Developing a Curriculum in Service Systems Engineering

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Abstract

Over the past two decades, there has been a significant decline in the size of the manufacturing sector. The engineering academic community has responded slowly to this change. Although some Industrial Engineering (IE) undergraduate programs have added service-focused content to their curricula, such additions are generally not fully integrated with other courses to provide holistic coverage of service systems engineering issues. The paper will describe the curriculum design and development and course selection for the Service Systems Engineering program. Finally, the lessons learned and the next steps to creating a multidisciplinary minor will be outlined.

Keywords

Service systems engineering, new curriculum, multidisciplinary

1. Introduction

Over the past two decades, there has been a significant decline in the size of the manufacturing sector. The engineering academic community has responded slowly to this change. Although some Industrial Engineering undergraduate programs have added service-focused content to their curricula, such additions are generally not fully integrated with other courses to provide holistic coverage of service systems engineering issues. After an extensive review of IE, engineering management, and systems engineering curricula, the Delphi technique was used to develop a multidisciplinary curriculum focusing on Service Systems Engineering. A Delphi Study is a consensus-building forecasting technique that has been used by organizations, agencies, and corporations for making predictions and setting agendas [6,7,8,9]. It was developed as a management tool but it is beginning to gain acceptance as a curricular development tool. The Delphi Study technique lends itself to reaching a consensus without the 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, a four round Delphi Study was conducted to reach consensus on the curricular requirements for a Service Systems Engineering program.

The curriculum was established within the Bachelor of Science in Engineering program at Michigan Tech, which is an ABET accredited program. This Service Systems Engineering curriculum has obvious overlap with traditional IE programs, but it also includes unique features due to the emphasis on service systems. The paper will describe the curriculum design and development and course selection for the Service Systems Engineering program. Finally, the lessons learned and the next steps to creating a multidisciplinary minor will be outlined.

2. Background

Services offerings are multidisciplinary requiring a curriculum that integrates engineering, sciences, and business. Part of the driving force behind the multidisciplinary curriculum development is based in part from the IBM Service Science, Management and Engineering [1] initiative. Another important component of the curriculum development

efforts were based on two NSF funded projects. The first project was an NSF planning grant allowing for the curriculum team to complete a Delphi Study on what the proposed content would be for a service systems engineering curriculum. The second project was an NSF CCLI grant that funded the finalizing of the content mapped into specific courses and the development of eight new courses with primary emphasis in industrial engineering tools, techniques, concepts, and applications with sole focus on service systems.

Many at IBM and in academia advocated a bold approach – creating a new academic discipline called *services science* [2][3][4], which aims theories and methods from many different disciplines at problems that are unique to the service sector. At the start, the particular disciplines (including some engineering, social science, and management disciplines) and the particular problems (e.g., improving service innovation and service productivity) were not clear [5]. Instead of using the name service science, we chose to call our program Service Systems Engineering (SSE). This is based on the initial studies we completed on what the curriculum should include, which indicated a heavier emphasis on engineering than on the science or management of services.. After reviewing the content, we felt that SSE was a better description of the discipline and aligned well with our existing ABET accredited Bachelor of Science in Engineering (BSE). The content of the program was primarily determined based on the SSE Curriculum team and their respective disciplinary backgrounds.

3. SSE Curriculum Development Team

The curriculum team consists of five Michigan Tech faculty and four external panelists. The Michigan Tech team consists of faculty representatives from Mechanical Engineering-Engineering Mechanics, Electrical and Computer Engineering, Business, Computer Science, and Civil & Environmental Engineering. The external team members are primarily in Industrial and Systems Engineering departments at University of Miami, Ohio University, Montana State University, and University of Illinois-Urbana-Champaign. Additionally, we have an instructional designer/education specialist from Northern Michigan University who serves as the program evaluator. This diverse team has allowed for a comprehensive evaluation of the initial curriculum. After the eight courses are completed, as a part of our continuous improvement process, will include evaluation and assessment to modify the curriculum based on our lessons learned. This will be done in conjunction with the program evaluator.

4. Programmatic Information

The Bachelor of Science in Engineering (BSE) allows for tailoring of the degree program based on a student's interests. It also allows for easily moving into a fifth year professional masters of engineering program or other professional masters programs like an MBA. The key highlights of the program include the following:

- Take advantage of coursework in an engineering technical emphasis area,
- Obtain certification or a minor in an approved university program,
- Receive a solid program in basic engineering principles,
- Acquire a sound technical education with flexible career path, and
- Spend a fifth year to earn a Master of Engineering or other professional masters.

