Future Engineers: Leading the Charge in the Service Sector

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Abstract

The demand for engineers to support the service sector is growing, and academic programs are needed to prepare students for these careers. This need was recognized at Michigan Tech and led to a dynamic effort by faculty members from different disciplines to develop a curriculum for Service Systems Engineering that integrates business, engineering, and the sciences and serves as a model for other universities. This is an exciting degree program that takes curriculum development beyond its current boundaries and branches into a new direction. In this paper, efforts related to the development of the curriculum will be described, as will the challenges faced by the project team to facilitate interdisciplinary education. The successes to date will be highlighted along with the lessons learned, and collaboration experiences with other university faculty members on curriculum development.

Introduction

In the next decade, the role of services will continue to grow and skilled individuals are needed to create the services of the future. Unlike other industries, where engineers are commonly utilized to design better products and processes, and solve the day-to-day problems that arise, the service industry has not benefited from engineering talent. In spite of the fact that the service sector dominates the economy, the academic world is not preparing students for careers in service systems engineering. To meet the need for service systems engineers, Michigan Tech has embarked on an interdisciplinary effort to develop a new curriculum. Faculty from business management and operations, civil engineering, computer science, electrical and computer engineering, and mechanical engineering are working together to develop a standalone degree program that includes eight new courses specifically geared to preparing students for working in the service sector. This curriculum development is being funded by a three-year National Science Foundation (NSF) grant that began on October 1, 2006. Prior to this grant, the team received NSF funding to complete a Delphi Study and worked with industry panelists for input on laying the foundation for the new program.

The Center for Service Systems Engineering (hereafter referred to as 'Center') was created to foster the development and management of the Service Systems Engineering (SSE) curriculum and to nurture coordinated research efforts focused on the service sector. The SSE team, along

with other Michigan Tech researchers, will participate in the Center. The Center will focus on industry based research, which is a growing area and is supported by such funding agencies as the Sloan Industry Studies – Sloan Foundation and NSF through the Service Enterprise Engineering program.

This paper outlines the grant activities to date and the challenges faced by the project team to facilitate interdisciplinary education. It will also highlight the successes to date and valuable lessons learned. Finally, the experiences in collaborating with four other universities in this curriculum development and information on how this has enhanced the overall project experience will be shared.

Center for Service Systems Engineering

The SSE program is being launched from within the ABET-accredited Bachelor of Science in Engineering (BSE) program. The path for curriculum development is similar to the way biomedical and environmental engineering were established on Michigan Tech's campus. Both existing programs had their beginnings as options within the BSE (environmental in the early 80s and biomedical in the late 90s). They are now established separate degree granting programs. It is anticipated that Service Systems Engineering will eventually become a stand-alone degree program within the College of Engineering (COE) as enrollments grow and the degree gains acceptance.

In order to develop the SSE program, faculty will need to be hired with expertise in this area. In order to accomplish this, there needed to be an academic home for the incoming faculty. It should be noted that there are already faculty at Michigan Tech with some expertise in this area; however, the infusion of additional faculty devoted specifically to SSE will greatly enhance Michigan Tech's ability to conduct research in this area and to provide our students with an optimal learning environment. In addition to faculty, students who enroll in the program needed an academic home so that they have the necessary infrastructure for advising, a place to identify with, and an administrative staff to answer non-advising questions. To address these issues, in the spring of 2007 the Center for Service Systems Engineering was created within the COE.

The Center for SSE has a Director who reports directly to the Dean of Engineering. The Director operates similarly to department chairs in the COE, attending Engineering Council and Academic Forum meetings. The Director is also responsible for the administrative details such as scheduling courses and teaching assignments for the SSE courses. Currently, the Associate Dean for Academic Programs in the COE serves as the Director for the Center for SSE. However, as the Center grows, it is expected that other faculty on campus or new hires will assume the Director position.

