

## **Future Engineers: Leading the Charge in the Service Sector**

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### **Abstract:**

In the industrialized world, the service sector dominates the manufacturing, agriculture, and mining sectors. The demand for engineers to support the service sector is growing, and academic programs are needed to prepare students for these careers. To meet this need, Michigan Tech has embarked on an interdisciplinary effort to develop a new service systems engineering (SSE) curriculum. Based on results from a Delphi Study, a new standalone degree program is being developed with funding from the National Science Foundation. To support the development and management of the curriculum, "The Center for Service Systems Engineering" was established. The Center also will facilitate coordinated research efforts to address service-related issues. In this paper, the efforts related to the development of the curriculum and the challenges faced by the project team to facilitate interdisciplinary education will be described. 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 in economies will continue to grow and the demand for service systems engineers will exceed the supply. The academic world has to prepare the students for service careers of the future. To meet the growing need for service systems engineers, Michigan Tech has embarked on an interdisciplinary effort to develop a new curriculum. Faculty from civil engineering, computer science, electrical and computer engineering, mechanical engineering, and business 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 provide coordinated research efforts focused on the service sector in multitude of industries that are classified as other than agricultural and manufacturing. It is anticipated 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**

This SSE program is being launched from within the ABET-accredited Bachelor of Science in Engineering (BSE) program. This path for curriculum development is similar to the way biomedical and environmental engineering evolved 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. The infusion of additional faculty devoted specifically to SSE will greatly enhance Michigan Tech's ability to conduct research in this area and provide students with an optimal learning environment. In the spring of 2007, the Center for Service Systems Engineering was created within the COE in order to establish an academic home for the incoming faculty and the students who enroll in the program. The center will provide the necessary infrastructure for advising, a place to identify with, and an administrative staff to answer non-advising questions.

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 a newly hired faculty 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 might not include any tenured faculty, the Dean and the 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 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 M.S. and Ph.D. 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.

### **Challenges in interdisciplinary curriculum development**

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

To address these challenges the related literature was surveyed and the models employed were either adopted or adapted. 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 MTU curriculum team brings together faculty from business management and operations, civil engineering, computer science, electrical and computer engineering, and mechanical engineering. The team works with academic and industrial advisory boards. The external academic advisory panel was established in YEAR. The team is in the process of assembling a representative industrial advisory board.

Petrie (1976) identifies three important 'nonepistemological considerations' as being crucial for the effectiveness of 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 department and career center. The administration support was important to obtain the necessary funding for faculty lines, student advising, and administrative support. The admissions department is instrumental in the recruitment of students along with 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.

The SSE curriculum is being developed using documented methodologies for interdisciplinary education. Many questions regarding the timing, content, and teaching 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 years. Another point of view emphasizes the need for disciplinary competence and thus favors interdisciplinary teaching 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 in 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. One such problem involves redesigning a university office.

### **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 the MTU team 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:

- The World of Service Systems Engineering,
- Service System Design and Dynamics,
- Analysis and Design of Web-based Services,
- Human Influences on Service Systems,

- Service System Operations, Optimization and Adaptive Decision Making,
- Project Planning and Management for Engineers, and
- Managing Risk.

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. The dissemination activities have included presenting papers and posters, and conducting workshops at a variety of conferences and professional meetings. The following papers and/or poster sessions have been conducted to date:

- Sorby, S.A., Bohmann, L.J., Johnson, D.M., Mattila, K.G., and Sutherland, J.W. "Defining a curriculum for service systems engineering using a Delphi technique," *Proceedings of American Society for Engineering Education* conference, Honolulu, HA, June 24-28, 2007.
- Johnson, D.M., Bohmann, L., Mattila, K., Sutherland, J., and Sorby, S. "Meeting the Needs of Industry: Service Systems Engineering Curriculum," *Proceedings of 2007 DSI Mini-Conference in Service Science*, Pittsburgh, PA, May 24-26, 2007.
- Sorby, S.A., Bohmann, L.J., Drummer, T.D., Friendewey, J.O., Johnson, D.M., Mattila, K.G., Sutherland, J.W., and Warrington, R.O. (October 2006). "Defining a curriculum for service systems engineering," *Proceedings of IBM Service Systems Science Conference*, October 7-8, 2006.

This stream of papers represents the dissemination component. One upcoming paper was written to further promote the new discipline of Service Systems Engineering:

- Bohmann, L., Johnson, D., Mattila, K., Onder, N., and Sutherland, J. (November 2007) "Update on Service Systems Engineering Curriculum – One Year Later" *38th Annual Meeting of Decision Sciences Institute*, Phoenix, AZ, November 17-20, 2007, abstract under review.

Soliciting feedback from academic and industry professionals regarding the curriculum is an ongoing activity. A workshop was conducted to gather input on the curriculum from academic professionals in the field of Production and Operations Management.

- Johnson, D.M. Bohmann, L.J., Mattila, K.G., Sutherland, J.W., Sorby, S.A., and Onder, N. (May 2007). "Curriculum Model for Service Systems," *Production and Operations Management Society*, 2007 POM – Dallas, workshop presented.

Working with the external academic panelists/partners from Montana State University, Rensselaer Polytechnic Institute, University of Illinois-Champaign-Urbana, and Wayne State University has provided access to additional expertise by also promoting curriculum development at these other institutions. A collaborative meeting was held the end of June 2007 with the entire project team to share ideas and gather 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 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 the 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 as a profession the field of Service Systems Engineering as a profession

The team is working closely with the admissions office and has used their existing web-based interfaces to reach the interested, applicant, and registered student pools.

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

As the SSE curriculum is deployed during the 2007-08 academic year, assessment information be collected and will subsequently be 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 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**

A common goal of developing an interdisciplinary curriculum to meet the demands of service sector organizations has led to a dynamic effort of faculty/researchers from different disciplines. The creation of Service Systems Engineering as a new field has led to the development of a curriculum to integrate across business, engineering, and the sciences. This is an exciting degree program that allows Michigan Tech to lead international curriculum development beyond its current boundaries and branch into a new direction.

### **Acknowledgement**

The authors gratefully acknowledge the support of the National Science Foundation for the conduct of this project through grant EEC-0343187 and DUE-0618537.

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