There is Always A Better Way: The Argument for Industrial Engineering

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Abstract: *Industrial engineering is founded on the idea that there is always a better way. This mantra rings true in everything an industrial engineer does, from lean manufacturing to six sigma, to quality control and ergonomics. This paper demonstrates the uniqueness of this discipline, the impact its techniques has in sectors outside of manufacturing, and the positive effects it has on businesses.*

Keywords: ***Industrial Engineering, Engineering Management, Systems Engineering, Engineering by the Numbers, Bureau of Labor and Statistics, Optimization***

I. Introduction

The term industrial engineering can be misleading. When one thinks of the term industrial, the mind automatically refers to manufacturing or piecework. Merriam Webster dictionary defines industrial engineering as follows: *engineering that deals with the design, improvement, and installation of integrated systems (as of people, materials, and energy) in industry*.

Industrial engineering evolved from piecework and rate setting, initially focusing attention to productive direct labor, with time having a predominant role [1]. Frederick W. Taylor led the development of the industrial engineering discipline. He believed that a factory manager's primary goals were to determine the best way for a worker to do the job, to provide proper tools and training, and to provide incentives for good performance. Frank and Lillian Gilbreth, also contributors to the discipline, collaborated on the development of micromotion study, which evolved into the time-and-motion studies we know today [2].

After WWII, the focus shifted to the well-being of the worker and to quality, and eventually transforming into the discipline we know today, whose scope far exceeds traditional manufacturing and increasing productivity [1].

Here, we will explore the skills and methodologies that make industrial engineering distinctly different from other disciplines. Different industries in which industrial engineering techniques and methodologies can be applied successfully is also discussed. The importance of industrial engineering is detailed, not only relative to businesses but to universities and educational institutions, and the availability of this degree program to prospective and current students both nationally and in Louisiana. The future of the discipline is also discussed with regard to automation and Industry 4.0, as well as different obstacles and challenges one may encounter when transferring these skills to the business world.

It is a common misconception that an industrial engineer's skills and knowledge are limited to traditional manufacturing, and it is my hope that by the conclusion of this article, the reader will have a different outlook and appreciation for this branch of engineering. I also hope to provide insight into the multitude of industries that industrial engineering methodologies can be applied successfully.

II. Methods

Coursework for different engineering disciplines was researched at Louisiana State University for comparing Industrial Engineering to other engineering disciplines. Graduate studies were also researched, which includes Engineering Management programs.

Engineering by the Numbers, a publication that delivers various information on university enrollment and graduates, was also consulted. This publication highlights trends associated with each

engineering discipline and breaks down the top 50 colleges with enrollment for particular engineering disciplines.

The United States Bureau of Labor Statistics provided information for national estimates for this occupation, including industries with the highest concentration of employment, geographical areas with the highest concentration of employment, and the projected growth. It also provided information on employment in Louisiana.

The Business Source Complete library database was utilized to research various articles and journals on Industrial Engineering and the impact it has on different industries outside of manufacturing.

The impact industrial engineering can have on business was also researched, along with different techniques such as Throughput Accounting and Theory of Constraints. Challenges and obstacles facing industrial engineering were also researched in various library databases, such as the development of Industry 4.0, and applying technical problem solving and decision-making to business.

III. Literature Review and Results

3.1 Undergraduate Studies: Industrial Engineering

My analysis began with identifying the uniqueness of industrial engineering. While industrial engineering does share some of the same coursework as other engineering majors, such as Calculus and Physics, the coursework for this major begins to change drastically from other majors once a student typically reaches their 5th semester of studies. Table 1 below shows a comparison of the industrial engineering curriculum to both mechanical engineering and civil engineering curriculums from Louisiana State University [4]. The table below shows crossover classes, as well as classes exclusive to industrial engineering.