Concurrently, with the development of the Center for SSE, a search for faculty began. Faculty with teaching and research interests that emphasize service systems design, analysis, and operations; human factors, risk management, project management, and/or optimization and adaptive decision making are being sought. Appointments may be at the Assistant Professor, Associate Professor, or Professor levels. Senior level hires will be considered for the Center

Director position. New faculty will be hired directly into the Center and will be eligible for joint or adjunct appointments with other units on campus depending on their wishes, their qualifications, and the needs of the affected unit. The primary unit for new hires will be the Center. Current Michigan Tech faculty who have an interest in collaborating with the faculty in the Center, are eligible for adjunct or joint appointments in the Center

Because the Center initially may not include any tenured faculty, the Dean and Center Director will appoint four faculty from the COE to serve on the unit-level tenure and promotion committee. These four faculty will also serve as mentors to Center faculty as they make their way through the tenure and/or promotion process. For purposes of tenure and promotion, the Center Director will fill the role of Department Chair. The College-level tenure and promotion committee and Dean of Engineering will provide input into the process as they do for other faculty in the COE.

While the Center will not initially have a graduate program, Center faculty will be expected to develop an externally funded research program and to actively advise and recruit graduate students at both the masters and PhD levels. Adjunct or joint appointments with the other departments in the COE will provide Center faculty with access to established graduate programs in the COE.

The Center activities have not moved forward as quickly as had been anticipated. There have been some changes in the project team along with administrative changes that have delayed the launch and implementation. The College is supportive of the new Service Systems Engineering curriculum. Once the Center is fully staffed, student recruitment efforts are expected to accelerate.

Challenges in interdisciplinary curriculum development

Service systems engineering is an interdisciplinary curriculum being developed by an interdisciplinary team. Thus, the challenges have arisen in two broad categories: (1) having the interdisciplinary team perform effectively, and (2) designing a comprehensive interdisciplinary undergraduate program.

To address these challenges, related literature was surveyed with the objective of adopting or adapting the models employed. A great deal of literature comes from medical fields where complex health problems such as palliative care require individuals with profound specialization to collaborate, and interdisciplinary teams are ubiquitous (Hall and Weaver, 2001). The curriculum team brings together MTU faculty from business management and operations, civil engineering, computer science, electrical and computer engineering, and mechanical engineering. It is envisioned that the team will work with academic and industrial advisory boards, however, only a small external academic advisory panel exists at this point. The team is in the process of assembling an industrial advisory board.

Petrie (1976) identifies three important 'nonepistomological considerations' as being crucial for interdisciplinary teams. The first consideration is 'idea dominance', i.e., the existence of a clear

and recognizable idea serving as the central focus of the work. Such an idea brings the team members together and serves as a guideline for how to operate collaboratively. To identify the dominant ideas, we convened a planning workshop in the summer of 2006 and used the preliminary objectives and outcomes to shape the boundaries of our efforts. The team is developing a 'concept map' that covers the entire curriculum and depicts the disciplinary and interdisciplinary boundaries of the courses involved.

The second consideration is 'characteristics of participants,' i.e., how to define when to apply disciplinary competence and when to use other team member's insights. In this work, the team interweaved individual development time with weekly meetings to synchronize the team members as well as to assign new responsibilities in light of recent developments. While overlapping efforts were inevitable during individual development times, frequent meetings helped minimize the overlaps.

The third and final consideration is assuring institutional support. In this regard, NSF funding was obtained and the team worked closely with the MTU administration as well as MTU Admissions Office and Career Center. The administration support was important to obtain the necessary funding for faculty lines, student advising, and administrative support. The Admissions Office is instrumental in the recruitment of students, and it is envisioned that the SSE Center will work with the Admissions Office through the outreach coordinator for the College of Engineering. The Career Center plays a critical role in assisting with the program communication to prospective employers for the SSE graduates as well as identifying potential employers for internship opportunities.

Many questions regarding the timing, content, and methodology of interdisciplinary education remain open and suitable for future research (Hall and Weaver, 2001). For example, one point of view favors teaching interdisciplinary topics as early as possible, during the first couple of years. Another viewpoint emphasizes the need for disciplinary competence and thus suggests that interdisciplinary topics be introduced at the senior or postgraduate levels. In the SSE curriculum, a staggered approach was adopted. Interesting problems and essential topics will be introduced at the sophomore level. These topics will be advanced and elaborated upon during courses at the junior and senior levels.

