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Competency-Based Curriculum for a Master's Program in Service Science, Management and Engineering (SSME): An Online Delphi Study

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COMPETENCY-BASED CURRICULUM FOR A MASTER'S PROGRAM IN SERVICE SCIENCE, MANAGEMENT AND ENGINEERING (SSME): AN ONLINE DELPHI STUDY

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ABSTRACT

The overarching purpose of this research was to provide theoretical and conceptual foundations for developing a competency-based curriculum for an interdisciplinary master's program in Service Science, Management and Engineering (SSME). Specifically, the objective was to ascertain the competencies and courses that are relevant for developing a competency model for a service scientist and a curriculum blueprint for SSME. The study employed three rounds of the online Delphi survey to achieve the research objectives. The three rounds were used to identify, prioritize, and define competencies and courses. A panel of industry professionals and university faculty were invited to participate as experts. A total of 51, 40, and 39 respondents participated in Round 1, Round 2 and Round 3 survey respectively.

Overall, a high degree of consensus was observed among the participants for the importance of competencies and courses, however, there were some differences noted by the disciplinary expertise and professional background of the respondents. Based on the consensus of the study participants, a final list of 10 competencies and 14 courses was generated. These competencies were used to develop a competency model and the courses were used to create a curriculum blueprint.

The final 14 courses were categorized into four modules, Module 1: Contextual Foundation (Information & Service Economy, Consumer Behavior, Leadership & Organizational Behavior, Project Management); Module 2: Service Core (Service Innovation, Service Design, Service Operations and Supply Chain); Module 3(a): Engineering Concentration (Business Process Modeling, Service Engineering, Quality Management); Module 3(b): Management Concentration, Strategic Management, Service Marketing, Enterprise Systems) and; Module 4: Integrative Capstone (Business and Technology Integration).

The final 10 competencies were categorized into three clusters; Cluster 1: Service Mindset (Needs assessment, Conceptualize service system, Problem-solving, Contextualize service science); Cluster 2: Integrative Competence (Business and technology integration, Interdisciplinary collaboration, Diversity orientation) and; Cluster 3: Meta-competence (Adaptability, Interpersonal communication, and Critical thinking).

The results of this study may serve as a common language among stakeholders to prepare future service scientists or “T-shaped” professionals for the service economy. This study also contributed to the body of literature of competency-based curriculum development in higher education.

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CHAPTER 1: INTRODUCTION

The structure and nature of the U.S. economy is changing and so is the nature of the work. For example, in a "flat world" where technology and globalization is leveling the competitive landscape (Friedman, 2005), the nature of knowledge work is changing at the interface of technology and services (Darr, 2007) and the demand for knowledge workers is increasing as the complexity of knowledge work intensifies (Cortada, 1998). These shifts indicate emergence of a "new knowledge-based service economy" that differs from the industrial economy. The distinctive characteristic of "knowledge-based economy is its dependence on human capital inputs, on know-how and skill, competence and expertise" (Alic, 1997, p. 8). While this new service economy is promising, higher education has not developed an academic community of scholars who focus on innovation and productivity of the service sector (Chesbrough & Spohrer, 2006; Siegel, Hefley, Evenson & Slaughter, 2008).

An emerging knowledge-based service economy poses new challenges for the U.S. professional education system as curriculum needs to be aligned with the corresponding demand for new competencies (Everwijn, Bomers & Knubben, 1993; Jones, 2002). In addition, as the demand for accountability and responsiveness from the American higher education system shifts towards learning outcomes and competencies development, the need for competency-based curriculum is becoming

prominent (Banta, 2001; Lemaitre, Le Prat, de Graaff & Bot, 2006; Paulson, 2001; Vaatstra & de Vries, 2007; Voorhees, 2001). The confluence of the above mentioned changes in the economy and challenges faced by the professional higher education has resulted in a call for reform by government, professional associations, national research bodies, and accreditors. Within professional education the expectations for relevancy, accountability, and effectiveness seem to be higher for engineering and management education, as they have an intricate relationship with economic activity and competitiveness. For example, according to the AACSB International (2002), "Management education is at risk, and industry-wide leadership is needed to position business schools to respond to emerging priorities and challenges" (p. 5). Similarly, the National Academy of Engineering (2004) asserts that "…engineering will only contribute to success if it is able to continue to adapt to new trends and educate the next generation of students so as to arm them with the tools needed for the world as it will be, not as it is today" (p. 5). Moreover, a report by the Council of Graduate Studies (2007) reiterates the relevance of graduate education in general and interdisciplinary education in particular, in preparing knowledge creators and innovators for a knowledge-based global economy. Thus, there is a widespread recognition of the changes in the economy and the need for engineering and management education to effectively respond to these changes.

The demand for qualified and competent workers in the labor market in general and in the professions in particular influences higher education's decisions about developing new courses, programs, and disciplines (Karseth, 1995). One such

emerging field is Service Science, Management and Engineering (SSME). SSME attempts to develop new professionals who would have a service mindset and a capacity to integrate elements of the disciplines like engineering and management to solve the complex and unique problems of service economy (IfM & IBM, 2008). At a time when complex problems of the service economy are demanding innovative solutions, higher education institutions need "to explore emerging interdisciplinary fields such as services sciences, management and engineering and to implement new models of curriculum development and delivery" (Spellings Commission, 2006, p. 23). Likewise, policymakers are also recognizing the potential of service science and hence the recently enacted America COMPETES Act (2007) emphasizes that to maintain the competitiveness and innovation in the U.S. economy there is a need to "better understand and respond strategically to the emerging management and learning discipline known as service science" (p. 577).

This call for focus on service education and research is not new. The need for service education and research has been emphasized for more than 30 years, however, "the urgency for rigorous study to guide service managers in improving the design, competitiveness, efficiency, and effectiveness of service delivery, both at the firm and industry levels, has never been greater" (Metters and Marucheck, 2007, p. 196). As a field of study, service gained prominence with the emergence of service marketing in the 1970s. However, this time service science is encouraged to integrate several disciplines such as engineering and computer science, industrial systems engineering, organization theory, and economics (Bitner & Brown, 2006). This urgent demand for

an interdisciplinary focus on education and research for the service economy is a reflection of the rapidly changing nature of knowledge work and the critical role played by professional higher education in preparing talent for the future.

Within the continuum of higher education from undergraduate to doctoral degree, the master's degree is uniquely positioned to provide professional competencies for a changing economy without compromising the value of liberal education at the undergraduate level or disciplinary research at the doctoral level. Conrad, Haworth, and Millar (1993) define master's degree as the "silent success" of American higher education. They note that since the 1980s more than four-fifth of the master's education occurred in professional programs, further validating the role of the master's degree in enriching knowledge and skills for the economy. The professional master's degree provides a new direction for the production of knowledge, one that is likely to be interdisciplinary, with emphasis on core and applied knowledge, technological and communication skills, and involves problem-solving practica or internship (Glazer-Raymo, 2005). The master's degree is becoming fully professionalized and interdisciplinary, reflecting the entrepreneurial, competitive, and accountable nature of professions (Glazer-Raymo, 2005).

1.1 Statement of the Problem

A discussion paper released by the University of Cambridge and IBM, calls for preparing "adaptive innovators" or "T-shaped" professionals through an interdisciplinary program in Service Science, Management and Engineering (SSME)

(IfM & IBM, 2008). According to IfM and IBM (2008) adaptive innovators or T-shaped professionals are system thinkers who are well educated in their home disciplines and at the same time have the ability to work across multiple disciplines. The interdisciplinary initiative of SSME focuses on "the application of scientific, management, and engineering disciplines to tasks that one organization (service provider) beneficially performs for and with another (service client)" (Spohrer, Maglio, Bailey & Gruhl, 2007, p. 71).

Henry Chesbrough (2005) in his Harvard Business Review article entitled *Breakthrough ideas for 2005: Toward a new science of services*, claims that the new discipline of service science holds promise but faces several challenges. He mentions that the emergence of computer science as a discipline from the shadows of engineering, physics and mathematics was not easy. Likewise, service science may also have to overcome the disciplinary barriers of engineering and management (Chesbrough, 2005). In addition, SSME has to clearly position itself against the existing interdisciplinary approach already offered by Systems Engineering and Engineering Management programs.

Interdisciplinary Engineering Management programs have existed for several years. Engineering Management programs gained prominence in the early 1980s as they provided required educational support to the engineers' natural career progression into managerial roles (Dieter, 1984). The American Society for Engineering Management (2007) defines Engineering Management as "the art and science of planning, organizing, allocating resources, and directing and controlling activities

which have a technological component." However, most of the Engineering Management programs are narrowly focused on technology based applications for the manufacturing sector (Badawy, 1998).

Systems Engineering was organized as a field of study in the early 1960s and today there is a strong need to apply these principles to the service sector (Tien & Berg, 2003). The International Council on Systems Engineering (2008) defines Systems Engineering as "an engineering discipline whose responsibility is creating and executing an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality, trustworthy, cost efficient and schedule compliant manner throughout a system's entire life cycle."

Both Systems Engineering and Engineering Management fields have a strong relationship with the proposed SSME, however, it is evident from the above mentioned definitions that Systems Engineering and Engineering Management programs are still predominantly engineering disciplines and they have not recognized the unique nature of the service economy nor they have moved away from their home discipline to embrace true interdisciplinarity. This exposes an immediate need to bridge the gap and offer an interdisciplinary program in engineering and management which studies and improves the service systems (Davis & Berdrow, 2008; Spohrer, et al., 2007; Tien & Berg, 2003).

Consequently, the need and relevance for a new program in SSME at the master's level is based on the following assertions. First, the nature of the work and competencies required for innovation and productivity improvement has significantly

changed with technology and globalization. Second, the existing Engineering Management and Systems Engineering programs were designed for the manufacturing based economy, while the current context of the economy is service and knowledge based. Third, the existing programs lack a systematic inclusion of the competency-based approach in curriculum development. Fourth, the origin of current Engineering Management programs was to develop managerial skills among engineers and the Engineering Management programs were not philosophically or theoretically grounded in interdisciplinarity. Finally, the master's level education is uniquely positioned to develop interdisciplinary professional competencies as compared to liberal education at the undergraduate level or disciplinary specialization at the doctoral level.

1.2 Purpose of the Study

The overarching purpose of this research is to provide theoretical and conceptual foundations for developing a competency-based curriculum for an interdisciplinary master's program in Service Science, Management and Engineering (SSME). Specifically, the objective is to ascertain the competencies and courses that are relevant for developing a competency model for a service scientist and a curriculum blueprint for SSME. The research objectives are addressed by the process of identification, prioritization and description of specific competencies and courses by an expert panel of university faculty and industry professionals. In other words, the study aims at identification of specific competencies and courses that may serve as a

common language between university faculty and industry employers to prepare future talent for the knowledge-based service economy. Through this study, the stakeholders will be able to brainstorm and arrive at a consensus on a blueprint of the competency-based curriculum for SSME. University faculty may use this blueprint to adapt and design their program. This study also aims to contribute to the body of literature of competency-based curriculum development in the field of higher education and to encourage other disciplines like engineering and management to draw on extensive research available in higher education.

1.3 Research Questions

Taking into consideration the changing nature of competencies required by the economy and the role of higher education in providing those competencies, the overarching purpose of this research is to provide theoretical and conceptual foundations for developing a competency-based curriculum for an interdisciplinary master's program in Service Science, Management and Engineering (SSME). Specifically, the study will investigate the following research questions:

1) What are the most important competencies required for a graduate of the master's level interdisciplinary program in SSME?
2) What courses/content domains may provide the most important competencies required for a graduate of the master's level interdisciplinary program in SSME?