Course ID	Industrial Engr.	Mechanical Engr.	Civil Engr.
Calculus I	X	X	X
Calculus II	X	X	X
Statics	X	X	X
Strengths	X	X	X
Mfg. Processes	X	X	
Econ. Principles	X	X	X
Materials		X	X
Fluids		X	X
Dynamics		X	X
Basic Statistics	X		X
Adv. Statistics	X		
Lean Mfg.	X		
QC & Six Sigma	X		
Supply Chain	X		

Table 1: Undergraduate Studies Comparison

As demonstrated above, the industrial engineering curriculum differs greatly from that of mechanical and civil engineering. The courses taken by industrial engineering students arguably constitute more of a business case, and what businesses are moving towards in this day and age: Basic and Advanced Statistics, Lean Manufacturing, QC (Quality Control) and Six Sigma, and Supply Chain.

3.2 Engineering by the Numbers: Industrial Engineering

The academic journal Engineering by the Numbers was consulted, which provides a break-down of engineering bachelor's degrees awarded by school and discipline in the United States. Figure 1 shows the 2016-2017 results. Georgia Institute of Technology holds the top spot for both industrial and mechanical engineering bachelor's degrees awarded, while Texas A&M holds the top spot for civil engineering [5].

Other discipline statistics worth noting are that of civil and mechanical engineering. As shown in Figure 1, mechanical holds the top spot for the number of bachelor's degrees awarded in 2016-2017 with a total of 30,030, and civil engineering holds the 4th highest spot., with a total of 11,920. Industrial engineering holds the 8th spot amongst awarded bachelor's degrees in 2016-2017 with a total of 6,439 [5].

3.3 Bureau of Labor Statistics: Industrial Engineers

The Bureau of Labor Statistics shows current employment of Industrial Engineers in the United States totals to 265,520 as of May 2017. The industries with the highest concentration of employment of Industrial Engineers is as follows (from greatest to least) [6]:

1. Aerospace product and parts manufacturing
2. Engine, turbine, and power transmission equipment manufacturing
3. Semiconductor and other electronic component manufacturing

4. Navigational, measuring, electromedical, and control instruments manufacturing
5. Communications equipment manufacturing

The states with the highest concentration of employment in this occupation are [6]:

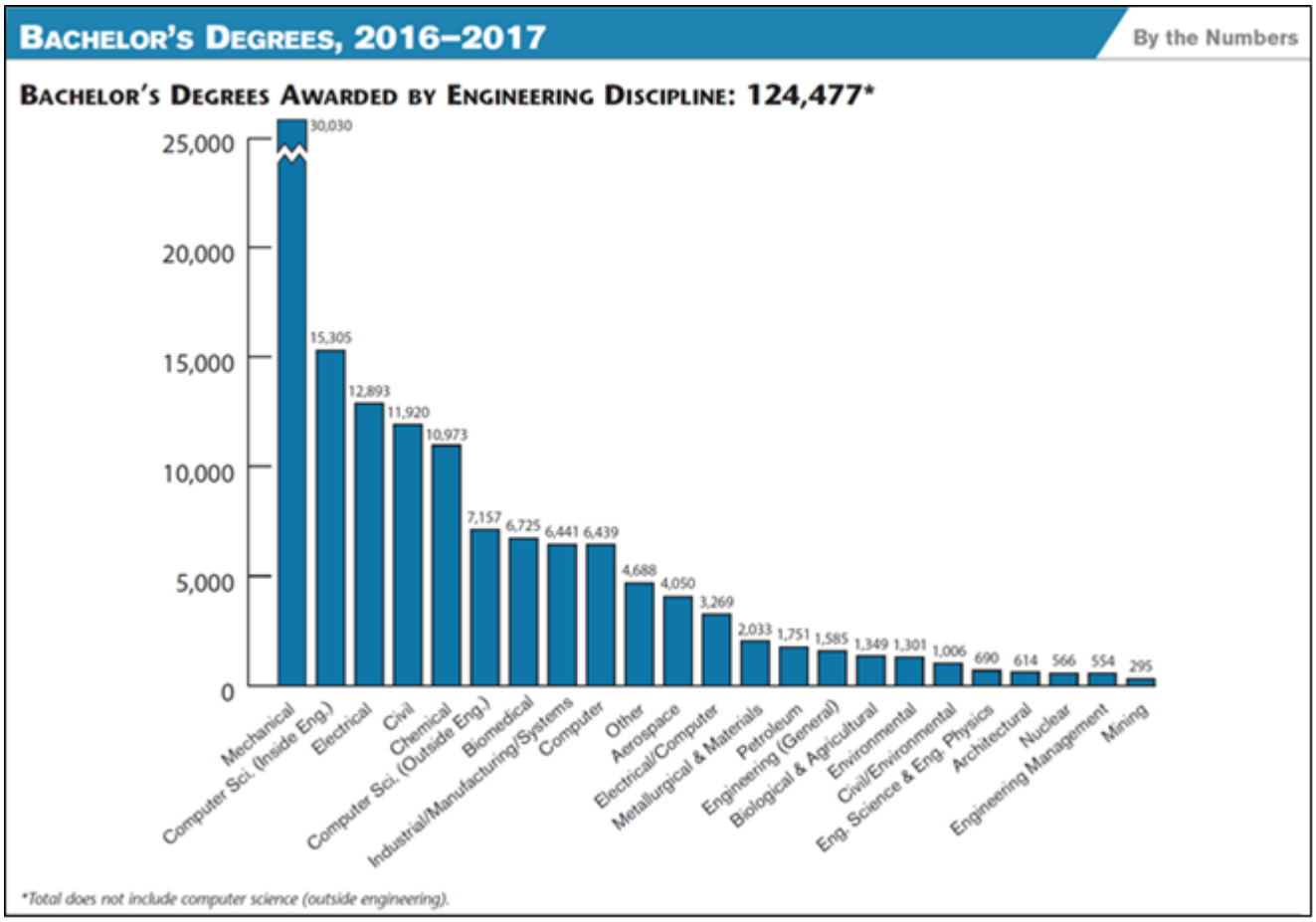
1. Michigan
2. South Carolina
3. Indiana
4. Minnesota
5. Connecticut

The employment total of Industrial Engineers as of May 2017 in Louisiana is 1,760 (only 0.66% of total employment in the United States) [6]. There are a total of 115 universities in the United States that offer industrial engineering as a course of study. Louisiana only has two universities that offer the undergraduate program: Louisiana State University and Louisiana Tech. In 2017, a total of 59 students were awarded Industrial Engineering bachelor's degrees in Louisiana [3].

IV. Discussion

As proven in Section 3, industrial engineering is an engineering discipline which offers a unique set of skills that differentiates itself from other engineering disciplines. However, when compared to other disciplines such as mechanical or civil engineering, its numbers in terms of university enrollment and employment are oddly low [3, 6].

While this discipline has been garnering more attention nationally in recent years (and is expected to increase), attention to the major in Louisiana still lags far behind the rest of the nation [3, 6]. Below, I discuss the positive impact industrial engineering can have on businesses, how they fit into the rise of automation and industry 4.0, challenges and obstacles faced by the major, and the adverse effects of low employment levels of industrial engineers in Louisiana.



4.1 Business Impact

There is one thing for certain: a business must have cash to survive and thrive. A company's cash flow, cash position, and liquidity all play important roles in evaluating a company's financial strength [7]. Industrial engineering can have a major impact on a company's financial strength due to the nature of one's technical expertise. While industrial engineering shares similar skill sets as other engineering disciplines, such as problem solving and critical thinking, what makes industrial engineering unique is where its focus lies: optimization. In other words, an industrial engineer's focus is making the best or most effective use of a situation or resource, something that applies across industries and something that all businesses strive to accomplish within their organization [8].

Optimization is linked to a company's financial strength
because of resource allocation and the ability to streamline processes and reduce cost. It is also not limited to manufacturing; it is inherently diverse in its application [8]. For example, one can study drive-thrus for fast food restaurants to determine which layout provides the fastest service (two windows vs two queues, etc) [9]. This can also be applied to hospitals, by determining how many beds are needed in an ER [10]. The list of application for optimization of resources goes on and on.