Finally, there exist new, non-traditional methodologies for teaching interdisciplinary topics. An example is problem-based learning (PBL) where students form teams to solve case problems (Hall and Weaver, 2001). Nikitina (2006) presents contextualizing, conceptualizing, and problem-centering as strategies that can be used to overcome the challenges of interdisciplinary teaching. Contextualizing refers to identifying the central core concepts of component areas and constructing bridges to reveal the connections. SSE examples of such core concepts include accounting, information technology, queuing theory, and human factors. Conceptualizing refers to connecting particular discovery or theories to historical happenings. *Introduction to Service Systems Engineering* includes sessions on the development of the service sector in the industrialized world. Problem-centering refers to presenting the students with a problem that requires skills from the disciplines involved.

Forming of an industrial advisory board will likely prove less challenging. Many of the existing

departmental, college, and school industrial advisory boards are represented by multiple disciplines.

In an ideal world, all the support garnered from administration for interdisciplinary education is emphasized and promoted in the context of external funding. Sharing resources outside of engineering becomes a real issue and territorial borders may prevent the successful implementation of interdisciplinary education. In general, the faculty team members are supportive of the interdisciplinary educational effort. However, the administration imposed constraints may severely limit and inhibit progress. In those cases, the issues that arise need to be dealt with on a case-by-case basis by any team attempting to implement an interdisciplinary curriculum.

Project Update

Emphasis on problem-based learning has played a key role in the curriculum development. The process used to design the curriculum relied heavily on service industry professionals. A group of professionals participated in a Delphi Study in order to define the characteristics of a Service Systems Engineering program. With these results, a Curriculum Planning Workshop was held to bring together service industry professionals with a team of academics to transform the program characteristics into courses and a curriculum. As a result of the two planning sessions, eight new courses were identified for development:

SSE2100 Introduction to Service System Engineering: The introductory course will allow students to see the breadth of the services field, while giving them an understanding of the challenges facing companies that supply services. Examples service industry examples will be provided and the students will be introduced to some important concepts such as quantitative problem solving, including linear programming.

SSE2300 Service System Design and Dynamics: This course introduces a systems perspective in solving complex problems. How systems are designed and implemented will be a focal point and topics such as simulation, life cycle, and regulation will be introduced.

SSE3200 Analysis and Design of Web-based Services: The focus of the course will be the strategy behind developing web-based service systems. Topics will include flowcharting, cost estimating, performance measurement, and alpha and beta testing. The course will include a semester project that demonstrates the use of these tools.

SSE3400 Human Influences on Service Systems: The goal of this course is to help students develop an understanding of the social, cognitive, and cultural influences on individual and group behavior in the context of service systems. Students will be introduced to methods for assessing human perceptions, such as surveys, focus groups, and structured interviews. The design of the service interface for human interaction will also be explored.

SSE3500 Service System Operations: This course focuses on the operation of service systems in a customer-focused environment. Topics covered will include work task breakdown,

performance measurement, and process evaluation and improvement. Supply chain, demand management and lean practices will also be introduced.

SSE3600 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.

SSE4300 Project Planning and Management for Engineers: The various stages in a project life cycle will be defined and explored such as planning, defining metrics, execution, completion, and maintenance. Basic project management tools such as CPM, PERT, Gantt, and budgeting will be introduced. Change assimilation in the context of project management will also be a course topic.

SSE4600 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, risk mitigation, and risk tolerance.

The above courses serve as a model core curriculum for the new engineering major, Service Systems Engineering. Four courses were developed during the summer 2007. These were The World of Service Systems Engineering, Service System Design and Dynamics, Human Influences on Service Systems, and Service System Operations. The first course, Introduction to Service Systems Engineering, is being taught in fall semester 2007.

While curriculum development is one of the primary thrusts for the NSF grant, dissemination of information, and receiving input and feedback, are additional activities for the team. Dissemination activities have included presenting papers and posters, and conducting workshops at a variety of conferences and professional meetings. Three papers and/or poster sessions have been conducted to date. (Johnson 2007b, Sorby 2006, Sorby 2007). This stream of papers represents the dissemination component. There are future papers planned to promote the new discipline of Service Systems Engineering.