1.4 Significance of the Study

The 21st century has seen numerous reports from stakeholders highlighting the changing nature of the knowledge-based service economy and the urgency to bring change in higher education (AACSB International, 2002; Council of Graduate Studies, 2007; National Academy of Engineering, 2004; IfM & IBM, 2008). These reports raised several issues related to teaching and learning, accountability, and effectiveness of higher education. Specifically, in the context of the changing needs of the knowledge-based services economy, SSME is proposed as an interdisciplinary field to develop adaptive innovators and T-shaped professionals for the service economy. However, the legitimization of SSME in academia would require investment in development and delivery of the required curriculum from undergraduate to doctoral levels to foster development of competent professionals in service science (Siegel et al., 2008). Further, developing a relevant and globally available curriculum for SSME is a huge undertaking for a single higher education institution and requires collaboration across several institutions, industry and government (Siegel et al., 2008).

For an emerging field like SSME, it is critical to encourage multiple perspectives and at the same time attempt to bring some consensus among the stakeholders about future directions. This study engaged two key stakeholders, faculty and employers, using online Delphi method to identify, prioritize and describe the future competencies and courses that may be provided by a master's level program in SSME.

This study contributes to the theory and practice of curriculum development in higher education in general and SSME in particular. First, it advances the theoretical perspectives of competency-based curriculum and interdisciplinary education. Second, this may be the first dissertation to develop a blueprint for the competency-based curriculum for master's level program in SSME. In other words, this study will provide a platform for systematically identifying and prioritizing the set competencies required for an interdisciplinary program in SSME. Third, this dissertation engages dialogue among industry professionals and university faculty to create a common language for the emerging discipline of SSME. Fourth, this study uses the conceptual framework and theoretical background from the higher education discipline and encourages future studies in other disciplines to leverage the intellectual and rigorous research base of curriculum development from the field of higher education.

Further, in an era where demand for accountability by stakeholders is more than ever before, interdisciplinary competency-based curriculum may satisfy the demands for defining and measuring the student learning outcomes for continuous improvement. Faculty may use the blueprint to design and adapt their courses in line with the overall competencies expected out of the curriculum. Students would be in a better situation to make informed decisions and set expectations about the programs as they may see a relationship between outcomes and curriculum. The economy in general and employers in particular would gain from the increased productivity and capacities of the workforce to deliver the expected performance. Individuals would acquire high end competencies that are of relevance and demand in the labor market

and hence would be able to foster their personal and professional growth. University administrators would benefit from having an understanding of the interactions and interface between learning outcomes in the form of competencies and curriculum designed by faculty for better program planning. Policymakers, accrediting agencies, and professional associations would benefit from an improved measure of accountability, quality, and performance.

1.5 Assumptions and Delimitations

This dissertation research rests on a few assumptions and delimitations as described below.

Curriculum, instruction, and assessment form the triad of educational process (Pellegrino, 2006). Curriculum consists of offering knowledge and skills in a subject matter with a planned sequence of learning (Pellegrino, 2006). This study excludes instruction and assessment and focuses only on curriculum and competencies. This is due to several reasons: (1) emerging nature of the SSME, which still lacks a consensus on the curriculum and competencies (2) expansion of the scope and hence a longer survey for a three round Delphi may result in higher dropout rates and loss of focus among participants (3) this study uses both university faculty and industry professionals as participants. While faculty may serve as experts on instruction and assessment related questions, it seems infeasible to expect similar expertise from industry professionals.

The study focuses on preparing a blueprint of competency-based curriculum for a master's program in SSME by identifying and prioritizing both courses and competencies. This study recognizes the diversity, autonomy, and uniqueness of educational programs and hence does not claims to be definitive or all encompassing. The curriculum blueprint may be used by faculty and administrators to adapt existing programs or develop new programs in line with their institutional missions. The study attempts to align the problem statement (lack of curricular standards for an emerging interdisciplinary field of SSME) with research question and method (identifying possible competency-based curricular standards using experts' opinions).

The study delimits the scope to the key competencies that are required for a graduate of a master's program in SSME. It acknowledges that the process of continuous workplace learning and its influence on the competencies required for an experienced professional as compared to an entry-level professional. Thus, the focus of this study is on the competencies required for a graduate of a master's program in SSME for an entry-level position as a service scientist. On a similar note, the study acknowledges the rapidly changing context of the work and hence the competencies identified in this study may have to be revisited in future.

The study rests on the premise that effective interdisciplinary education requires deep understanding of the disciplines. In other words, interdisciplinary programs should build on the complementary strengths and overcome weaknesses of the underlying disciplines. SSME is proposed to be built on management and engineering disciplines; consequently, the literature review is presented from the

respective disciplines and then integrated to identify the potential of interdisciplinary curriculum for SSME.

The study assumes that university faculty and industry professionals would be able to interpret the instructions correctly, and they would make their best efforts to respond to the survey. In addition, the study assumes that the participants are experts in the field of SSME and hence understand the context and need of the study. Few more limitations of the study are discussed under section 3.8.

1.6 Conceptual Framework

Theory and research on curriculum development from the higher education discipline may aid faculty in other disciplines in organizing and developing their curriculum (Ball, 2006). Ball (2006) claims that the curriculum development process at business schools is less holistic and impactful as the business school faculty are not quite aware of the formal theory and research of curriculum development available in the discipline of higher education. Ball (2006) uses the case of academic plan model of Stark and Lattuca (1997) to exemplify its application and relevance to the curriculum development in graduate management education and claims that bridging the gap "between the business and higher education disciplines has great potential for graduate management curricular reforms" (p. 94). This study also uses the conceptual framework from the field of higher education for building the research foundations.

Stark, Lowther, Hagerty and Orczyk (1986) proposed a conceptual framework which defines various influences, processes, and outcomes, for a better understanding

of the professional education programs. They asserted that the professional programs are influenced by internal, interorganizational, and external forces. These forces interact to create a professional "environment", which in turn, influences the educational processes to achieve expected outcomes. Stark et al. (1986) acknowledged that the professional programs differ in terms of interaction among three influences, environment, educational processes, and outcomes. The external influences are factors outside the specific program and is divided in two primary categories—societal influences and professional community characteristics. The intraorganizational influences are derived from the organizational structure and context. The internal influences are the components of the specific program and are divided into four categories—staffing, structure, curricular tensions, and continuing professional education. The curriculum acts both as a resultant of various forces and also as a contributing force.

Stark et al. (1986) asserted that the "amount of curricular conflict among professional faculty about core knowledge issues is a significant element of the preparation environment" (p. 245). The educational processes are the strategies and actions to achieve the goals of the program. The outcomes of the professional program are defined as a set of competencies and attitudes that characterize the graduate of the program. Specifically, competence is further divided into six categories—conceptual competence, technical competence, integrative competence, contextual competence, adaptive competence, and interpersonal competence (Stark et al.). The authors encouraged future studies to use the conceptual model for designing interdisciplinary

programs within a university and also examine the influence of expected outcomes on the educational processes (Stark et al., 1986).

The curriculum framework proposed by Stark et al. (1986) is adapted to develop a conceptual framework for investigating the research questions. This framework guided the literature review so as to understand the theoretical and research foundations for developing a competency-based curriculum for the service economy. In the adapted framework (see Figure 1) external influences set the context of the study, internal influences are limited to the curriculum, and outcomes are the expected competencies. Intraorganizational influences are not included as they are organization specific. The literature review presented in the next chapter, intersects bodies of literature in competency-based higher education in general and management and engineering education in particular.

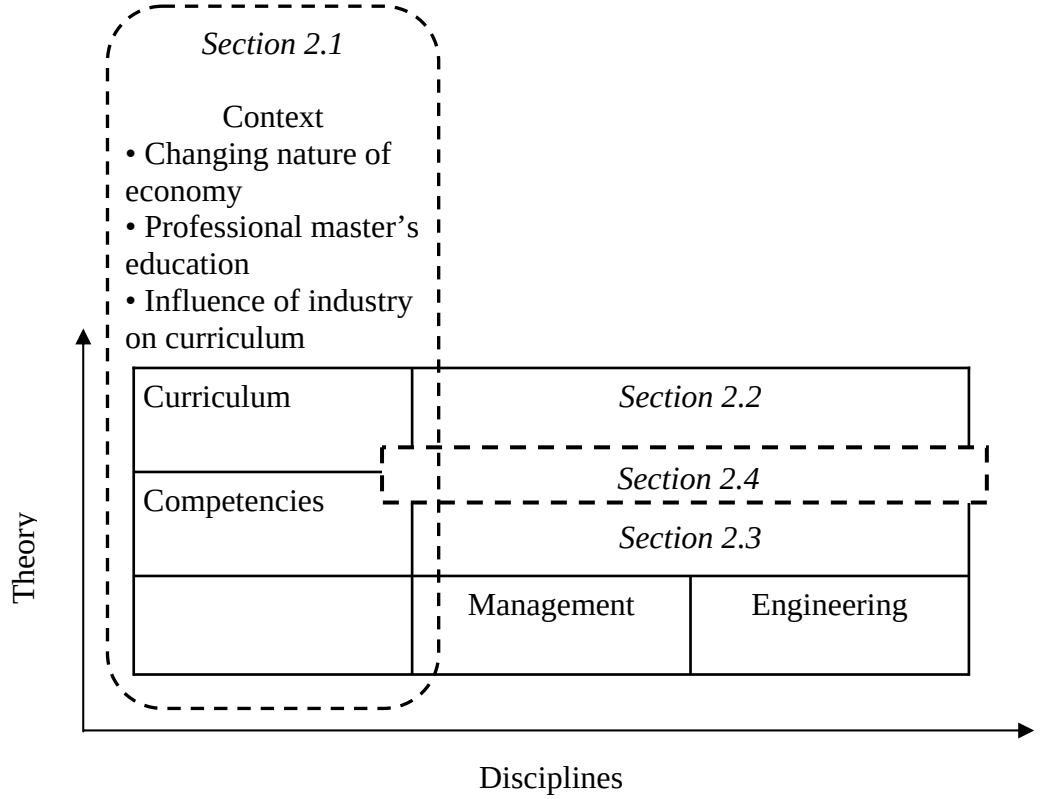


Figure 1. Conceptual framework

1.7 Organization of the Study

The study is organized in five primary chapters. Chapter 1—Introduction, sets the context, need, significance and conceptual framework of the study along with the definition of key terms. Chapter 2—Literature Review, presents the synthesis of theoretical and research foundations related to the competency-based education in engineering and management disciplines, and interdisciplinary education. Chapter 3—Methodology, discusses the relevancy of the Delphi method and its application for answering the research questions of this dissertation research. Chapter 4—Results,

summarizes the data and reports the key findings of the study. Finally, Chapter 5—Discussion, presents the competency model and curriculum blueprint along with the limitations, conclusions, recommendations, and implications of the study.

1.8 Definition of Key Terms

Competency: Competency, competence (plural competencies), outcomes, and attributes are used interchangeably to define a combination of knowledge, skills, and attitude to achieve a desired performance in a particular context. Banta (2001) used the term competence interchangeably with skills, learning objectives, or expected learning outcomes.

Consensus: One of the primary goals of Delphi method is to achieve consensus among participants on the topic of study. Consensus is defined as the reduction in the variance of responses i.e. smaller variance indicates greater consensus (Rowe & Wright, 1999). For this study, consensus is reached when at least 75% of the participants rate any competency or course item as Very Important (4) or Important (3) on a four-point scale.

Competency-based curriculum: A set of courses or content domain offered to students with specific emphasis on identification and integration of competencies expected from the students.

Curriculum: A set of courses or content domain offered to students as learning plan (Pellegrino, 2006). Curriculum is also conceptualized as a site of interaction and communication between external stakeholders and educators.

