Service Sector Systems Engineering: The Early Stages of an Innovative Degree Program

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ABSTRACT: *This past year the College of Engineering at Michigan Technological University has initiated a study to develop a new degree program which we are calling Service Sector Systems Engineering. An industrial advisory group has met and we are convening a panel of experts from industry and academia for a Delphi study to reach consensus on the curricular requirements for this new discipline. The Delphi technique was first developed in the business world as a forecasting and consensus-building method and it has subsequently been adapted for use in academia. Approximately 80% of the U.S. economy is based on the service sector in terms of employment and this segment of the economy is the fastest growing. Providing engineering talent to this vital area will be critical to our long-term sustainability and the improvement of our quality of life. It is anticipated that this new discipline will have many features of the traditional industrial, management, and systems engineering degree programs and it will be an attractive degree option for females and under-represented minorities who are attracted to the people- oriented service areas. Service providers who would be interested in this degree include health care and social assistance, transportation and logistics/distribution, security, real estate and leasing, financial systems, entertainment and recreation, information, public administration and policy, hospitality and food services, etc. The results of the Delphi study and the elements of the proposed curriculum will be presented at the conference. This effort is part of the NSF Department-Level Reform of Undergraduate Engineering Education program..*

1 BACKGROUND

The modern-day engineering profession has its origin in the 14th century where artists such as Leonardo daVinci were hired to design better weapons or better defenses, depending on the client [Ferguson, 1992]. Early engineers were engaged in the art of war—building better roads, bridges, and sanitation systems. Soon, the civilian population demanded luxuries such as those afforded the army, giving birth to civil engineering. With the dawn of the Industrial Age, mechanical engineering evolved to feed the need for individuals who could design and build efficient steam-powered machinery. Electrical and chemical engineering soon followed as the standard of living continued to improve in the developed world. Engineering disciplines have continuously evolved throughout history, giving birth to disciplines such as biomedical, computer, aerospace, and others. Throughout its long history, however, the engineering profession has been clearly focused on designing better devices or manufacturing processes.

At the same time the engineering profession evolved to meet the needs of society, the economic basis for society also changed dramatically, due in large part to the technological advances that were developed. Two hundred years ago, the economy was primarily based on agricultural production. Manufacturing superceded agriculture in the past century, however, today's economy is based largely upon the service sector. Today, the service sector accounts for nearly 80% of all economic activity, far outstripping manufacturing (14%) and agriculture (2%) [NSF, 2001]. It is clear that long-term sustainability issues for the global economy will ultimately depend on how well we manage our food supply and other supply systems, our transportation systems, our natural resources, and our water systems. In other words, global sustainability will hinge on our ability to manage the service sector. In March of 2004 William A. Wulf, President of the National Academy of Engineering, spoke at a conference sponsored by the American Society of Mechanical Engineers regarding engineering in the coming century. In his speech, he highlighted the need for engineers to be involved in solving the problems of the service sector industries.

However, even though NSF and other bodies recognize the need for engineers to work within the service sector, present-day engineering curricula are inadequately suited to meet the needs of the sector. The curricula reflect a focus on designing and building better machines, instruments, and other devices or improving manufacturing processes. Major design experiences are geared towards solving problems in the manufacturing and construction industries. Thus, if we are to better serve society and students for work in the 21st century, we believe that it is essential to provide them with an engineering career path aimed at the service sector.

A working definition of service sector engineering is that it is focused on integrating industrial and systems engineering methodologies in the design and operation of service systems for non-manufacturing industry, academic, and public sectors. Areas of focus will likely include simulation modeling and analysis, distribution and logistics, facilities design, work design, quality improvement, transportation systems, economic analysis, information transmission/communication, decision analysis, psychology, human factors, marketing, and management policy and organization. It is envisioned that graduates of a Service Sector Engineering degree would support the following industries:

- Accommodation and Food Services
- Waste Management and Remediation Services
- Arts, Entertainment, and Recreation
- Educational Services
- Finance and Insurance
- Health Care and Social Assistance
- Information
- Public Administration & Policy
- Professional, Scientific, and Technical Services
- Real Estate and Rental and Leasing
- Retail and Wholesale Trade
- Transportation and Warehousing
- Utilities
- Security
- Others important to sustainability and the quality of life

2 BROADER IMPACTS

There is evidence to suggest that groups that are underrepresented in engineering, particularly women, are attracted to careers where they feel that they can have a positive impact on society. In a presentation given by eminent scholar Sheila Widnall [Widnall, 2000], Institute Professor at MIT, she cites the "Top Ten Reasons that Women don't go into Engineering." Number one on this list is: "Lack of connection between engineering and the problems of our society. Lack of understanding what engineers do." In a recent Chronicle of Higher Education article [Farrell, 2002], responding to a query about how engineering can attract more women, Domenico Grasso, director of engineering at Smith College, is quoted as saying "The challenge for engineering programs is not to show that math and science are fun, but that these disciplines have social value and relevance."

In recent articles in the Woman Engineer magazine [Wolff, 2003; Amato-McCoy, 2003], careers in fields such as civil and environmental engineering were highlighted as a means to have a positive impact on society. Also, in a recent issue of Minority Engineer [Meyer, 2003], an article appeared extolling the virtue of an engineering career in a governmental agency, serving society through technological expertise. Colorado School of Mines has recently implemented a certificate in "Humanitarian Engineering" that stresses service to society, particularly in the developing world. This program has experienced broad appeal for public-minded students [Konegni, 2003].

