
A Benchmark Study- How Industrial Engineering Undergraduate Programs are Addressing Healthcare Needs

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Abstract

While healthcare in the U.S. has made great strides at improvement, the delivery system still needs major changes, as evidenced by increasing costs (4-10% per year) and ongoing problems with patient safety. Healthcare improvement requires skills in quality, information technology, safety, human factors, and project management, which are all topics taught in the Industrial Engineering (IE) curriculum. However, for IE to accurately address healthcare's needs, curricula need to be enhanced with healthcare applications and reinforced with hands-on experience. As the influence of IE in healthcare grows, it is important to assess if academia is keeping up with this change. This study benchmarked IE undergraduate programs in the U.S. to evaluate their emphasis on healthcare, including courses, certificate programs and concentration areas or tracks. In addition, this study reviews an approach taken by the Louisiana State University IE program through a "Partnership to Prepare Undergraduates in Industrial Engineering for Careers in Healthcare" with the W. M. Keck Foundation as an example of integrating healthcare into IE curriculum. Lessons learned from this study are discussed and used to propose guidelines to integrate healthcare topics in IE curricula. Findings from this research will contribute to a better understanding of the availability of IE programs with a healthcare focus and formally develop as an academic path for undergraduate students.

1. Introduction

Healthcare and medical delivery systems are rapidly changing and striving for improvement, however, the road to improvement for healthcare is slow. A few challenges include rising costs of healthcare delivery, increase in patient volumes, and the high risk of chronic disease in an aging population coupled with a shortage of medical professionals and governmental penalties for readmissions and errors that reduces hospital reimbursements (Nambiar, Bhardwaj, Sethi, & Vargheese, 2013). More than half of all healthcare spending is attributed to waste, that is \$1.2 trillion of the \$2.2 trillion spent by the US annually (PwC, 2008).

Previous studies have shown efforts in utilizing industrial and systems engineering and lean methodology concepts to make improvements in three main areas: data analysis, inefficiencies and waste, and adapting a lean culture (Agarwal, Sands, & Schneider, 2010; Bentley, 2008; Brandao de

Souza, 2009; Gotz & Borland, 2016; Kumar, Ghildayal, & Shah, 2011; Vazquez, 2019). Moldovan (2018) found the most significant lean improvements in healthcare were in standardizing patient care and improving efficiencies and concluded that lean thinking in healthcare could potentially improve process performance, organizational structure and health performance outcomes. The Institute for Healthcare Improvement states that lean thinking in healthcare requires a shift in leadership, culture and processes (IHI, 2005). Additionally, promotion of electronic health record (EHR) systems and digitization efforts combined with the push for more efficient and effective healthcare delivery processes will require data collection and analysis of quality measures (Gotz & Borland, 2016).

Traditional IE course competencies that address these three areas are shown in Figure 1. Even though industrial engineers are taught concepts that can be applied in healthcare, there are still gaps in the widespread use of IE tools. An AHRQ report titled “Industrial and System Engineering and Healthcare: Critical Areas of Research”, identified nine barriers and four facilitators to achieving breakthrough change in healthcare delivery. The report emphasized how crucial IE tools can be in addressing the issues of the healthcare industry. However, a noted barrier is the lack of professionals that understand both IE and healthcare (Valdez, Brennan, & Ramly, 2010). Bridging this gap requires tailoring traditional IE curriculum and tools to the unique needs of healthcare.

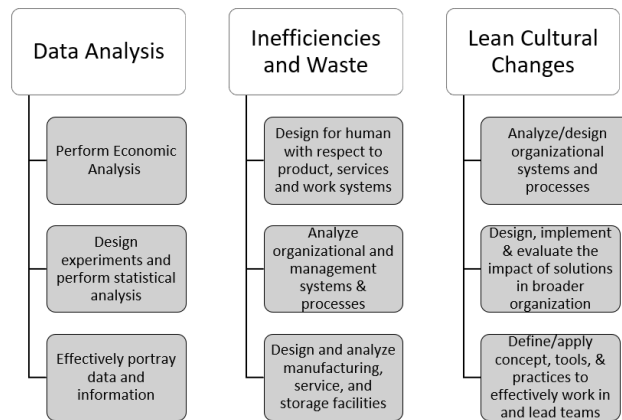


Figure 1: Industrial Engineering Course Competencies related to Healthcare Needs

These gaps are due to the unique differences in healthcare as compared to other industries. For example, metrics are more difficult to operationalize and track due to lack of sufficient IT infrastructure, patient-driven rather than finance-driven project impacts, and teamwork requiring input from multiple disciplines with a single viewpoint (IHI, 2005; Valdez, 2010). It is difficult to drive change in healthcare through the use of data due to lack of transparency with frontline staff. In addition, the lag in healthcare data puts patients at risk for harm to occur before issues are realized.