Delphi: The Delphi method facilitates group communication among geographically dispersed participants for idea generation and consensus, which is characterized by feedback mechanism, multiple rounds, and anonymity of participants.

Expert: An expert for the Delphi panel is defined as "someone who possesses the knowledge and experience necessary to participate in a Delphi" (Clayton, 1997, p. 377). University faculty and industry professionals who are already actively engaged with the advancement of SSME are considered experts for this study.

Interdisciplinary: Interdisciplinary is used as a generic or umbrella term that integrates two or more disciplines to provide more holistic solutions to complex problems. I have not attempted to distinguish between the nuances in the definitions of interdisciplinary, multidisciplinary, crossdisciplinary, transdisciplinary, and integrative education.

Service economy: Knowledge economy, service economy, new economy, knowledge-based service economy is used interchangeably. The term refers to the nature of economy that involves service interaction, complex problem-solving and technology or information based transactions. Knowledge work is an integral part of this service economy.

Professional education: Here professional education is used loosely for degree programs that focus on developing competencies for specific roles, industries or sectors. For example, MBA degree for business sector or MA in Student Affairs degree for education sector. It is not restricted to professions like law or medicine that may require licensure for practice. The focus of the study is on full-time traditional

education. There are several other interpretations and modes of offering professional education including distance learning, part-time, certifications, and executive education that are not part of this study.

Service Science, Management and Engineering (SSME): Service Science, Management and Engineering (SSME) and service science are used interchangeably to refer to the emerging interdisciplinary field that studies the service systems for innovation and productivity improvement.

Service Scientist or T-shaped professional: IfM and IBM (2008) define the T-shaped professional or service scientist as an individual with deep problem-solving and expert thinking skills in their home discipline coupled with complex communication skills to interact with specialists across a wide range of disciplines. As SSME is an emerging field, there is some level of ambiguity and vagueness about the conceptualization of the T-shaped professional (Glushko, 2008). This study attempts to explicate the key competencies expected from a service scientist or a T-shaped professional.

CHAPTER 2: LITERATURE REVIEW

In order to build theoretical and empirical foundations for the research questions, the review is presented in five major sections. First section presents the context for developing a competency-based curriculum for the new service economy. Second section reviews the literature related to the competency-based curriculum in the disciplines of engineering and management. Third section discusses the concept of competencies and its application in the disciplines of engineering and management. Fourth section presents theory and literature related to the interdisciplinary curriculum. Fifth section discusses the evolution of SSME.

The literature search for answering the research questions was conducted in three broad stages. First, generic online search tools and indexes including Web of Science, ERIC, Google Scholar, Academic Search Premier, and a combination of keywords—competency, skill, curriculum, program, professional education, and interdisciplinary education were used to identify relevant literature. Second, the above combinations of keywords were used to search discipline specific databases like ERIC, Business Source Premier, and Engineering Village for higher education, management and engineering respectively. Third, the references mentioned in the articles found in first two stages were used to identify more articles relevant to the study.

2.1 Context

This section sets the context for developing a competency-based curriculum for the new service economy in three subsections—the changing nature of economy and work, professional master's education, and the influence of industry on curriculum.

2.1.1 Changing Nature of the Economy and Work

The world around us has undergone dramatic transformations in terms of social, political, economic, and technological changes. Friedman (2005) identified ten flatteners that have changed the world around us. The ten flatters are opening of Berlin Wall, Netscape, work flow, outsourcing, offshoring, open-sourcing, insourcing, supply-chaining, in-forming, and the steroids amplifying and reinforcing each other. Friedman asserts that the complementary convergence of these flatteners resulted in "…the creation of a global, Web-enabled playing field that allows multiple forms of collaboration—the sharing of knowledge and work—in real time, without regard to geography, distance, or , in the near future, even language" (p. 176). He defines this phenomenon of convergence and collaboration as the flattening of the world. Further, the flat world is demanding a large cadre of managers, innovators, IT specialists and workers to develop and deploy new value-creation processes and perspective that could take advantage of the flat world (Friedman, 2005). America will do well in a flat world provided it "…continues to churn out knowledge workers who are able to produce idea-based goods that can be sold globally and who are able to fill the

knowledge jobs that will be created as …there is no limit to the number of idea-generated jobs in the world" (Friedman, 2005, p. 230).

In addition, to the impact of technology and globalization on the demand for knowledge workers, the American economy is increasingly becoming services driven. This is also manifested in the projected changes in the occupational structure and growth. According to the U.S. Bureau of Labor Statistics (BLS), professional and related occupations, and service occupations are two occupational groups that are projected to show highest increase in employment between 2006 and 2016 of nearly 17 percent as against a decline of nearly 5 percent for production and manufacturing occupations (Dohm & Shniper, 2007).

The scale and scope of the service activity is wide and quite different from agricultural and manufacturing sectors (Chesbrough & Spohrer, 2006). While the service sector comprises nearly 80% of the economic activity but it does not have an academic community of scholars focused on innovation and productivity improvement (Chesbrough & Spohrer, 2006). Further, service exchange involves a complex combination of both tacit and codified knowledge (Chesbrough & Spohrer, 2006). Codified knowledge is easily transmittable as information in standardized form while tacit knowledge is difficult to transfer as it is person and context dependent. It is this high level of tacit knowledge combined with codified knowledge which complicates the service exchange. Thus, both the scale of services economy and its characteristics have implications for the knowledge involved in innovation and productivity improvement in services sector. Chesbrough and Spohrer (2006) conclude that service

innovation needs "…an interdisciplinary effort that unites academic silos around common set of problems" (p. 39).

Within the overall service sector, the knowledge-based services are the becoming more complex and influential in driving the economic growth. According to BLS, occupations requiring a bachelor's degree or higher are expected to increase by 15.3 percent and add about 5 million new jobs, by 2016 (Dohm & Shniper, 2007). The focus of this study is on knowledge-based service occupations like computer systems analysts and teachers that require at least a bachelor's degree (Dohm & Shniper, 2007). The core of knowledge-based economy is the set of occupations that are at the interface of service and technology (Darr, 2007). In its simplest form a knowledge-based economy refers to economic wealth generation "through the creation, production, distribution and consumption of knowledge and knowledge-based products" (Harris, 2001, p. 22). According to Davenport (2005) "Knowledge workers have high degrees of expertise, education, or experience, and the primary purpose of their jobs involves the creation, distribution, or application of knowledge" (p. 10). There are several definitions and interpretations of knowledge economy, however, there has is a consistent emphasis on "…new information-handling skills and knowledge expertise, requiring more specialised [sic] and educated employees" (Williams, 2007, p. 512).

This new knowledge-based economy calls for a need to understand the nature of work and the types of skills required for delivering effective knowledge work (Darr, 2007). The higher education system has been slow in identifying and capitalizing on

the changing nature of the knowledge work, technological sophistications, economic impacts of globalization and the massification opportunities (Williams, 2007). The demands of knowledge-based service sector are not being met by existing education system and therefore it should integrate future skills in the curriculum (Darr, 2007). Within the higher education system, professional education especially at the master's level plays an integral role in providing skills and competencies required by the society and the economy (Council of Graduate Schools, 2007).

2.1.2 Professional Master's Education

The professions exist in the context of the market and societal needs, and the higher education system plays an integral role in producing the professionals for the society and the economy. Rudolph (1984) asserts that the American educational practices reflect the growth of the specialized professionals. He claims that "[a] profession does not exist until a group of practitioners is accorded autonomy and prestige by society in return for certain services for which there is a market" (p. 15). Likewise, professional education is primarily offered through universities and universities are characterized by the presence of professional schools as "…professions rest on knowledge and universities are the seat of knowledge in modern societies" (Abbott, 1988, p. 194).

Professional education influences the quality of services provided and "[p]rofessional education is directed toward helping students acquire special competencies for diagnosing specific needs and for determining, recommending, and

taking appropriate action" (Hoberman & Mailick, 1994, p. 3). Abbott (1988) identified at least four roles played by universities in professions—universities serve as legitimators by providing credible and exclusive opportunity to practice profession, they support knowledge advancement of professionals to develop new techniques outside of practice, they train young professionals, often in collaboration with research and finally universities may become another arena for interprofessional competition (Abbott, 1988). Vocationalism remains deeply rooted in the American higher education and there is need to leverage the strengths of professional education by integrating it with the larger educational purposes (Grubb & Lazerson, 2005). It is critical to distinguish between professional education and vocational training. Generally, the knowledge-based professions relate to the professional education while, the labor-intensive services correspond to the vocational education. At the core, the focus of vocational and professional education may be same—to fulfill the requirements of the society and economy, however, they differ substantially in terms of impact, engagement, and complexity of educational offerings.

The master's degree has been a critical channel for preparing professionals in the United States (Council of Graduate Schools, 2007). While the original intent of the master's degrees was to be an entry-level qualification for the college teachers; by late nineteenth century its purpose had transformed to prepare talent for the professions (Conrad et al., 1993). Since the early 1980s, more than 80 percent of the master's degree is awarded in professional fields like engineering, and business (Conrad et al., 1993). Recently, the Council of Graduate Schools (2007) in its report *Graduate*

Education: The Backbone of American Competitiveness and Innovation, emphasizes the role of graduate education in preparing professionals with skills to compete in a knowledge-based global economy and encourages stakeholders in the U.S. higher education to engage with the graduate education. It highlights the growth of professional master's education and urges development of new collaborative programs across disciplines to prepare future workforce, which needs both technical competence along with social consciousness. According to Glazer-Raymo (2005) "Operating at the interstices of academic degree, it [master's degree] contributes to the discourse of interdisciplinary innovation and organizational change" (p. 3).

There are several catalyzing forces that contribute to the professionalization of the master's degree including technological advances, global initiatives, quality control and accountability, and the convergence of academic and professional field across disciplinary, departmental, and institutional boundaries (Glazer-Raymo, 2005). Master's degree has witnessed unprecedented growth and has become a critical component of the university strategy and operations (Glazer-Raymo, 2005). The future projections of master's degree also reflect the demand of the new economy. From nearly 575,000 master's degree awarded in 2004-05, master's degrees are projected to grow by 35 percent to nearly 778,000 degrees by 2016-17 (Hussar & Bailey, 2007).

The unprecedented expansion of master's education along with the increasing importance of master's education to growing numbers of students and employers, has also led to issues of program quality and relevancy (Haworth & Conrad, 1997). For example, Conrad et al. (1993) in a national study of the master's degree investigated

how people view their master's education experiences, and what are the characteristics of an ideal master's degree. This research resulted in a typology of four "idealized" program types—ancillary, career advancement, apprenticeship, and community centered. Among the four program types, MBA programs were generally characterized as career advancement programs that relied heavily on prescribed core curricula, and emphasized theory-to-practice model of pedagogy. Engineering programs were generally characterized as apprenticeship model where faculty emphasized on "doing-centered learning", and committed to master's program in engineering for preparing future professionals.

2.1.3 Influence of Industry on Curriculum

The relevancy and quality of professional education with the needs of the new economy requires collaboration across stakeholders including employers (Jones, 2002). There is abundant research literature available on university-industry collaborations in the area of research and development, however, the focus of this review is on the role of industry in education, new program development, and curriculum development. Barnett (1994) argues that the relationship between knowledge, higher education and society is under constant interaction and transformation. The higher education system is an integral part of the knowledge industry and society expects it to develop operationally competent and efficient students (Barnett, 1994).