4.1 Program Overview

The BSE degree is an engineering program based on courses that are fundamental to all engineering disciplines. Courses in technical areas meet engineering accreditation standards while still maintaining a large number of elective courses. The elective courses allow completion of a university approved minor or certificate program. This structure allows students to pursue an innovative and individualized path to career objectives that fulfill the requirements of an accredited engineering degree. The details will be provided in Section 5.

4.2 Program Objectives

The program objectives include:

- A sound technical foundation with a disciplinary focus and the flexibility to pursue professional interests in areas outside of engineering that could lead to a wide variety of career paths.
- In-depth technical preparation in multidisciplinary or emerging engineering fields that could serve as a springboard to professional degree programs such as the Master of Engineering.
- The knowledge, skills, and attitudes needed to facilitate a lifetime of professional success. These attributes would include excellent communication skills, an understanding of ethical and global issues, and a commitment to life-long learning and professional development.
- The ability to function on multidisciplinary teams that extend the traditional boundaries of engineering.

4.3 General Information About the BSE
The BSE program is a College of Engineering (COE) program and is administered by the Engineering Fundamentals Department. Periodic review and assessment of these program objectives rely on input by the COE and department Industrial Advisory Board, the Engineering Council (COE department chairs) and the entire COE faculty.

5. Curriculum Structure
The curriculum consists of foundation courses for the Bachelor of Science in Engineering, eight Service Systems Engineering courses (technical emphasis), and directed electives.

5.1 Foundation Curriculum – Bachelor of Science in Engineering
The foundation curriculum was based on the ABET approved program and then added the requirements for an emphasis area for Service Systems Engineering. This poses limitations regarding the flexibility of adding courses that we feel may be more appropriate for this discipline and which would also be typical of a foundation curriculum in an Industrial Engineering undergraduate program. A core of engineering fundamental courses (26 to 27 credits) is required for the BSE degree. These fundamental engineering topics include problem solving, ethics, computer use and analysis, teaming, statics, strength of materials, materials science and engineering, basic circuits and instrumentation, thermodynamics, and fluid mechanics. In addition, students must complete a minimum of a one semester senior design project and one of three possible design implementation options. The design implementation courses expose students to the many facets of executing typical engineering projects. The purpose of leaving the traditional topics (i.e., statics, mechanics of materials, thermodynamics, etc.) in the curriculum was to enable students to be able to meet the educational requirements to sit for and pass the Fundamentals of Engineering exam to obtain eventual licensure. It also allowed us to offer a new program without going through the ABET to obtain approval for a new discipline. The foundation curriculum includes the following:

University defined General Education (22 cr.)

Mathematics (15 cr.)
MA1160 Calculus with Technology I
MA2160 Calculus with Technology II
MA2320 Elementary Linear Algebra
MA3520 Elementary Differential Equations
MA3710 Engineering Statistics

Science (11 cr.)
CH1100 General Chemistry
PH1100 Introductory Physics Laboratory I
PH2100 University Physics I - Mechanics
PSY2000 Introduction to Psychology

Engineering Core (26 cr.)
CS1121 Computer Science 1
ENG1101 Engineering Analysis & Prob. Solving
ENG1102 Engineering Modeling & Design
ENG2120 Statics & Strength of Materials
MY2100 Intro to Materials Science & Engineering
EE3010 Circuits and Instrumentation
ENG3200 Thermodynamics & Fluid Mechanics
ENG4900 Multidisciplinary Senior Design Project I

5.2 Service Systems Engineering Technical Emphasis
The Service Systems Engineering Technical Emphasis area consists of eight new courses, all starting with the SSE prefix, and two existing courses in engineering and technology. The two existing courses include coverage of service systems applications. These courses include:

Service Systems Engineering (30 cr.)
SSE2100 Introduction Service Systems Engineering
SSE2300 Service Systems Design
SSE3200 Web Based Services
SSE3400 Human Interactions in Service Systems
SSE3500 Operations of Service Systems
SSE3600 Optimization and Adaptive Decision Making
SSE4300 Project Planning and Management for Engineers
SSE4600 Managing Risk
MET4400 Simulation
MEEM4650 Quality Engineering

The course descriptions for each of the SSE courses are provided below:
SSE 2100 - Introduction to Service Systems Engineering Introductory course covers the evolution of service systems engineering within the broader context of the engineering disciplines. Careers and professional practice within the discipline will be explored. Topics include systems analysis and design, introduction to quality tools and

service systems engineering examples.

SSE 2300 - Service Systems Dynamics and Design Introduces system dynamics principles and explores the effect of system structure and variable interactions on system behavior. Waiting line theory is introduced. Other topics include simulation, mental models, socio-technical systems, rational decision-making, and design. Prerequisite: statistics

SSE 3200 - Analysis and Design of Web-based Services The strategy behind developing web-based service systems will be the focus of the course. Topics will include flowcharting, cost estimating, performance measurement, database management, and alpha and beta testing. A semester will illustrate the use of these tools. Prerequisites: computer programming and SSE2300.