Traditional IE programs have competencies that meet the needs of healthcare (Figure 1), but there are programs across the US that are specifically designed for the healthcare industry. The purpose of this study is to identify undergraduate IE programs that are taking a step further to bridge the knowledge gap between IE and healthcare.

2. Methodology

The methodology used in this research is of an exploratory nature. The first step in this research was to identify programs being offered in the US specifically for IE in the healthcare industry. For the purpose of this study, the focus was on undergraduate level IE programs across the United States.

The American Society of Engineering Education (ASEE) directory of participating institutes was used to search for institutions in the United States offering an undergraduate degree in Industrial Engineering, Engineering Management, or Systems Engineering in 2018 and whether or not those institutions claimed to have an Area of Emphasis on Industrial Engineering in healthcare (ASEE, 2019). We narrowed down the institutions that met that criteria and reviewed the websites of those programs to find out what is being offered to students to address IE in healthcare, specifically courses, certificate programs, and concentration/emphasis areas.

3. Findings

In total, 91 IE undergraduate programs were found in the ASEE listing out of 279 institutions. Out of the 91 programs, 25 institutions listed healthcare as an area of expertise (Figure 2). The websites of these institutions were reviewed to find out what type of program was being offered to address Industrial Engineering in healthcare.

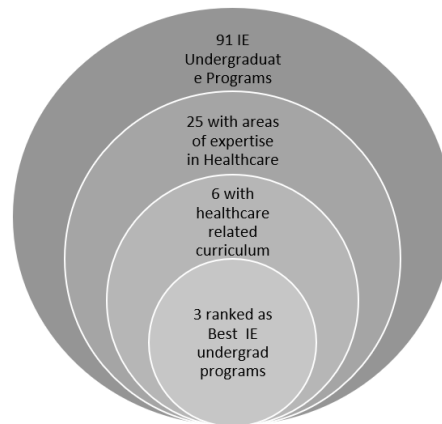


Figure 2: Findings Summary of Universities with Programs Related to IE in Healthcare

We found six universities that offered either an emphasis/concentration area, certificate program or course related to healthcare. Each of the six universities had at least one technical elective course related to IE in healthcare. In addition, two universities offered an emphasis/concentration area, two offered a certificate program, and one had both an emphasis/concentration and a certificate program. The certificate programs all included an initiative to provide students with industry experience through senior design projects or internships with local hospitals and agencies. Out of these six universities, three were ranked as Best IE Undergraduate Programs by US News in 2019 (US-News, 2019). The findings are summarized in the Figure 3 below.

College (Undergraduate IE Programs)	Area of Expertise	IE Technical Elective Course	Certificate	Emphasis/ Concentration	Industry Experience
Purdue*	✓ [?]	✓ [?]		✓ [?]	
University of Wisconsin*	✓ [?]	✓ [?]			
North Carolina State*	✓ [?]	✓ [?]	✓ [?]		✓ [?]
University of Pittsburgh	✓ [?]	✓ [?]	✓ [?]	✓ [?]	✓ [?]
Northern Illinois	✓ [?]	✓ [?]		✓ [?]	
Louisiana State	✓ [?]	✓ [?]	✓ [?]		✓ [?]

University					
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Figure 3: Summary of Offerings from Universities Across the US (* indicates top 12 university)

Figure 4 provides further detail on the healthcare concentration area offered at each institution:

University of Pittsburgh	Northern Illinois University	Purdue University
<ul style="list-style-type: none"> • 6 credit hours of required courses • 3 credit hours of approved electives • Senior design project in a healthcare related organization 	<ul style="list-style-type: none"> • A degree plan is available for Health Systems • Choice of electives from list of courses pertaining to healthcare 	<ul style="list-style-type: none"> • Choice of electives from list of courses related to Healthcare, Healthcare Systems, and Simulation and Optimization

Figure 4: Requirements for a Concentration in Healthcare

Figure 5 provides further detail on the certificate program at each institution:

University of Pittsburgh	North Carolina State University	Louisiana State University
<ul style="list-style-type: none"> • At least 15 credit hours of healthcare related courses • Internship or Co-op within a healthcare organization 	<ul style="list-style-type: none"> • Senior design project in healthcare • Course(s) related to healthcare 	<ul style="list-style-type: none"> • Completion of a Healthcare Engineering Class • Completion of a Seminar Series • Senior design project with a healthcare organization • Internship with a healthcare organization

Figure 5: Requirements for a Certificate in Healthcare

Additionally, information available on the websites about the courses offered at each university were reviewed to get an idea of their content and further explore how these programs addressed the needs in healthcare related to data analysis, inefficiencies and waste and adapting a lean culture. The courses introduced the interconnected sectors in healthcare delivery systems, focused on the management of healthcare services by using IE principles and quantitative decision-making methodologies, and the adaptation of lean and six sigma to rapid and continuous healthcare systems improvement through organizational and process transformation. The courses also looked at the social, regulatory and economic factors unique to healthcare. The contents of these courses tie back to the needs of healthcare (data analysis, inefficiencies and waste, and adapting a lean culture) and show that they are being addressed in a class setting. However, from the information available online, it cannot be determined how effective these courses are in addressing the needs or how in depth the course content is beyond a basic overview.

4. How These Programs Relate Back to the Needs of Healthcare

The courses related to IE in healthcare offered by the six universities provide a basic overview of the industry, which includes the three areas of need in healthcare. A concentration or an emphasis area require students to take a set of courses and may also require them to complete a senior design project. This allows students to get a much better understanding as well as practical experience with the areas of need. Certificate programs require students to complete an internship with a healthcare organization, where students get to understand lean culture and gain practical experience. Figure 6 illustrates the degree to which each program addresses the needs of healthcare:

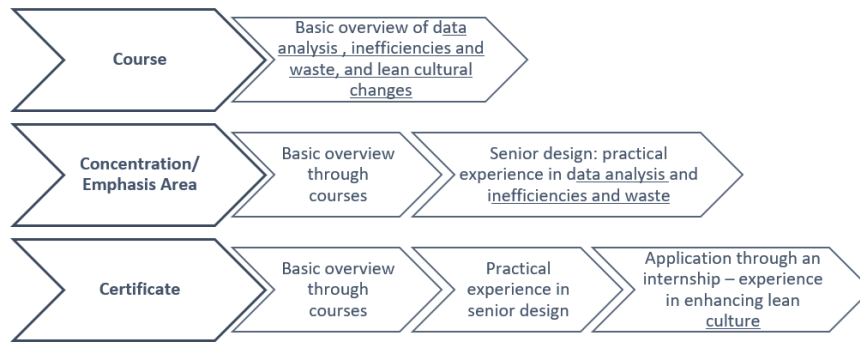


Figure 6: How University Programs Address the needs of Healthcare

5. Case Study: Louisiana State University’s Healthcare Certificate Program

The IE department at LSU has partnered with the W.M. Keck Foundation to create a program titled “Partnership to Prepare Industrial Engineering Undergraduates for Careers in Healthcare”. It is a certificate program created to bridge the gap between IE curricula and the healthcare industry. The program involves completion of a class in healthcare engineering, a seminar series with healthcare professionals, a senior design project in collaboration with a local healthcare organization, and a healthcare internship.

In 2018, which was the first full year of the partnership program, five students completed their internship with the following local organizations: Our Lady of the Lake Regional Medical Center, Baton Rouge General Medical Center, St. Jude Children’s Research Hospital, and East Baton Rouge Parish Emergency Medical Services. Additionally, one student completed their internship with GE Healthcare in Wisconsin. Leaders from the healthcare organizations provided feedback on the performance of the students following the internship and identified areas that they believe require further emphasis to prepare students for careers in healthcare. The five leaders that were surveyed acted as supervisors for the students. This group included one physician, one registered nurse, and three non-clinical healthcare professionals. Their reviews were grouped into the three components, shown in Figure 7.