In engineering field, there are several cases where corporate involvement and partnerships fostered development of new programs and curriculum. Chesbrough and Spohrer (2006) mention that in the 1940s, Computer Science was still not accepted as a discipline and external support played a critical role in bringing credibility and acceptance of the Computer Science as a discipline. For example, Thomas Watson Sr., then chairman of IBM also served as a trustee of the Columbia University and promoted the Computer Science discipline (Chesbrough & Spohrer, 2006). More than two decades ago, when computer-based tools were gaining prominence in manufacturing, IBM contributed ten million dollars across five universities to develop graduate programs in manufacturing systems engineering (Dieter, 1984). More recently, IBM is taking lead in promoting the service science and is sponsoring events, and awarding research and course development grants (Lohr, 2006). Universities are also taking proactive role in collaborating with the industry. For example, Bodmer et al. (2002) discussed the case of MIT that actively engages with industry to offer a "broad, fundamental, yet practical education that …is influenced by the curriculum and the co-op program with industry and the industrial connection program" (p. 205).

The business schools in 1950s and 1960s were relevant to the needs of the industry, however, they lacked academic rigor and were considered as trade schools (Zell, 2005). In search for gaining professional credential, business schools adopted a more theoretical and scientific approach (Zell, 2005). The adoption of scientific model led business schools to loose relevancy with the practice (Bennis & O'Toole, 2005). Better engagement and involvement with the employers is recommended to improve

the relevancy of management education (Doria, Rozanski & Cohen, 2003; Hamilton, McFarland & Mirchandani, 2000). Bennis and O'Toole (2005) assert that the business community has the strongest potential of creating changes in the professional higher education and "business leaders have not demanded enough from the educational institutions purporting to serve them" (p. 103). According to AACSB International (2006) "[e]ngaging business leaders in discussions about curriculum, the assurance of learning process, and other assessments of learning activities could be valuable" (p. 9).

This section reviewed the context for developing a competency-based curriculum for the new service economy. In summary, it seems that the changing nature of economy is influencing the demand for a new set of professional competencies. This new set of competencies may be effectively delivered by the professional education at the master's level. Higher education plays a critical role in providing talent for the professions and industry supports higher education through funding and feedback. Thus, design and development of curriculum for the new service economy has to be collaborative and competency driven.

2.2 Competency-based Curriculum Development

This section of the review presents the theoretical and conceptual foundations of the curriculum development with specific discussion on the need and benefits of the competency-based curriculum. This section also includes two subsections on engineering and management education and reviews the literature on competency-based curriculum from the respective disciplines.

Curriculum is the centerpiece of academic decision-making, institutional values, professional lives of students and faculty, and reason for the existence of universities, however, "…the literature on college and university curriculum is unquestionably amorphous" (Conrad & Pratt, 1986, p. 235). Curriculum in higher education literature has been defined from several perspectives. Lattuca (2006) suggests that curriculum is better conceptualized as a site for social interaction among students, faculty, and content. By defining curriculum as the site for social interaction, we acknowledge several factors that influence the curriculum planning (Lattuca, 2006). She traces the history of the evolution of the curricula and notes that the changes in the educational purposes is a result of changes in the social, political, economic, professional, institutional, and cultural needs. For example, early 1800s marked the inclusion of the scientific studies like agriculture and natural sciences as there was a consistent pressure to prove the utility of the higher education. Likewise, demand for specialized professional led to the introduction of elective system and academic majors in the latter half of 1850s. In more recent times, social and political movements of 1960s demanded more student-centered curriculum from the universities and the beginning of this century called for greater accountability and outcome-based curriculum as there are concerns about the quality of graduates (Lattuca, 2006).

Another perspective conceptualizes curriculum as a site for epistemological debate where stakeholders contest for what counts as valid and acceptable knowledge. Gumport and Snydman (2002) support this perspective and suggest that organizational

structures and knowledge legitimation processes are interdependent and that academic innovation is also manifested in the educational programs and curricula. Karseth (1995) argues for a dual perspective on new educational program and curriculum development where one perspective uses cognitive and epistemological debates to define what counts as valid knowledge and the other perspective uses social legitimation process where external socioeconomic and political factors demand practical utility.

Curriculum is also conceptualized as a set of student learning outcomes or competencies. Diamond (1998) suggests that the goals of curriculum should be well defined in terms of required student competencies, "…beginning with an institutional statement of goals and ending with the assessment of each student prior to graduation and after" (p. 51). Thus, Diamond (1998) emphasizes the role of outcomes and student competencies in defining the quality of the educational process including curriculum. According to Conrad and Pratt (1986) "…academic programs or curricula denote those educational experiences that encourage purposeful learning. Academic programs are forms at the core of higher learning that organize the acquiring, transmitting, and applying of knowledge" (p. 235).

Curriculum is at the core of the relationship between higher education and employer (Geiger, 1980). The changing economy is demanding a better alignment between competencies demanded and the curriculum offered. According to Fincher (1986) the most significant influence on college curriculum since the 1960s has been the demand for measured or assessed outcomes that would ensure the competency and

proficiency of graduates. There is growing loss of confidence among the stakeholders including students, employer, trustees, and policymakers that the higher education system is adequately preparing individuals for the demanding challenges facing the current and future workplace (Banta, 2001; Jones, 2002; Haworth & Conrad, 1997). Higher education institutions are under pressure to convince their stakeholders about the value addition they bring to students' knowledge, skills, and attitude (Banta, 2001; Vaatstra & de Vries, 2007).

The demand from the stakeholders is leading to the emphasis on competency-based education. Masters and McCurry (1990) highlight that the competency-based movement is gaining prominence as it attempts to make explicit the skill standards necessary for performing competently within a profession. Competency-based curriculum identifies and includes set of knowledge and skill, which may be neglected in traditional discipline based course structures (Toohey, 1999). Van der Klink and Boon (2003) assert that the current curriculum design processes is slow to adapt to the labor market requirements, however, "[c]ompetency-based education holds the promise of curricula with a practical orientation that are tuned to the needs of employers" (p. 129). Competencies serve as a conceptual framework and a common communication language between education providers and employers to design curricula (Van der Klink & Boon, 2003).

Literature presents several benefits for using the competency-based curriculum. Brownell and Chung (2001) identified five major benefits of competency-based education—a change in the student-teacher relationship, an increase in emphasis

on internal information sharing, improvement in clarity of desired student outcomes and program effectiveness, better articulation of the competencies of program graduates, and an increase in student satisfaction and learning. Toohey (1999) notes three advantages of competency-based curriculum—first, competency-based curriculum is more likely to produce graduates with competencies that a conventional curriculum may not provide. Second, competency-based curriculum is developed in concert with industry to ensure that it is relevant to the job requirements. Third, competency-based curriculum offers promise of more flexibility and continuous learning (Toohey, 1999).

Within the higher education system, professional programs are more receptive to the competency-based curriculum (Banta, 2001). Jones (2002) believes that a gap exists between ideal expected professional education outcomes and actual competencies of graduates, and urges professional education programs to "…reexamine their overall curriculum, including the important outcomes that all college graduates should master to be more effective in the changing workplace" (p. 5). Likewise, Hoberman and Mailick (1994) note that "[b]asic professional education should ensure general competence at an acceptable level in the entire field. However, as conditions change, knowledge increase, and better services are demanded, earlier levels of competence are not considered sufficient for effective practice" (p. 10). This requires a systematic approach to curriculum reform in professional education as piecemeal changes do not deliver expected results (Hoberman & Mailick, 1994; Jones, 2002; Van der Klink & Boon, 2003).

Curriculum development in professional education also faces several challenges. They are—(1) knowledge acquisition may not lead to successful application, (2) successful knowledge application may not be a result of conceptual comprehension, (3) subject-specific knowledge and skills may lead to inability to apply beyond the very subject, and (4) possession of general knowledge and skills may not imply mastery over specific subject areas (Everwijn et al., 1993). Everwijn et al. (1993) propose that the ability or competence-based approach provides a solution to above problems in professional education as apart from "disciplinary and functional instruction, simultaneously attention is paid to the development of such basic abilities and generic skills as problem solving, communication, information handling, social interaction and leadership" (p. 426).

2.2.1 Engineering

The practice of engineering dates back to 5th and 6th centuries B.C. and the core responsibility of engineer is to provide solutions to the technological and societal problems (Turmeau, 1982). However, engineering education has been criticized for not keeping pace with the change in the societal and technological needs. Even more than 25 years ago, the issues of relevancy of the engineering curricula were being raised (Turmeau, 1982). The curricular issues of engineering education relate to its focus on knowledge acquisition and "neglect the process of personal and social construction of knowledge and the development of professional competence" (Lachiver & Tardif, 2002, p. F2F-9). The editors of the special issue of the *European*

Journal of Engineering Education on engineering competencies highlighted that the primary goal of engineering curricula is to develop professionally competent engineers (Lemaitre et al., 2006).

In recent years, competency-based curriculum in engineering education is gaining support to "…reflect the changing nature of society, the world of work and education" (Walkington, 2002, p. 133). Curriculum development is no longer the sole responsibility of the university professor, and curriculum development process should engage internal and external stakeholders to bring a holistic view (Walkington, 2002). There are several approaches discussed for the competency-based curriculum development in engineering education. Walkington (2002) proposes a four stage interactive and iterative process with a goal to produce actionable engineering curriculum that influences effective student outcomes. Lachiver and Tardif (2002) conceptualize learning as the transformation of information into knowledge and competency and hence propose curriculum development on two primary frameworks—learning framework on how students learn and conceptual framework describing the design of learning activities. Rompelman and de Graaff (2006) propose a systems design approach for developing a competency-based engineering curriculum, where input is the course content, output is the students' competencies, assessment provides a feedback mechanism, and teaching is educational process.

Competency-based curriculum development process has been applied for master's level programs. For example, Sutcliffe, Chan and Nakayama (2005) discuss the competency-based curriculum development for a master's level degree in

information systems (MSIS). Sutcliffe et al. (2005) mention that the MSIS curriculum development process involved four primary stages—review of curriculum model and conceptualization of competency-based approach, feedback from industry, feedback from faculty outside the information systems discipline, and consultation with information system faculty. They conclude that the MSIS curriculum developed with above framework is inclusive of stakeholders' views and provides a flexible modular approach to competency-based education.

Gorgone, Gray, Stohr, Valacich and Wigand (2006) propose a model curriculum for graduate degree programs in information systems—MSIS 2006 and add that the model curriculum provides a balance of flexibility and consistency to faculty, students, and employers as they can be assured that graduates are "competent in a set of professional knowledge and skills" (p. 129) and at the same time accommodates diversity by being "sufficiently flexible to meet both institutional and student needs and objectives" (p. 137).

Shah (2004) used Delphi method to identify a set of competencies that are considered important by practitioners for developing a master's degree in engineering management. He asserts that most engineers move into a managerial role based on their work experience and find themselves unprepared for managerial tasks. Shah (2004) developed a competency-based curriculum for a traditional engineering management program focused on operation and technology and not on the services nature of the economy.

2.2.2 Management

Over last decade, business management education has been constantly criticized for its inability to produce business ready professionals. Bennis and O'Toole (2005) argue that irrelevancy of the curriculum is the reflection of the culture of the business school, which has been focusing too much on scientific research and has been out of alignment with practice. Bennis and O'Toole (2005) conclude that "The entire MBA curriculum must be infused with multidisciplinary, practical, and ethical questions and analyses reflecting the complex challenges business leaders face" (p. 104). Boyatzis, Cowen and Kolb (1995) suggest that "Managing change in the academic curriculum, in what is taught and how it is learned, must rank among the top twenty-first-century management challenges for higher education" (p. 1).

