiated. The first research effort focused on the Emergency Department (ED) to reduce the 'patient turnaround time' (or PTAT). The PTAT was reduced through the use of process mapping, modeling, and simulation. The effect of (i) changes in the patient flow within the ED, (ii) scheduling of nurses to match patient arrival volumes, and (iii) the addition of beds during peak hours of operations were studied through simulation. The recommendations at the end of the work potentially led to a reduction in the PTT of 15 minutes, which would result in annual savings of 15,000 patient hours per year along with an increase in capacity of 4500 patients. The proposed recommendations did not require any additional capital investment or an increase in the number of personnel. Further details on this work can be found in<sup>7,8</sup>.

Subsequently, similar research efforts were focused on the Operating Rooms and the Computerized Tomography (CT) areas of the hospital group. The work has been published in several peer-reviewed conferences<sup>9,10</sup>. Further, the potential applications of ISE concepts in the area of telemedicine were briefly studied. The research team consistently grew with the research work in the healthcare arena.

## **Research and Curriculum in Healthcare**

A survey of the curriculum within ISE departments that was specifically dedicated to the healthcare systems was performed. It was observed that only four universities had exclusive research labs and coursework within the ISE departments that were focused on health systems<sup>11-14</sup>. These research centers were funded through local groups of hospitals in addition to government grants. ISE departments at many other universities had been working in the healthcare domain but did not offer specific coursework related to the healthcare industry. It was concluded that there was a limited effort on training the students of ISE with the knowledge of health systems engineering in comparison with the potential requirement in the industry.

## **Framework for Coursework in Health Systems Engineering**

Based on the knowledge gained through the collaborative research effort and the exhaustive survey of the literature, a plan was proposed to introduce a graduate program in health systems engineering. The program was designed around the core coursework within the ISE department. The framework of the curriculum in health systems

engineering is shown in figure 1. The coursework in health systems engineering was introduced in two phases, both of which are discussed below.

### *Phase 1*

The concept of healthcare systems was first introduced to the students in the form of homework assignments and term papers within the existing coursework. For example, the role of Artificial Intelligence (AI) in healthcare systems was introduced in the AI course that was otherwise limited only to manufacturing. Also, doctoral students were asked to write about specific applications of ISE tools in the healthcare industry as part of their qualifying examinations. Information and perception about the issues in the healthcare industry was gathered through these exercises. Students working in collaboration with the local group of hospitals presented their research to fellow students and faculty in the regular “Manufacturing Group Meetings” that were organized in the ISE department.

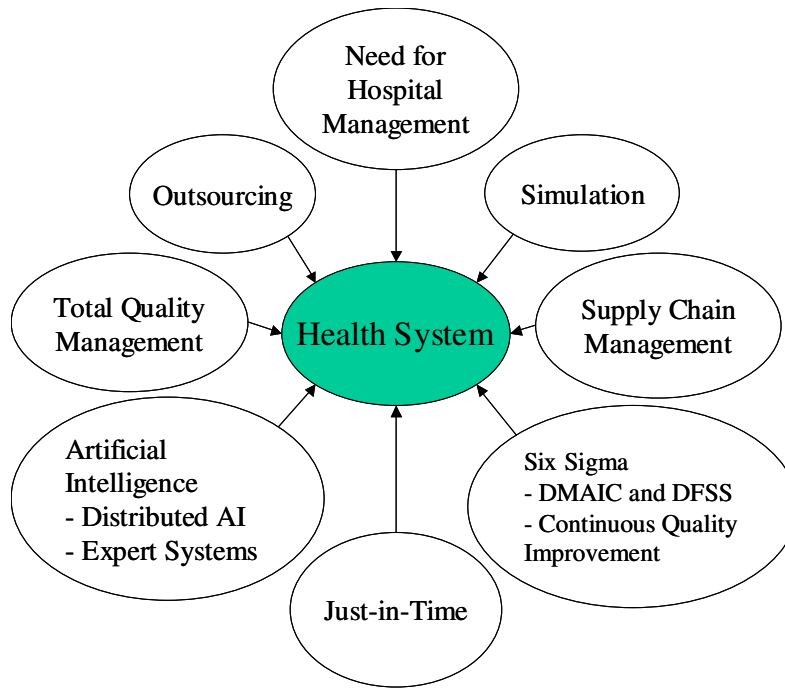


Figure 1. Framework for Curriculum in ISE and Health Systems Engineering

### *Phase 2*

This phase comprised of putting together a structure for multiple courses. Three new courses were proposed – Health Information Systems, Quality in Healthcare, and Healthcare Systems. It was proposed that the healthcare information systems course would address the role of data mining, decision support systems, expert systems, and AI in the healthcare industry. The topics would cover the following:

1. Bioinformatics: theory and applications
2. Stochastic processes and simulation of healthcare activities
3. Clinical Decision Support Systems

#### 4. Artificial Intelligence in Healthcare Systems.

The course on Quality in Healthcare would cover the aspects of Industrial Engineering such as:

1. Total Quality Management in Healthcare
2. Six Sigma in Healthcare
3. Simulation in Healthcare
4. Quality tools and the Healthcare Domain

Finally, the course on Healthcare Systems would largely cover the structure and functioning of the healthcare industry in the United States. In parallel, an exhaustive search for a textbook was made. Several other books that served as reference material were also identified.

One course that covers the elements of all the aforementioned courses (as shown in figure 1) has been introduced in the Fall of 2004, and taught every year since then. The course primarily focuses the application of ISE concepts vis-à-vis the observations and recommendations the Committee on the Quality of Health Care in America<sup>15</sup>. The course was designed to be highly interactive in nature with an emphasis on student participation through project-work and papers. New concepts such as the role of ISE in health systems to prepare against weather emergencies and bio-terror were also discussed in this course. At a macro-level, this course discusses the application of ISE techniques including quality methods, six sigma methodologies, production control techniques, modeling and simulation concepts, the application of inventory theory and just-in-time philosophies, and supply chain management concepts. Numerous technical publications are reviewed, at the rate of at least one per week. All the examinations are 'take home'. They are coupled with homework assignments, a term project and a term paper. All these assignments are designed to help the student research and learn new material. Critical thinking is encouraged. The enrollment and interest in this course has grown over the past three years.

#### **Impact**

The first course on health systems engineering had a significant impact. Several students were introduced to a very different application of Industrial and Systems Engineering. Since the inception of the concept of research and coursework in health systems engineering, students have turned their attention to career avenues in the healthcare industry. Several of our graduates have found excellent career opportunities in health systems, especially at large hospitals.

#### **Summary**

This paper has presented our experience in the introduction of a new course in health systems engineering. The course design evolved through our own research effort in the healthcare domain and through the inputs of several graduate students and faculty members. The course is a first in the series of courses that will enable ISE students to

graduate with a concentration in health systems engineering. The course has been received very well by the student community thus far.

Note: Dr. Kaustubh Nagarkar contributed to this work when he was a doctoral student at Binghamton University.

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