SSE 3400 - Human Interactions in Service Systems Understanding the social, cognitive, and cultural influences on individual and group behavior is the focus of the course. Methods for assessment of human perception, such as surveys, focus groups, and structured interviews, will be introduced. The design of the service interface for human interaction will also be explored. Prerequisites: psychology and statistics.

SSE 3500 - Service System Operations Focuses on the operation of service systems in a customer-focused environment. Topics will include work measurement, performance management, and process evaluation and improvement. Supply chain, demand management and lean practices will also be introduced. Prerequisite: statistics

SSE 3600 - Optimization and Adaptive Decision Making Techniques in optimization and adaptive decision making will be introduced. The fundamentals in linear, integer, and goal programming will be applied to real-world problems with a service systems focus. Adaptive decision making techniques including Bayesian analysis, fuzzy systems, and neural networks will also be investigated. Prerequisite: linear algebra and statistics

SSE 4300 - Project Planning and Management for Engineers The various stages in a project life cycle will be defined and explored such as planning, metrics, execution, completion, and maintenance. Basic tools such as CPM, PERT, Gantt, and budgeting will be introduced. Change assimilation in the context of project management will also be discussed. Prerequisite: statistics

SSE 4600 - Managing Risk Risk definition and identification in terms of financial, human, legal, and physical constraints will be introduced. Techniques for analyzing and managing risk such as FMEA and Reliability studies will be covered. Other topics will include risk elimination, mitigation, and tolerance. Prerequisite: statistics

5.3 Business/Economics and Electives

Business and economics courses allow for multidisciplinary integration of courses. The five required courses include:

Business/Economics (15 cr.)	BA3200 IS/IT Management
BA2330 Accounting 1	BA3710 Leadership
BA3400 Principles of Finance	EC3400 Economic Decision Analysis

The final component of the curriculum is the list of electives. The students are required to take nine credits of electives, which would be three, three credit courses. The current list includes a combination of business and psychology electives. Since service systems have a high level of interaction with people (customers, employees, and other stakeholders), this unique aspect of relationship management is important. The electives consist of the following:

Electives	BA3210-Business Database Management
BA 3800 - Principles of Marketing	BA3580-Legal Environment of Business
BA 4620 - Supply Chain Management	PSY4120 – Engineering Psychology
BA4630 Operations Strategy	PSY 4020 - Industrial Organizational Psychology

Our approach to developing the curriculum can serve as a model for other universities in adapting this type of program and integrating either with existing Industrial Engineering curriculum or offering it as a stand-alone program.

6. Lessons Learned

There are special challenges associated with multidisciplinary efforts in academic institutions. The faculty curriculum development teams functioned well in developing the new courses and the collaboration with the external panelists was valuable. Although we have a solid curriculum, the major challenges have been recruiting students into the program. Since it is a new offering, students are unfamiliar with Service Systems Engineering. This is further complicated by the fact that we do not have an Industrial Engineering program. Topics similar to those found in an IE program are embedded in undergraduate programs within the School of Business and Economics and

the Mechanical Engineering-Engineering Mechanics Department. Several of the team members are Industrial Engineers by education.

Another challenge is engaging the companies who will hire students upon graduation. We have met with several of the Industrial Advisory Boards, specifically the Career Center board. The challenge we faces is that there is a lack of name recognition regarding Service Systems Engineering, and even for that matter, Service Sciences. Some employers may be skeptical in hiring our graduates.

Finally, the Industrial Engineering profession needs to recognize there is an emerging discipline that is an offshoot of traditional Industrial Engineering programs. We chose not to call our program Industrial Engineering because of the history in this profession and its educational programs of having a major emphasis in manufacturing operations. Many of the courses include the topics typically found in Industrial Engineering curriculum, but all the examples are in the context of service industry applications.

7. Conclusion and Next Steps

The next step is to focus on recruitment of students. This has been challenging because there is no specific department with ownership and many of the team members have primary responsibilities of research and teaching and not administrative activities like student recruiting. If the degree program is going to get to the point of a stand-alone discipline, the number of students in the program is going to need to be increased.

We also believe that the curriculum could be better tailored to include more systems related and computer related courses and more people skills related content. We believe with the major emphasis on people that this program would be attractive to women and minority students, who have been traditionally drawn to these types of programs. This means that through our assessment and evaluation process we would need to modify the curriculum.

A final step is to move this towards a stand-alone degree program. We have had success in launching new disciplines using the BSE at Michigan Tech, including Environmental Engineering and Biomedical Engineering. We believe we can also deliver another discipline based program in Service Systems Engineering.

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