There is a shift in curriculum debate in business education from traditional functional areas to more integrated cross-functional curriculum focused on skills and competency development (Doria et al., 2003; Hamilton et al., 2000). Consequently, "…redesigned curriculum curricula must cut across traditional boundaries to develop and reinforce the appropriate bundles of technical knowledge as well as social and organizational skills" (Hamilton et al., 2000, p. 103). According to Brownell and Chung (2001), competency-based models are bound to gain prominence in graduate business education as they "…emphasize learner outcomes and suggest that regardless of how well planned the academic intervention, success can only be measured by the changes that take place in students' performances, whether demonstrating cognitive, affective, or skills-based learning" (p. 125). Business schools need to improve on the

curriculum in the area of social skills, relationship management, problem solving and leadership (Doria et al., 2003).

Competency-based curriculum development process has been applied for master's level management programs. Boyatzis et al. (1995) presented the process of curriculum innovation at the Weatherhead School of Management and concluded with a set of design and process principles for an ideal professional program. They claim that generally curriculum development and planning is driven more by the faculty's professional and knowledge needs rather than students'. Boyatzis et al. suggest that there is a need to focus on learning from the student's perspective who may be seeking less discipline specific and more problem-centered and contextually defined learning.

Wooten and Elden (2001) discuss the process of moving from a conventional human resources (HR) functions-based program to a competency-based program. They used a cogenerative learning process to include stakeholders in all stages of curriculum development. The four key stages of competency-based curriculum development were—identification of stakeholders and resources, data collection and analysis, curriculum revision and rollout, and assessment evaluation. Sims and Sauser (1985) propose Kolb's Experiential Learning Model as a framework for developing a competency-based business curriculum.

Chyung, Stepich and Cox (2006) present the case of developing a competency-based curriculum at the Boise State University. According to Chyung et al. (2006) "[t]he core of competency-based curriculum design is to ensure that learners will be able to demonstrate their learned capabilities after they have acquired a necessary

combination of knowledge, skills, and abilities" (p. 307). Competence-based curriculum focuses on enabling student to achieve minimum acceptable standards and not necessarily providing expertise. Chyung et al. (2006) note that certain competencies are context-specific and hence competency-based curriculum should be contextualized.

This section reviewed the theoretical foundations of competency-based curriculum development in the disciplines of management and engineering. In summary, the competency-based curriculum seems to provide necessary framework for meeting the demands of accountability and relevancy in professional education for the new economy. The literature in engineering and management disciplines provided several studies that effectively used the competency-based curriculum development model. However, there is very little literature available that specifically addresses the use of competency-based curriculum development for a master's level program in SSME.

2.3 Competencies

This section of the review presents the theoretical and conceptual foundations of the competencies. This section also includes two subsections on engineering and management education and reviews specific competencies that are found to be important in the respective disciplines.

Competency-based education is based on the premise that competencies differ with respect to their context of application and require different bundles of knowledge

and skills (Voorhees, 2001). The challenge for higher education system is to "…determine which competencies can be bundled together to provide different types of learners with the optimal combination of skills and knowledge needed to perform a specific task" (Voorhees, 2001, p. 9). Competency-based education brings clarity and consensus of outcomes among all stakeholders involved in the learning process and enables them to work towards competencies in a focused and relevant manner (Voorhees, 2001). Employers are demanding more from higher education institutions for curricular integration of transferable skills such as leadership, communication, quantification, adaptability to change, and interpersonal relations (Banta, 2001). Jones (2002) discussed several case studies and concluded that the success of curriculum initiatives rests on systematic and collaborative effort to identify the learning outcomes in terms of professional knowledge, skills, and attitudes that the educated professional graduate should achieve. These outcomes are best defined by consulting with external stakeholders including accrediting agencies, employers, and professional associations.

Accrediting associations both at regional levels and disciplinary levels had traditionally focused on input and processes as compared to outcomes (Banta, 2001). From late 80s onwards, accrediting associations have also started emphasizing on the outcomes in their standards (Banta, 2001). Engineering education accreditor, ABET, Inc. (formerly the Accreditation Board for Engineering and Technology) moved from being an input-oriented to output-oriented accreditation process and defined 11 competencies which every engineer should be able to exhibit (Muffo, 2001). Business

education accreditor, AACSB International (formerly the Association to Advance Collegiate Schools of Business) accredits business management programs in colleges and universities and has been emphasizing link between curriculum, assessment, and competencies (Palomba & Palomba, 2001).

Competence has been conceptualized in several ways. Competence is not the same as being an expert or skilled, and competency-based curriculum should enable transformation of the students' learning into performance-based organizational outcomes (Chyung et al., 2006). Chyung et al. (2006) suggest that both means and an end are integral to the definition of competency. The means are knowledge, skills, or abilities and the end is effective performance to expected standards. Competencies are contextual and involve a combination of skills, knowledge or attitudes in the context of application (Van der Klink & Boon, 2002). Van der Klink and Boon (2002) focused on the composition of competency profiles that provide an input for the design of competency-based education. They defined a competency profile as "…an empirically validated, systematic description of professional activities within a certain professional domain" (Van der Klink & Boon, 2002, p. 412).

The conceptualization of professional competence requires a more holistic and contextual approach, where emphasis is on problem-solving approach based on an ability to draw on and to integrate a variety of knowledge and skills (Masters & McCurry, 1990). Gonczi, Hager and Oliver (1990) define a competent professional "…as a person who has the attributes necessary for job performance to the appropriate standard" and hence successful professional performance requires a set of underlying

attributes that include knowledge, skills, and attitudes. Identification of appropriate competencies helps professions to suitably improve and align their curriculum (Gonczi et al., 1990).

The concept of competencies is not perfect and has several interpretations and challenges (Van der Klink & Boon, 2002). Some of the challenges with the use of competencies are—lack of specificity of the competencies, lack of exact and clear relationship between education and professions, overemphasis on professional requirements, and challenge of keeping the definition of competencies current (Van der Klink & Boon, 2002).

2.3.1 Engineering

Literature in engineering education seems to suggest a shift towards identification of specific competencies required for preparing engineering talent. The professional knowledge of engineers is no more limited to designing technical products, but includes customization of applications, and understanding the social context (Lemaitre et al., 2006). Engineering education has to respond to this need by adopting competence driven approach that integrates problem-based learning, with productivity improvement, innovation, and social consciousness (Chong & Crowther, 2005; Lemaitre et al., 2006). Coll and Zegwaard (2006) argue that curriculum development should be inclusive of the stakeholders' view and "…if educational institutions wish to produce graduates with skills desired by employers, it is important that they have an understanding of specific skills desired by the workplace" (p. 33).

Competence represents a value judgment which conveys importance of competence in a particular context, culture, and socio-professional environment (Lemaitre et al., 2006). This increased emphasis on competencies development in education is also driven by the dominance and evolution of knowledge-based services in the economy, which has a completely new set of complexities and context as compared to industrial economy for which engineers are trained (Lemaitre et al., 2006). There is also an increasing support for the movement from resource and reputation indicators as predictors of college student learning to emphasis on demonstrable changes in student outcomes (Cabrera, Colbeck & Terenzini, 2001).

There are several studies in engineering education that have attempted to identify set of competencies required for engineering graduates. Cabrera et al. (2001) investigated the relationship between classroom practices and students' gains in professional competencies for engineering students as a part of a curriculum improvement study. They found positive relationship between classroom practices and engineering students' gains in students' professional competencies like problem-solving skills, group skills, and understanding of engineering as an occupation. Coll and Zegwaard (2006), found top competencies desired by employers of science and technology graduates as— ability and willingness to learn, teamwork and cooperation, initiative and analytical thinking.

Bodmer, Leu, Mira and Rütter (2002) conducted a benchmark study called SPINE—Successful Practices in International Engineering Education, to evaluate the quality and relevance of engineering education and to identify successful practices

among ten leading European and U.S. universities including Massachusetts Institute of Technology, Carnegie Mellon University, and Georgia Institute of Technology from the U.S. Based on the survey of 543 professors, 1372 engineers and 145 corporate managers, Bodmer et al. (2002) identified critical engineering competencies. They found that among general professional competencies communication skills, English language skills, presentation skills, leadership skills and teamwork abilities were regarded more important and among specific engineering competencies problem-solving skills, analysis/methodological skills, basic engineering proficiency were rated important.

Among the attributes for the engineer of 2020, National Academy of Engineering (2004) identified strong analytical skills, practical ingenuity, creativity, communication and business and management skills, leadership and high ethical standards as critical. Chong and Crowther (2005) proposed outcomes-based framework—SERVQUAL-TRANS that measures a range of student competencies and allows the stakeholders to measure the quality of engineering education offered and improve the curriculum accordingly. SERVQUAL-TRANS consists of five major set of outcomes dimensions namely—technical competencies, generic competencies, management and organization skills, communication and social skills, and teamwork. Lohmann, Rollins and Hoey (2006) propose a curriculum model for incorporating the global competence among engineering students. Lohmann et al. (2006) identified three major skills that are critical in the new global economy: (1) a broader interdisciplinary

knowledge base, (2) engineers need well developed interpersonal skills, and (3) ability to live and work in a global setting.

The accreditation requirements for engineering education have also suggested the importance of competencies and student learning outcomes. In response to the continuing demand for student performance, ABET Inc. adopted Engineering Criteria 2000 (EC2000) in 1997. EC2000 marked a shift from input based measures to output based measures that define student learning outcomes (Banta, 2001; Schachterle, 1999). EC2000 defines criterion 3—Program Outcomes and Assessment as a set of performance outcomes that student should demonstrate for successful completion of the program (Schachterle, 1999). The outcomes are given below:

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (Lattuca, Terenzini, Volkwein and Peterson, 2006, p. 7).

Lattuca et al. (2006) reported the results of a study to assess the impact of EC2000 on engineering students' professional preparation. According to program chairs and faculty members, their engineering program curricula have changed to increasingly emphasize on professional skills as defined by EC2000. Likewise, the employers' responses indicated that the EC2000 criterion 3 learning outcomes are important to their hiring decisions of recent graduates.

2.3.2 Management

Several authors have sharply criticized the value and relevance of management education (Bennis & O'Toole, 2005; Pfeffer & Fong, 2002). Business schools seem to serve as a filtering device where students have to exhibit competence in getting admitted and not necessarily to graduate (Pfeffer & Fong, 2002). Business schools focus too much on analytical and theoretical aspects while missing on the communication skills, leadership skills, and interpersonal skills (Bennis & O'Toole, 2005; Pfeffer & Fong, 2002). Thus, the curriculum offered in the business schools and the competencies developed among the management students have little relevance to the business practice (Bennis & O'Toole, 2005; Pfeffer & Fong, 2002).

Boyatzis, Stubbs and Taylor (2002) claim that management education should help students "develop the functional, declarative, procedural, and metacognitive

knowledge needed" (p. 150). They add that knowledge is the basic requirement for a manager, however, ability to apply the knowledge effectively is what determines the performance of manager. Based on literature review Boyatzis et al. (2002) identified three clusters of managerial competencies—cognitive or intellectual abilities, self-management or intrapersonal abilities, and relationship management or interpersonal abilities. Jaeger (2003) emphasizes the need for investigating the role of emotional intelligence in graduate professional education by developing the interpersonal and intrapersonal competence of students. Based on exploratory empirical study Jaeger (2003) found that students with emotional intelligence related curriculum reported higher emotional intelligence scores than those in non-emotional intelligence curriculum.

Based on alumni survey, industry analysis, professional standards, and curriculum benchmarking, Chyung et al. defined a set of 38 competencies in 4 categories—professional practice, analytical process, technical product, and interpersonal communication. These competencies were then used to redesign the courses in the business curriculum. According to Boyatzis et al. (1995) the new management program should reflect the "added value" by developing the knowledge and abilities of students and equipping them with the capacity to think and act creatively. They developed a learning assessment model measuring 22 managerial abilities and 11 knowledge areas.