Being able to design and build a faster race-car simply does not appeal to most women and does not attract them to the engineering profession. It is primarily for this reason that engineering disciplines with a strong environmental or human focus (environmental, chemical, biomedical, and industrial) rank among the highest in terms of their ability to attract women students. At Michigan Tech, for example, women make up 50% of the students in environmental engineering, around 50% of the students in biomedical engineering, and around 40% of the students in chemical engineering. (Michigan Tech does not currently

have an industrial engineering program.) These proportions mirror national enrollment trends and clearly illustrate the appeal of "society minded" disciplines for women. We believe that an engineering program that promises students the ability to work in the service sector will have broad appeal to women and minorities in ways that traditional engineering programs can not.

3 DELPHI TECHNIQUE FOR CURRICULAR DESIGN

In September 2003, we received a planning grant from the Department-Level Reform program of the NSF to define a new engineering curriculum with the help of industry leaders—Service Sector Engineering. Through our planning activities to date, we have identified several components of a potential curriculum for this new discipline. In our planning project we have been utilizing a systematic method for the design of a suitable curriculum for Service Sector Engineering. The technique for curriculum design that we are employing during this planning stage is a Delphi Study, which utilizes a diverse panel of experts and statistical analysis to establish characteristics and content for the new program.

A Delphi Study is a consensus-building forecasting technique that has been used by organizations, agencies, and corporations for making predictions and setting agendas. Although this technique was developed in the "business world," a number of educational leaders have suggested its use in the design of curricula and programs [Clark & Scales, 1999, Paige, Duggar, & Wolansky, 1996, Volk, 1993, Zargari, Campbell, & Savage, 1995]. In this context, a Delphi Study typically consists of four rounds (but could have more or fewer), conducted with a panel of experts, to reach consensus on defining the important elements of a curriculum. A Delphi Study also lends itself to reaching consensus without a need for face-to-face meetings among panel members, making the study relatively easy to implement, especially for a panel with broad geographic representation among its members. For these reasons, we are employing the Delphi technique in the development of the curricular requirements for the Service Sector Engineering discipline.

A key to conducting a Delphi Study for curricular design is to identify and recruit an appropriate panel of experts. For our planning grant activities, we have contacted program officers at NSF, attended an NSF-sponsored conference on engineering the service sector, met with individuals from various industrial advisory boards associated with Michigan Tech, and networked with others identified through our efforts. We sent a letter to potential panel members asking for their assistance in defining the curriculum.

In December 2003, we conducted a brainstorming session with industry leaders on Michigan Tech's campus to help us identify topics that might be important for the service sector engineering curriculum. The following is a list of some of the curricular topics identified by these leaders:

- How an organization works
- Psychology – creativity, innovation
- Resource Allocation
- Customer/client relations
- Service systems – measurement, metrics
- Leadership and change management
- Management/management philosophy
- How does an individual make decisions?
- How does an organization make decisions?
- Documenting how processes work
- Reference Models (SCORE, ITIL)
- Performance Metrics
- Benchmarking
- Six Sigma, Reliability
- Quality Assurance
- Perfect Order Performance
- Decision making
- Modeling processes
- Data collection/management/analysis
- Statistical work
- Supporting metrics with tools
- Domain knowledge
- Optimization/networks
- Queuing
- Simulation
- Legal issues
- Project management
- Scheduling
- Risk assessment, insurance
- Estimation, bidding
- Government issues
- Regulations/compliance
- Budgeting/accounting
- Finance/economic justification
- Algorithms/computing

After establishing our panel of experts and identifying potential curricular topics, we began the Delphi Study. For the first round of the study, we developed a survey instrument that was based on examples from previously successful curricular Delphi studies [Wicklein, 1993, Adler & Ziglio, 1996, and Jones, 1996]. This instrument contains several categories and characteristics that might be relevant to a Service Sector Engineering curriculum. In the first round, experts are asked to accept, modify, delete, or add to the list of categories and characteristics on the instrument. Panel members then have several options: 1) they can state that an entire category be deleted, 2) they can select individual characteristics from each list for deletion, 3) they can add to the list of characteristics within a category, or 4) they can rename individual characteristics. In addition, since there are several categories that they are evaluating, they can move items from one list of characteristics so that they fit under a different category if necessary. When developing our initial round one instrument, we took care to ensure that all categories and characteristics were listed randomly so that we can obtain unbiased feedback from panel members. In the second round, experts will be asked to rate each category and characteristic on a 5-point Likert scale. In round 3, they will rank order categories and characteristics within each category. In the final round, panelists will again be asked to either accept or reject surviving categories and characteristics.

The first survey instrument was mailed to our panel experts at about the time that this conference paper was submitted. Over the next 5-6 months we will work with our panel to refine our list of curricular topics through several more survey rounds and will likely have preliminary results to share at the time of the conference. Based on our preliminary findings, courses within the new curriculum will likely focus on:

- Processes of the service sector
- Scheduling, estimation, and contracts
- Risk assessment, quality assurance, and data management
- Modeling and simulation
- Statistical analysis, optimization, and decision-making

4 CONCLUSIONS

Throughout history the engineering profession has continuously evolved to meet the changing needs of society. Because global economies are becoming increasingly dominated by the service sector, it is imperative that engineering education be transformed accordingly. Traditional engineering education has focused on improving products or manufacturing processes resulting in vastly improved efficiency and cost-savings. The service sector of the economy will also benefit through the application of engineering problem-solving capabilities aimed at improving its processes. The service sector engineering program may also enable us to attract a greater number of women and minorities to the engineering profession in ways that traditional programs can not.

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