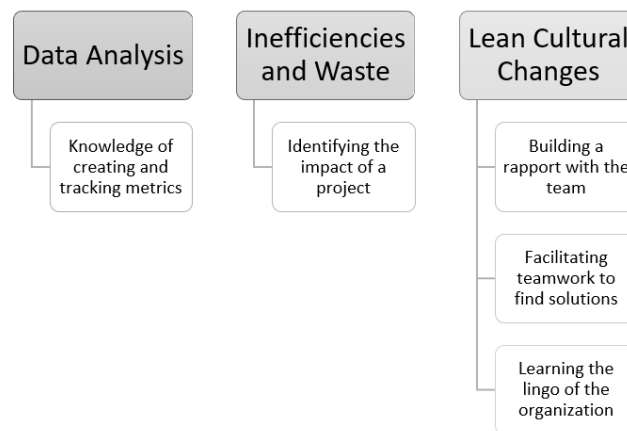


Figure 7: Gaps Identified from Local Healthcare Organizations

From the information gathered in the ASEE search, the gaps identified by the leaders can be addressed by creating programs for healthcare in IE. A course can provide students with knowledge about tracking metrics and identifying the impact of a project. A certificate program or an emphasis

area would provide an opportunity for practical experience where students can implement lean into healthcare and start to understand how to work with a team in a healthcare environment.

With the Keck Certificate Program requiring student to complete coursework, a senior design project, and an internship in healthcare, it is successfully addressing the specific needs of healthcare and reinforcing them with real world experience. In turn, the Keck Program is ensuring industry needs noted by healthcare professionals are met.

6. Recommendations

Three percent (3 out of 91) of universities with an undergraduate IE program have an area of concentration/emphasis in healthcare, while another 3% have a certificate program. Eighty percent (19 out of 25) of universities that list healthcare as an area of expertise do not have any courses, emphasis/concentration areas or certificate related to healthcare. Moving forward, the six universities with existing healthcare curricula in IE can network to share best practices and then spread those to other interested IE programs through workshops, conference presentations, webinars, etc. This will benefit IE students looking for expanded career options, IE researchers looking to apply traditional IE methods to healthcare, and the healthcare industry by providing a skilled workforce to address efficiency and cost problems.

In 2017, healthcare spending in the U.S. grew 3.9 percent, reaching \$3.5 trillion or \$10,739 per person. As a share of the nation's Gross Domestic Product, health spending accounted for 17.9 percent (CMS, 2018). With the healthcare industry being such a substantial part of the economy, it is critical to address its needs. From the results found in the ASEE search, it is evident that there is a lack of undergraduate level IE healthcare programs available. Expanding existing programs and developing new ones will aid in furthering the use of IE principles in healthcare and improve the industry.

For universities attempting to start or expand these programs, the following recommendations are made:

1. Information on healthcare programs in IE needs to be prominent and easily accessible to students.
2. Universities that have faculty that are already conducting research in the area can use their knowledge to support healthcare education in IE.
3. Based on how much emphasis a university wants to achieve, schools can provide courses, concentrations or certificates.
4. IE programs can develop healthcare courses that specifically address the needs pointed out in this research. Current courses address the needs at a very high level and discuss them all in one course. These courses do provide a few ways to adapt traditional IE curriculum to healthcare, but they may not provide enough detail and application to each of the needs.
5. The cultural challenges of adapting lean in healthcare can be tough to introduce in a class, and so a practical experience such as an internship or a senior design project can be a great opportunity to address that need. Consult with local healthcare organizations to create opportunities for practical experience.

7. Conclusion

IE tools and competencies can help address the needs of healthcare. Even though industrial engineers are taught concepts that can be applied in healthcare, there are still gaps in the wide spread use of IE tools because of the lack of professionals that understand both IE and healthcare

(Valdez et al., 2010). Bridging this gap requires tailoring the traditional IE curriculum to the unique needs of healthcare. A benchmark study using a database of universities across the United States showed that only 6 of 91 IE programs have substantial offerings to undergraduates in healthcare-related topics. These universities offer at least one course, concentration/emphasis area, or a certificate program related to IE in healthcare. Based on the findings, it is evident that not enough is being done to tie the IE curriculum to the needs of healthcare. A series of recommendations are made for universities that want to start or expand programs in order to address this gap. There is incredible opportunity for industrial engineers to make an impact in the healthcare industry and the development of these programs can prepare IE undergraduates for a successful and impactful career in healthcare.

8. Acknowledgements

The authors wish to acknowledge the W.M. Keck Foundation for their support in funding the LSU Industrial Engineering program through the Partnership to Prepare Industrial Engineering Undergraduates for Healthcare Careers. This support does not constitute an endorsement by the W.M. Keck Foundation of the views expressed in this report.

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