Tanyel, Mitchell and McAlum (1999) surveyed the faculty and prospective employers to identify the skills and competencies they believe are critical for business

school graduates. Based on extensive literature review they identified 16 attributes for business school graduates as—responsibility and accountability, ethical values, interpersonal skills, oral communication, time management and punctuality, ability to work in teams, decision making and analytical ability, written communication, creativity and creative thinking, ability to assimilate new technology, project management, presentation skills, computer problem-solving skills, computer word-processing skills, persuasive ability, and global awareness. Tanyel et al. (1999) found that faculty and prospective employers differed on the importance of 7 out of 16 attributes investigated. This indicates a gap between understanding of faculty and demands of the employers for student competencies and hence faculty needs to better align their curriculum.

Wooten and Elden (2001) identified 84 exit competencies for HR professionals divided into five clusters—core HR processes, general business management, strategic decision making and problem solving, change management, and personal mastery and influence. Wooten and Elden (2001) conclude that "[t]he specific outcome competencies and curricular reconstructions that make an educational program relevant to its customers must be coproduced with all stakeholders working as partners" (p. 255). Gilmore and Carson (1996) identified a set of core management competencies and applied them to the field of services marketing. The core management competencies analyzed were—creativity, motivation, vision, adaptability, communication, coordination, leadership, and analytical skills. They argue that the complex nature of services calls for identification of competencies, so

that the most appropriate competencies may be developed and continuous improvement in management performance is achieved.

Mallick and Chaudhury (2000) discussed the case of curriculum development in technology management MBA program and highlighted that for an evolving discipline like technology management, there is a need for identifying a set of knowledge and skills to develop a relevant curriculum. Mallick and Chaudhury (2000) presented the survey results of faculty and practitioners to identify and prioritize the required set knowledge and skills. They asked the respondents to rate 23 knowledge areas and 17 skills on a five point scale. They found that there are both areas of agreement and disagreement between faculty and practitioners. Four important knowledge areas identified by both the faculty and practitioners were the strategic role of technology in business, the implementation of new technology, new product development, and business strategy and competition. Top two important skills identified by both the faculty and practitioners were achieving implementation and effective written communication.

The accreditation standards for management education have also emphasized importance of competencies and student learning outcomes. According to Palomba and Palomba (2001) “because of AACSB’s strong emphasis on the link between assessment and curriculum, a number of business schools have spent considerable effort developing statements of expected competences for students” (p. 123). AACSB International (2006) identified preparation of the next generation of business leaders

by offering relevant education among the key challenges for business schools and suggests that:

> Management education must develop mechanisms for understanding the essential competencies and skill sets of business school graduates, forecasting how those competencies will change in the future, and assessing the level of mastery of those skills and competencies. These processes are essential measures in helping to ensure the capability and competency of the next generation of business leaders. (p. 9)

This section reviewed the professional competencies as defined in the disciplines of management and engineering. In summary, the competencies seem to provide a common language and standard for meeting the needs of a profession. The competencies are contextual in nature and hence with the changing context of the knowledge-based service economy, there is a need for defining a new set of competencies. The literature in engineering and management disciplines provided several studies that attempted to identify competencies. However, there is very little literature available that specifically identifies the competencies for a graduate of master's level program in SSME. There seems to be a demand for interdisciplinary competencies like cross-functional communication, team skills, systems thinking, and creativity.

2.4 Interdisciplinary Education

This section of the review presents the theoretical and conceptual foundations of the interdisciplinary education. Specifically, this section will present the need, benefits, and challenges of interdisciplinary education and its relevance to management and engineering education.

The history of U.S. higher education since the nineteenth century has been one of increasing disciplinary specialization and organization (Lattuca, 2001). World War II encouraged interdisciplinary research applications in military services and political agendas (Lattuca, 2001). The creation of National Science Foundation (NSF) and National Institutes of Health (NIH) further provided impetus to the interdisciplinary projects. Interdisciplinary curricula also gained prominence during the social transformations of the 1960s influenced by the environmental consciousness (Lattuca, 2001). Interdisciplinary approach is required as real world problems seldom present themselves in well defined disciplinary boundaries (Davis, 1995; Lattuca, 2001). Woods (2007) identified three major arguments in favor of interdisciplinary learning and curriculum—educational benefits of critically examining one's own discipline from another disciplinary perspective, the nature of the work is calling for more cross-functional and collaborative approach, and the global challenges require a new comprehensive problem-solving approach.

Disciplines can be defined as set of problems, methods, and research practices or as bodies of knowledge that are unified by any of these (Lattuca, 2001). They can also be defined as social networks of individuals interested in related problems on

ideas. Interdisciplinarity builds on the disciplinary bases and is defined as "… the interaction of different disciplines" (Lattuca, 2001, p. 78). Hence, successful interdisciplinary education cannot exist independent of the basic disciplines.

Interdisciplinarity combines theories, concepts, and/or methods from different disciplines to address questions that cannot be answered completely by a single discipline (Davis, 1995; Lattuca, 2001). Salter and Hearn (1996) defined interdisciplinarity as "any challenge to the limitations or premises of the prevailing organization of knowledge or its representation in an institutionally recognized form" (p. 43). They differentiate between two forms of Interdisciplinarity—instrumental interdisciplinarity and conceptual interdisciplinarity. Instrumental interdisciplinarity is a pragmatic approach that focuses on interdisciplinarity as a problem solving activity and while conceptual interdisciplinarity emphasizes a synthesis of knowledge (Salter & Hearn, 1996). Franks, Dale, Hindmarsh, Fellows, Buckridge, and Cybinski (2007) synthesized the literature on the conceptualization of interdisciplinarity and mention that:

> [Interdisciplinarity] unifies and integrates knowledge and must include an interaction, overlap, sharing of insights or bridging of disciplines among two or more disciplines from a theoretical, practical-outcome or problem-oriented approach. It borrows or applies tools between disciplines, and it may lead to the emergence of a new discipline and new fields of knowledge. (p. 171)

According to Davis (1995), interdisciplinary courses involve two or more professors collaborating in significant ways to provide integrative disciplinary perspectives. The interdisciplinary teaching focuses on for collaborative tasks—planning, content integration, teaching, and evaluation (Davis, 1995). He presented

five cases from the University of Denver, to illustrate the value of interdisciplinary and team based teaching to overcome the limitations of disciplinary and professional specializations. Davis (1995) argued that students in an information society need advanced set of skills to find, retrieve, understand, and use information which "are best carried out . . . in interdisciplinary courses, where the focus is on developing critical thinking skills, employing multiple perspectives, and relating information to some larger conceptual framework than the concerns of a single discipline" (p. 38).

Higher education stakeholders including accreditors, professional associations, employers and policy makers are encouraging interdisciplinary programs. For example, the Council of Graduate Schools (2007) encourages development of new collaborative programs across disciplines to prepare the future workforce, which needs both technical and business competence for the new economy. They highlight IBM's leadership in collaborating with universities and policy makers to develop a new academic discipline called services science and recommend that, "In the new knowledge-based economy, the need for graduates with interdisciplinary skills requires that businesses, governments, and nonprofits collaborate with universities to develop and expand professional master's programs" (Council of Graduate Schools, 2007, p. 20). Additionally, government agencies like National Science Foundation (NSF) are increasingly encouraging collaboration across disciplines. For example, NSF funded program—Integrative Graduate Education and Research Traineeship (IGERT) disbursed $58 million to 22 universities in 2001 to encourage and train graduate students for interdisciplinary and collaborative research (Brainard, 2002).

According to Lattuca (2001) "[i]t is fruitless to talk about the process of doing interdisciplinary work without discussing the influence of the contexts in which it is done" (p. 20). The context of interdisciplinarity for this review is to explore development of a competency-based curriculum for a master's level program focused on the needs of the service economy. Interdisciplinary nature of the master's education is found to be of significant value addition to the employers and graduates as it is responsive to the workplace needs (Conrad et al., 1993). The Council of Graduate Studies (2007) in its report discussed the case of interdisciplinary master's degree that is adapting graduate education to the workforce needs. The Council of Graduate Schools is promoting Professional Science Master's (PSM) degree with support from the Alfred P. Sloan Foundation, and innovative professional master's programs in the humanities and social sciences through a project funded by the Ford Foundation (Council of Graduate Schools, 2007). The objective of interdisciplinary master's degrees is to professionalize sciences, social sciences, and humanities degrees to produce graduates with both disciplinary expertise and business skills. It asserts that "Interdisciplinary research preparation and education are central to future competitiveness, because knowledge creation and innovation frequently occur at the interface of disciplines" (Council of Graduate Studies, 2007, p. 18).

Some universities are taking initiatives to align their research and education strategies on the interdisciplinary approach. For example, the Commission on Graduate Education at the Stanford University (2005) recommends to foster intellectual innovation through interdisciplinary graduate education and asserts that

"the availability of opportunities for more cross-disciplinary and interdisciplinary educational experience will be an essential part of a top quality graduate education" (p. 18). The President of the University of Michigan emphasized the importance of interdisciplinary culture at the University of Michigan and launched a faculty hiring program that will fund 100 tenure-track faculty positions, specifically committed to interdisciplinary work (Coleman, 2007).

The need for interdisciplinary and cross-functional management education is emphasized by several researchers (Boyatzis et al., 2002; Bennis & O'Toole, 2005; Hoberman & Mailick, 1994; Pfeffer & Fong, 2002). Management education tends to present a simplistic and modular picture of complex systems by using general theory and models rather than developing practice-oriented interdisciplinary problem solving skills (Hoberman & Mailick, 1994). Al-Hawamdeh (2005) discussed the case of design and development of an interdisciplinary graduate program in knowledge management. They assert that complex and evolving nature of the knowledge management discipline requires identification of the set of skills and competencies so that the curriculum may align with the accepted norms and standards.

Likewise, literature in engineering education has also emphasized interdisciplinary knowledge. National Academy of Engineering (2004) recommends that engineers need broader interdisciplinary training to adapt to the increasing pace of technological innovation and global competition in industries. Engineers' education should include exposure to the humanities and training in analytical, communication, and foreign-language skills (National Academy of Engineering, 2004). National

Academy of Engineering (2004) aspires "…to an engineering profession that will rapidly embrace the potentialities offered by creativity, invention, and cross-disciplinary fertilization to create and accommodate new fields of endeavor, including those that require openness to interdisciplinary efforts with nonengineering disciplines such as science, social science, and business" (p. 50). Bodmer et al. (2002) discussed the case of Carnegie Mellon University (CMU) and found that "[o]ne of the reasons interdisciplinary activity thrives at Carnegie Mellon University is the long-held belief that many important problems cross several disciplines" (p. 131).

Despite the promise and potential of interdisciplinary education, there are several challenges in its implementation and acceptance. Al-Hawamdeh (2005) presents several challenges in developing an interdisciplinary graduate program like, challenge of gaining consensus and positive and unbiased contribution from faculty members involved in the curriculum development process. Another major challenge is to find the resources and faculty who would be able and willing to teach newly created curriculum and integrate various disciplines to develop meaningful interrelationships (Al-Hawamdeh, 2005). Research also highlights that teaching outside the core functional area may have potentially damaging effect on the faculty career in terms of tenure and promotion (Hamilton et al., 2000). Interdisciplinary approach is critical as management problems in general are not compartmentalized and disciplines provide the development of specialized professionals and knowledge (Boyatzis et al., 1995).

Interdisciplinary skills complement the disciplinary expertise and have a genuine place in university curricula (Klein, 1990). However, there is a need to

balance the disciplinary and interdisciplinary emphasis in educational programs (Boyatzis et al., 1995). Interdisciplinary projects emphasize integration over discrete disciplinary studies and hence require more collaboration, coordination, and communication across disciplines (Klein, 1990). Woods (2007) agrees that interdisciplinary problem solving requires the ability to communicate with a diverse group of specialists and hence "the degree of integration of disciplinary knowledge, and the appropriateness and novelty of solutions proposed, will be held to be at least as important as the depth of knowledge displayed in any particular field" (p. 859). Everwijn et al. (1993) challenge the position that curriculum designed around the disciplinary and functional areas alone would develop required competencies in the students. However, they add that functional and disciplinary knowledge and skills are prerequisite for developing interdisciplinary competencies.