During curriculum development the team continues to address the following challenges:

- Facilitating effective communication between SSE team members, course developers, and course instructors: A conceptual map of the topics included in each course is being developed. This enables each participant to easily identify and modify the purpose, the prerequisites, and the later requirements for each topic.
- Keeping the extent of the material covered at reasonable levels for undergraduate students: One danger in developing an interdisciplinary curriculum is to pack too much course content due to the diversity of topics. Each course is scrutinized to merge common topics while allowing for a healthy amount of material from other courses to be reviewed. Changes in the general engineering education classes were requested to seamlessly incorporate Service Systems Engineering.
- Soliciting feedback regarding the curriculum from academic and industry professionals:

A workshop was conducted to gather input on the curriculum from academic professionals in the field of Production and Operations Management (Johnson, 2007a). Working with external academic partners from Montana State University, Rensselaer Polytechnic Institute, University of Illinois Urbana-Champaign, and Wayne State University has allowed us to access additional expertise at other institutions. A collaborative meeting was held at the end of June 2007 with the project team sharing ideas and gathering feedback regarding curriculum development to date. This information was used to aid in the curriculum development process.

Future Activities

In addition to the current curriculum development and course improvement efforts, there are a number of ongoing activities and planned future initiatives for the Service Systems Engineering program and associated Center. These include to:

- Recruit students for SSE degree program
- Hire SSE faculty
- Form a SSE industrial advisory board
- Cultivate relationships with industrial partners for senior design projects and internships for SSE students
- Migrate BSE-based SSE degree to a separate stand-alone degree
- Continue curriculum and course assessment and improvement
- Communicate the success of the curriculum through workshops, seminars, and conference presentations
- Solicit feedback as a part of continuous improvement
- Promote the field of Service Systems Engineering as a profession

The team is working closely with the Admissions Office and has gained access to their existing web-based communications to interested, applicant, and registered student pools.

The SSE faculty positions have been advertised with a number of professional organizations. Additionally, the faculty positions were promoted when the team members attended conferences and gave presentations about the SSE program.

As the SSE curriculum is deployed during the 2007-08 academic year, assessment information will be collected and subsequently used for course revisions. Another critical activity for the coming academic year is to constitute an industrial advisor board (IAB) for the degree program. The IAB will include representatives from industry, government, and academe, with a wide range of service-based organizations. The IAB will provide valuable input on the curriculum and provide access to senior design and internship opportunities. The information gathered for the IAB and the external academic panelists will be used as part of the continuous curriculum improvement process.

It is anticipated that sometime after the first few students graduate from the BSE-based SSE curriculum, that there will transition to a stand-alone SSE degree program. While the BSE degree represents an excellent launching pad for the creation of new degree programs, it does

incorporate several constraints that would be eliminated with the establishment of a stand-alone degree. For example, the BSE-degree includes within its core such courses as "Statics & Strength of Materials," "Introduction to Materials Science & Engineering," "Circuits and Instrumentation," and "Thermodynamics & Fluid Mechanics." A design implementation experience is also required that includes a choice from among several extremely product-design focused courses. Creation of a separate SSE degree would free us from the restrictions associated with the existing BSE-core requirements and permit the curriculum to evolve to better address the educational needs associated with service systems engineering. This may include, for instance, additional computer science courses within the curriculum. In addition to SSE curriculum changes, it is also expected that we will transition the Center for SSE into a stand-alone Department within the COE.

As a part of the grant requirements, dissemination and communication of results as well as promoting curriculum development in SSE are ongoing activities. Near the close of the three-year grant, a seminar/workshop will be held to share the information with other academic institutions with the intent of broadening the exposure of the curriculum and promoting the field of Service Systems Engineering.

Conclusion

The model described serves as a basis for fostering development of new curriculum and field recognition as a basis for eventual inclusion as an ABET accredited program. Other universities and colleges desiring to expand their engineering offerings can use this model as a starting point. A common goal of developing an interdisciplinary curriculum to meet the demands of service sector organizations has led to a dynamic effort of faculty members from different disciplines. The creation of Service Systems Engineering as a new field has led to the development of a curriculum that combines elements from business, traditional engineering disciplines, and the sciences. This innovative new degree program allows Michigan Tech to cross the boundaries of traditional engineering curricula and respond to an industry need that traditional engineering disciplines do not serve.

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