Another reason an industrial engineer's field of study has a large impact on business is the fact that one needs to look at a much larger picture than that of other engineering disciplines. To be an effective industrial engineer, one must not only create solutions, but also view possible outcomes of how their solution affects the entire system [8,15]. For example, when applying Theory of Constraints to bottlenecks, one must view how increasing throughput on one bottleneck affects other processes involved, and what other bottlenecks may be produced as a result [11]. Also, one must look at the monetary implications of making these changes. Information about costs and production progress should also not only be fed back to the bottlenecks, but also as a way to foresee and avoid problems [1].

An industrial engineer's work provides a business case in all aspects of optimization and streamlining processes. Companies can benefit tremendously from this application of knowledge to one's business, and the results from these improvements are visible through a number of different performance indicators, in addition to monetary gains.

4.2 Future Trends and Industry 4.0

Manufacturing and other industries are moving towards high-tech automation of processes and tasks. Where do industrial engineers fit into this world of automation? How can process improvement methods be applied to something automated, with no people working on tasks within a manufacturing facility or business?

While there are many benefits to automation, such as speed, consistency and quality, some drawbacks can occur from automating too much, too fast. One proponent of automation is Elon Musk. He stated in 2016 that "You can't really have people in the production line itself. Otherwise you'll automatically drop to people speed." At the time, Musk was working towards having a fully automated conveyor system to produce his Tesla car line. Fast forward to a few months later after he made this statement, and Musk's network of conveyor belts in his production plant are gone. Musk stated "It was not working. So we got rid of the whole thing." While Musk's idea of a fully automated system had good intentions, the implementation of such a system requires a large amount of analysis with regards to many different factors, one of which includes the potential for break downs and maintenance issues, loss of time due to maintenance, and the need for highly-trained people to be able to maintain such a complicated system [12].

Another example of automation gone wrong is Toyota Production Systems (TPS), a company who is well known for their operational excellence. TPS had to learn the hard way from one of their highly automated plants located in Japan that automation is not the answer to everything. The vehicles made at this plant did not sell well, and TPS lost money because of the financial implications of automation: automation offers too little flexibility to adjust to market demand and a high fixed cost. This leads to a high break-even point that is difficult to meet [12].

The lesson to be learned from these two examples is that people are still a critical component needed in automated systems. People are needed to maintain the machines, upgrade them, and deal with anomalies. Also, the same industrial engineering principles can be applied whether a person or machine does the work. People can be trained to see waste even in an automated process, and industrial engineering is key to teaching people to see waste in these automated processes [12].

4.3 Engineering Management

Industrial Engineering's curriculum is closely tied to an emerging master's degree program known as Engineering Management. This degree is offered to those who have received an undergraduate degree in engineering. Engineering Management equips engineers with a crucial mix of business and

technical skills, and exposes engineers to many industrial engineering methodologies such as Theory of Constraints. It provides a foundation in project management, financial management, organizational behavior, and improves leadership skills [3, 15].

Engineering Management is important because it teaches engineers the skills needed to look at an organization in a broader sense. Most times, businesses ask to solve not only engineering problems, but customer problems, organizational problems, and stakeholder problems [3, 15]. Adding organizational context and business context helps broaden an engineer's problem-solving skills and allows them to make better business decisions.

The Engineering Management degree is gaining popularity amongst universities, and enrollment is predicted to increase steadily over the coming years [3]. In 2016-2017 in the United States, 3,225 master's degrees in Engineering Management were awarded (5% of engineering master's degrees). In Louisiana, there are currently two universities that offer a master's degree in Engineering Management: Louisiana Tech, and the University of New Orleans. There were forty graduates that received a Master's in Engineering Management in 2016-2017 in Louisiana [3].