This section reviewed the role of postsecondary interdisciplinary curriculum in developing professional competencies. In summary, interdisciplinary education by its definition attempts to provide solution to complex problems by combining two or more disciplines. The complex challenges of the knowledge-based services economy at the interface of services and technology, require interdisciplinary education in engineering and management. A master's level interdisciplinary program in SSME holds promise and potential for adapting to the changing context of the knowledge-based service economy and delivering competencies like cross-functional interactional expertise and systems thinking.

2.5 Evolution of SSME

The vision of SSME is "to discover the underlying logic of complex service systems and to establish a common language and shared frameworks for service innovation" (IfM, & IBM, 2008. p. 1). Service systems are complex and current disciplinary approaches are ineffective in dealing with the challenges. Consequently, SSME is proposed to be an interdisciplinary initiative that leverages the strengths of existing disciplines to develop adaptive innovators or T-shaped professionals (IfM, & IBM, 2008).

As discussed in the literature review, engineering and management disciplines are increasingly accepting competency-based education, but they seriously lack service mindset in their curriculum. Richard Larson, Professor at Massachusetts Institute of Technology, agrees that "Narrow, purely technocratic solutions are not adequate for service systems; perspectives and tools from multiple disciplines are required" (Larson, 2008, p. 41). To this end, Michigan Technological University received a three-year funding from National Science Foundation to develop a new interdisciplinary undergraduate level program in service systems engineering (Bohmann, Sorby, Johnson, Mattila & Sutherland, 2007).

Likewise, several proponents from management discipline have called for interdisciplinary curriculum in service science (Bitner & Brown, 2006; Davis & Berdrow, 2008; Maerki, 2008). Based on the curriculum review of elective courses at the top 20 MBA programs ranked by the U.S. News & World Report, Metters & Marucheck (2007) found that the depth of course coverage on service domain is very

limited. They found that there were 130 courses listed that were related to Operations Management (manufacturing focus) as compared to 16 courses focused on services. Davis and Berdrow (2008) agree that "a significant gap exists between the education received by business school graduates and skills that they need in today's service-intense environment" (p. 29).

SSME is an emerging field that is gaining increased support from various stakeholders. Since 2004, IBM has been actively promoting SSME as a new field, as it was observing a rapid shift in its business revenue and profits towards services as compared to hardware (IfM, & IBM, 2008). This trend was also experienced by other organizations and encouraged executives at IBM and Oracle, to establish a new nonprofit consortium called Service Research & Innovation (SRI) Initiative that will advance service innovation and research (Jana, 2007).

The year 2006, witnessed increasing support from the policymakers and federal agencies. The National Science Foundation, US Department of Commerce, and IBM Research jointly organized a *Workshop on Education for Service Innovation* with one of its key goals as "To identify and make explicit the knowledge and skills that industry has empirically observed are important to service innovation, and the gaps in our existing curricula." (Workshop on Education, 2006). Following this workshop IBM organized another conference, *Service Science, Management, and Engineering: Education for the 21st Century,* which was attended by more than 250 participants from government, industry, and academia (SSME Conference, 2006).

More recently, the year 2008 is characterized by several publications highlighting the need and relevance of SSME. A white paper was jointly released by IBM and the University of Cambridge with the purpose of engaging discussion among education, research, business and government on SSME (IfM, & IBM, 2008). Similarly, an edited book entitled *Service Science, Management and Engineering (SSME): Education for the 21st Century* was recently published (Hefley & Murphy, 2008). Finally, *IBM Systems Journal* released a special issue (Volume 47, Number 1) on the current thinking in the field of SSME.

Professional associations play an integral role in shaping the curricula as they are at the interface of the needs of the academy, state, and economy (Slaughter, 2002). Even in the case of SSME several professional associations have supported the advancement of the field. For instance, INFORMS, the leading professional association for operations research, established a special interest group on service science (Larson, 2008). Likewise, Service Research & Innovation (SRI) Initiative is also expected to encourage collaboration among education, research, government, and business to advance the field of service science (Jana, 2007).

Several academicians and universities are taking a lead in developing the field of SSME. For example, the University of California, Berkeley, offers a certificate program in SSME, and North Carolina State University offers a concentration in Services Management for its MBA program (Davis & Berdrow, 2008). Some universities have research centers that focus on service innovation and are advancing the field of SSME. For example, the Arizona State University has the Center for

Service Leadership and the University of Maryland houses the Center for Excellence in Service (Davis & Berdrow, 2008).

Legitimization of SSME in academia would require investment in development and delivery of the required curriculum from undergraduate to doctoral levels to foster development of competent professionals in services science (Siegel et al., 2008). Hefley (2006) asserts that "there is a need for curriculum and programs that address the problems, challenges, and issues of developing and deploying a workforce capable of innovating and providing leadership for the evolving services economy" (p. 2). However, developing a relevant and globally available curriculum for SSME is a huge undertaking for a single higher education institution and requires collaboration across several institutions, industry and government (Siegel et al., 2008). This study attempts to fill this need by engaging stakeholders and providing theoretical and conceptual foundations for developing a competency-based curriculum for a master's program in SSME.

CHAPTER 3: METHODOLOGY

This chapter describes the study methodology implemented to answer the research questions stated in Chapter 1. The purpose of this dissertation study was to provide theoretical and conceptual foundations for developing a competency-based curriculum for the master's program in SSME. As discussed earlier, the need for the SSME program is driven by the nature of a service economy and the corresponding changes in the professional competencies required. For an emerging field or discipline like SSME, it is critical to encourage multiple perspectives and at the same time attempt to bring some consensus among the stakeholders about future directions. This study used the online Delphi method to identify the most important competencies required for service science professionals and ascertain a set of courses to develop a curriculum blueprint for SSME.

The Delphi method is likely to be useful when there is a change in the occupational structure and new trends are emerging (Toohey, 1999). The Delphi is also appropriate when there is little or no history about the research issue and collective opinions of geographically spread experts are required (Murry & Hammons, 1995). Franklin and Hart (2007) agree that "the very value of the Delphi method is to generate ideas that are more recent than the literature and the experiences of the researchers" (p. 245). Stewart (2001) supports the appropriateness and value of the

Delphi method for professional education and suggests “Its capacity to capture those areas of collective knowledge that are held within professions but not often verbalized, makes it enormously useful in the field of professional education” (p. 922).

In line with the exploratory nature of the study and the context of the evolving and interdisciplinary nature of the SSME field, the Delphi method was found to be most appropriate to address the research questions. Alternate methods evaluated for the study were focus groups and survey methods. The focus group method was not found to be suitable because of the cost and time involved in reaching to geographically disperse senior experts and the infeasibility of assembling them for a focus group. Likewise, the survey method was rejected because of the emerging nature of the SSME field, which limits the availability of a large enough random sample of experts to conduct survey research and inferential analysis. A comparison of the Delphi method with the traditional survey method further explains the uniqueness and fit of the Delphi method for this study (see Table 1).

Table 1

Comparison of Traditional Survey with Delphi Method

Evaluation criteria	Traditional survey	Delphi study
Representativeness of sample	Statistical sampling techniques are used to randomly select a representative sample of the population.	Questions addressed by Delphi are of high uncertainty and speculation that require a purposefully selected panel of experts.
Sample size	As generalization of results is a goal, large sample size and power analysis is required to detect statistically significant effects.	Goal is exploration and consensus among experts and hence group size is not dependent on statistical power. A Delphi panel of 10-18 experts is acceptable.
Individual vs. group response	Individual responses are averaged out to determine sample response.	Group decision making process is proven to be effective for questions requiring expert judgment.
Reliability and response revision	Reliability like test-retest is very critical for survey effectiveness.	Test-rest reliability is not applicable as study expects participants to revise their response.
Construct validity	Construct validity is assured through survey design and pretesting.	Checking with experts about researchers' interpretation and categorizations.
Anonymity	Respondents are usually anonymous to each other and the researcher.	Respondents are usually anonymous to each other and but not to the researcher
Non-response issues	Need to investigate non-response bias for generalizability of results.	Non-response is relatively low are individual consent are obtained from participants.
Attrition effects	Participant drop-out or attrition needs to be checked for its random and non-systematic nature.	Attrition is usually low as researcher attempts to be in constant touch with the participants.
Richness of data	Depends on questionnaire and possible follow-up interview which is difficult to organize.	Provides "richer data because of multiple iterations and their [participants'] response revision due to feedback" (p. 20).

Adapted from Okoli & Pawlowski (2004)

3.1 Delphi Method

The Delphi method originated in the early 1960s as a forecasting tool at the RAND Corporation and focused on investigating future technology and potential political issues by using a panel of experts (Gordon, 2003). Over the years, the Delphi method has found significant acceptance from the researchers in various disciplines including the social sciences (Nielsen & Thangadurai, 2007); education (Clayton, 1997); healthcare, medicine and the nursing field (Mullen, 2003) and; technology and policy forecasting (Skulmoski, Hartman & Krahn, 2007). With the advancement of computer mediated communication technology, Delphi has also moved from the traditional paper and pencil based format to the online Internet based Delphi surveys (Wong, 2003).

A Delphi study aims to achieve the most reliable consensus of opinion by conducting two or more rounds of intensive surveys to the same group of experts utilizing anonymity and controlled feedback (Clayton, 1997; Gordon, 2003; Toohey, 1999). Loo (2002) mentions that "the Delphi method structures and facilitates group communication that focus, upon a complex problem so that, over a series of iterations, a group consensus can be achieved about some future direction" (p. 763). The Delphi method also follows a constructivist research paradigm as the results are based on the iterative communication among expert panelists and integration of their combined experiences and opinions (Nielsen & Thangadurai, 2007). Thus, the Delphi method facilitates group communication among geographically dispersed participants for idea

generation and consensus that is characterized by feedback mechanisms, multiple rounds, and the anonymity of participants.

The flexibility and versatility of the Delphi method has led to its applications in various disciplines. Within the higher education field, the Delphi method has been used primarily in four areas—to develop goals and objectives, to improve curriculum, to support strategic planning, and to develop criteria (Murry & Hammons, 1995). This study focused on the combination of two applications areas—developing criteria in terms of identification of the most important competencies and improving curriculum by integrating it with the identified competencies.

Several researchers have recommended the use of the Delphi method for educational planning (Blair, & Uhl, 1993; Clayton, 1997; Judd, 1972; Reeves & Jauch, 1978; Toohey, 1999). Kantz (2004) notes that "An in-depth analysis devoted just to curriculum should be conducted as part of the development of any new program" (p. 142). Kantz (2004) recommends that the Delphi method may provide support for new program development by getting responses from the experts in determining the needs of an educational program. Several recent studies have used Delphi method for curriculum planning and identification of competencies (Clark, 2005, Eskandari et al., 2007; Kantz, 2004; Senyshyn, 2002). For example, Clark (2005) used the Delphi method to define the competency framework for a professional education program for master strategists in national security. Eskandari et al. (2007) used the Delphi method to identify a set of desired professional competencies for an industrial engineer and emerging topics that are required for an undergraduate degree

in industrial engineering. An indicative list of recent doctoral dissertations using the Delphi method for curriculum development is presented in Table 2.