4.4 Industrial Engineering in Louisiana

As shown in Section 3.2 and 3.3, Louisiana ranks among one of the last states in terms of industrial engineering graduates, universities that offer the degree program, and employment in this field. This may be linked to poor recruitment and advertisement by universities and companies, and lack of knowledge of the discipline's existence or field of study. Low availability of the discipline in Louisiana universities is a major contributing factor, because the fewer colleges that offer this degree in the state means a lower enrollment in the degree program. Long term, this could be detrimental to Louisiana business, as shown in Section 4.1.

As stated in Section 3.3, the industries with the highest concentration of industrial engineers are [6]:

1. Aerospace product and parts manufacturing
2. Engine, turbine, and power transmission equipment manufacturing
3. Semiconductor and other electronic component manufacturing
4. Navigational, measuring, electromedical, and control instruments manufacturing
5. Communications equipment manufacturing

According to the Louisiana Economic Development website, the key industries in Louisiana contain Aerospace and Advanced Manufacturing. Even with these two industries alone, industrial engineering should garner more attention from universities and businesses in Louisiana due to the nature of an industrial engineer's services [13].

Industrial engineering is also gaining more attention in the areas of healthcare and government agencies. These two sectors utilize industrial engineers to provide their expertise to streamline processes. Both of these sectors, not just in Louisiana but across the nation, can benefit from industrial engineers [10].

4.5 Challenges and Obstacles

Even with an industrial engineer's skill set and expertise, there are still many challenges and obstacles one may face. As mentioned before, cash is king, and businesses most often focus on the financial impact of projects and processes as opposed to technical metrics. Some of these metrics may be difficult for those without a technical background to understand, limiting communication of a project's success between engineers and those with a business or management background. One way to counteract this is by focusing on equating improvements to monetary value [14].

Another obstacle industrial engineers may face when implementing improvements is that of cost accounting. Cost accounting is the traditional approach to accounting, and one that majority of businesses still use today. Cost accounting's major limiting factor is that it does not provide information in a format to help management identify, prioritize, and solve problems on a day-to-day basis. Stagnation in cost accounting's methods leave engineers and managers with the impossible task of making day-to-day decisions based on overall company metrics, such as net profit and return on investment. However, there is a way to bridge the gap between cost accounting and measuring the impact of local improvements, and this is by utilizing throughput accounting [14].

Another potential obstacle is that an engineer's mindset is considered to be much different than that of a manager or salesman, and are unjustly accused of having their heads buried in numbers and product design rather than concerning themselves with business and managerial decisions. However, it is not that an engineer is incapable of making management decisions; in fact, most engineers are consulted to make key decisions based on their ability to analyze and solve problems. The problem lies in engineers exchanging their roles as doers and executors to that of advisors and catalysts for solving problems [1]. One way to encourage this mindset is to refine an engineer's business skills by incorporating more business courses into engineering curriculums, as explained in Section 4.3.

V. Conclusions

Industrial engineering was born out of piecework manufacturing during the Industrial Revolution. The focus was initially on time reduction and efficiency, and then broadened into other areas of study [1]. The discipline has adapted and evolved over the centuries due to the changes in technology and manufacturing environment. This evolution was critical to the survival of the discipline and has proven the chameleon-like properties that industrial engineering techniques possess. This has also opened doors for industrial engineering to permeate other sectors outside of manufacturing. Application of these methods has shown great improvements and success, especially in areas such as health care and the government [1, 8, 10].

Industrial engineering will be especially important with the boom of automation and Industry 4.0. Integration and implementation of these complex systems require analyzing the system in its entirety, including placement of knowledgeable personnel to manage and maintain the system, as well as analyzing the risks associated with high fixed-cost and inability to adapt to changes in the market [12].

Even though industrial engineering is gaining popularity amongst industries outside of manufacturing, enrollment in universities and employment levels are still low when compared to other engineering disciplines, especially in the state of Louisiana. Universities in the state need to understand and recognize the importance of this discipline and the positive impact it can have in industries that are crucial to the economic health and development of Louisiana.

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