Table 2

Doctoral Dissertations using Delphi method for Curriculum Development

Dissertation Title and Author
Defining a competency framework to shape the professional education of national security master strategists: A web-based Delphi study (Clark, 2005).
Use of a Web-based Delphi for identifying critical components of a professional science master's program in biotechnology (Kantz, 2004).
An investigation and critique of competencies needed by human resource development (HRD) master's degree graduates in Korea (Lee, 2006).
Consensus of academic and industry experts and practitioners on essential information systems curriculum elements: A Delphi study (Matkin, 2000).
Key competencies for institutional researchers in the first decade of the twenty-first century: A Delphi technique for curriculum planning (Polk, 2001).
Cross-cultural competencies in international management curricula: A Delphi study of faculty perspectives (Senyshyn, 2002).

Benefits of the Delphi Method

Gupta and Clarke (1996) reviewed the theory and applications of the Delphi technique from 1975–1994 and found that continued popularity of the Delphi method is because of its unique strengths in planning, forecasting, and decision-making. The Delphi technique enables structured group decision making while at the same time

maintaining the anonymity of the participants to avoid group think or the influence of a senior personality in the group (Murry & Hammons, 1995). The Delphi method relies on engaging knowledge and authority of the experts for solving complex problems that may have multiple dimensions (Gupta & Clarke, 1996). Since the panel experts are expected to be strategic decision makers on the research topic, the Delphi method also serves as a learning and communication tool for the panel (Gupta & Clarke, 1996). Next, group decision-making or consensus may be arrived at irrespective of the geographic location of the participating experts (Murry & Hammons, 1995). Controlled feedback mechanism and anonymity enables participants to think and revise their opinions without publicly admitting it (Gupta & Clarke, 1996). The Delphi method also has a capacity of capturing the environmental changes and their impact on a particular issue; however, this sensitivity to the environment may also become its limitation (Franklin & Hart, 2007). In summary, the Delphi method allows for controlled, iterative, anonymous, and collaborative group communication processes that may lead to improved solutions to the complex problems.

Limitations of Delphi Method

Like any research method, Delphi also has its limitations. The Delphi method is critiqued by positivists as a “soft method” that does not follow the traditional scientific approach (Mullen, 2003). The background and experiences of experts may not be all inclusive and hence the results are not generalizable to larger populations

(Clayton, 1997). The Delphi study may take a longer time frame to complete all rounds of surveys and to achieve desired consensus level (Murry & Hammons, 1995). Sample attrition may occur because of lack of time or interest from the participants and in turn influencing their ability to consider and report on all issues under investigation (Clayton, 1997; Murry & Hammons, 1995). Some researchers also argue that consensus in the Delphi method may be a result of pressure to conform to the panel's majority opinions and participants with weak opinion may switch positions without providing rationale (Gordon, 2003). Some of the panelists may also bring strong comments or opinions to influence the overall direction of study (Gupta & Clarke, 1996). However, considering the pros and cons of the Delphi method, it was found to be appropriate for the specific objectives and research questions of the study.

3.2 Research Design

The Delphi method is a mixed method design of systematic data collection and analysis (Franklin and Hart, 2007). Quantitative inquiry is present in the form of statistical aggregation of group responses (Skulmoski et al., 2007). This study used descriptive statistics for describing participants' views about the importance of competencies and courses. Qualitative inquiry is available through the opportunity of open ended comments that are primarily focused on exploration and inductive analysis (Patton, 2002). The research design was exploratory in nature as SSME is an emerging field with very little research available on the competencies and courses expected from a master's level program. The Delphi method primarily consists of three types—

classical, decision, and policy (Franklin & Hart, 2007; Stewart, 2001). The classical Delphi focuses on establishing facts; decision Delphi encourages collaborative decision-making; and policy Delphi is used for generating alternative ideas. This study used the decision Delphi because the objective was to arrive at a consensus for developing the foundations for a competency-based curriculum.

Trustworthiness of a qualitative study is associated more with the relevancy of the cases selected rather than the sample size (Patton, 2002). In support of the small sample size of the Delphi method, Loo (2002) asserts that a careful selection of a small and relevant panel for a particular study can still yield valuable answers for the research questions. As explained earlier, the Delphi method is appropriate for exploratory study where little research is available. The Delphi study is based on the assumption that validity is enhanced by the group based decisions and reasoned communication process between the experts (Hasson, Keeney & McKenna, 2000).

The trustworthiness of this study was ensured at several levels. First, purposeful sampling of experts in the field of the service science ensured that the experts have the knowledge, interest and influence on the development of the field. Second, the heterogeneity of the panel in the form of their professional backgrounds as faculty and industry professionals along with the representation from several different organizations created a more diverse perspective. Third, iterative nature of the Delphi study with controlled feedback contributed towards the member checks (Clark, 2005). Finally, the literature review for the study aided in developing the first round of the Delphi survey and hence contributed towards content validity.

The study was directed to identify, prioritize and describe the competencies and courses for a master's level program in SSME. To operationalize the attributes of a future graduate of the SSME program or a service scientist, competency statements were used. Similarly, to develop a curriculum which may align with the required competencies for a service scientist, course titles or content domains were used. In spite of the limited information conveyed by competency statements and course titles, they were highly pertinent for addressing the research questions. This is especially relevant considering the nascent stage of development of SSME field, where consensus and standards on even competencies and content domains have not emerged. Specifically, the study focused on the providing broad directions for developing competency-based curriculum and did not attempt to delve deep into the content within the courses. Future studies may further test and investigate the details for each course and competency. Several research studies have used competency statements (Clark, 2005; Kantz, 2004; Lee, 2006; Polk, 2001; Senyshyn, 2002) and course titles (Badawy, 1998; Bohmann et al., 2007; Eskandari et al., 2007; Mallick & Chaudhury, 2000, Shah, 2004) for research purposes.

The traditional paper and pencil based Delphi method may take several months to complete and often requires follow-up with the participants through postal mail and telephone (Wong, 2003). In addition, the focus and interest of the experts may fade over the long period of conducting the Delphi method (Wong, 2003). The growth of technology and Internet applications has significantly improved the efficiency and speed of the Delphi research process. In recent years, several studies have used the

Internet for conducting round-based Delphi surveys. For example, Kantz (2004) used a Web-based Delphi method to identify key components of a professional science master's program in biotechnology and business. Likewise, Senyshyn (2002) used the Delphi method to solicit e-mail responses from faculty to identify a set of cross-cultural competencies that may be included in international management curricula at the graduate level. This study utilized the Microsoft Excel program to design and conduct the Delphi surveys through e-mail communication.

The study was conducted in accordance with the requirements of the Institutional Review Board for the Protection of Human Subjects at the University of Denver. Informed consent was obtained from the participants by e-mail after full disclosure about the nature and aims of the research (see Appendix A). The return of Round 1 questionnaire by the participant implied his or her consent to participate in the study. Panelists were informed that they may discontinue participating in the study without any loss of benefit or penalty. Participants were contacted using individual e-mails, which ensured that their identity was known only to the researcher. Confidentiality was guaranteed in the data analyses and reporting phase and any subsequent publications. Participants' responses are not reported with their individual or institutional identity and data access was restricted to the researcher only.

3.3 Participants

The Delphi method is suitable for addressing questions that have high uncertainty and speculation and require a purposefully selected panel of experts (Okoli

& Pawlowski, 2004). Several researchers have highlighted that selection of the participants is very important for the relevancy and success of the Delphi study (Clayton, 1997; Franklin & Hart, 2007; Gordon, 2003; Skulmoski et al., 2007). An expert for the Delphi panel is defined as "someone who possesses the knowledge and experience necessary to participate in a Delphi" (Clayton, 1997, p. 377). The participants should have expertise in the area of research, and be committed towards the participation in various rounds of the Delphi study. The Delphi method does not attempt to produce generalizable results and is more suitable for exploratory studies where experts are expected to apply their knowledge in the context of the specific problem under investigation. Thus, non-probability sampling techniques like purposeful sampling or criterion sampling are used to create a panel with desired expertise (Hasson et al., 2000). The purposeful sampling allows for selecting information-rich cases that allow in-depth understanding of the issues relevant to the study (Patton, 2002). Thus, the participants for the study were purposefully selected so that they represented expertise and interest in service science.

A master list of prospective panelists was prepared from four primary sources. First, participants who presented at professional conferences related to the service science were selected. For example, *Workshop on Education for Service Innovation* jointly organized by the National Science Foundation, U.S. Department of Commerce, and IBM Research was one of the sources of participants. Second, authors of recent journal articles and books related to SSME were included. For example, contributors of the recently edited handbook *Service Science, Management, and Engineering:*

Education for the 21st century (Hefley & Murphy, 2008) were included as potential participants. Third, faculty information was collected from the website of institutions already offering SSME related programs. For example, North Carolina State University offers an MBA program with a concentration in Services Management and hence its faculty were included as potential participants. Finally, IBM sources were requested to provide reference of experts who are already actively engaged in the field of SSME. IBM with its SSME initiatives acted as the key informant for the study to provide valuable insights and contacts. Patton (2002) notes that key informants are an important source of information and explanation of contextual knowledge. IBM is taking the lead in advancing the disciplines of SSME by organizing several conferences and providing funding (Lohr, 2006). The participants in these conferences included both practitioners and faculty from several organizations.

The master list generated from all the above sources resulted in a database of 159 potential participants. They represented a wide variety of academic and business organizations engaged with the file of SSME. Considering the nascent stage of the SSME field, time constraints for senior professionals, and some drop out of the panelists through several rounds of the Delphi, this list of potential participants was found to be sufficient.

The literature reports varying range of numbers for the optimum size of panels. Clayton (1997) states that 15-30 participants for a homogeneous population of experts from a single discipline and 5-10 participants for a heterogeneous group of experts from different professional backgrounds is sufficient. Murry & Hammons (1995) note

that final panel of experts should not be less than ten, as long as a representative sample is selected. Among the recent studies that used the Delphi method for curriculum planning and identification of competencies, employed varying number of rounds and expert panelists. For example, Kantz (2004) started with 24 participants in round 1 and ended with 13 participants in round 5; Clark (2005) received responses from 16 participants in round 1 and 12 participants in round 3; and Senyshyn (2002) conducted a two-round Delphi and received responses from 17 participants in round 1 and 15 participants in round 2.

3.4 Instruments

As indicated earlier, the online Delphi method has significant advantages of quick turnaround time, low cost and availability of data in usable format as compared to the traditional paper mail based Delphi (Franklin & Hart, 2007). The study utilized the Microsoft Excel program to design and conduct the Delphi surveys. As the participants for this study included senior professionals and university faculty, it was assumed that participants would be comfortable with the use of Excel.

The Delphi method consists of a few iterations or rounds of survey to facilitate group decision making and achieve consensus (Loo, 2002). The first round of the Delphi survey is to understand the changing demands of professional practice and identify the need for a new set of knowledge and skills expected from new graduates (Toohey, 1999). The results from the first round are summarized and used to develop a

second survey that is sent to the participants to draw their final conclusions (Toohey, 1999).

This study comprised of three rounds for identification, prioritization and description of competencies and courses (see Figure 2). The objective of Round 1 of Delphi was to identify a set of competencies and courses that may be relevant for the master's level program in SSME. The first round of the Delphi survey consisted of an initial set of competencies and courses with an option of adding more competencies and courses (see Appendix B). The participants were asked to rate each of the competency and course on a four-point Likert scale ranging from Very Important (4), Important (3), Somewhat Important (2) to Not Important (1). The initial list of professional competencies and relevant courses for a master's level curriculum in service science was generated utilizing two primary sources. First, a literature review related to engineering, management and interdisciplinary education including standards established by professional accreditation bodies was conducted. Second, a review of courses offered by the schools offering curriculum related to services science aided in identifying courses and underlying competencies desired by them. This initial list of competencies and courses constituted the first round of the Delphi survey.

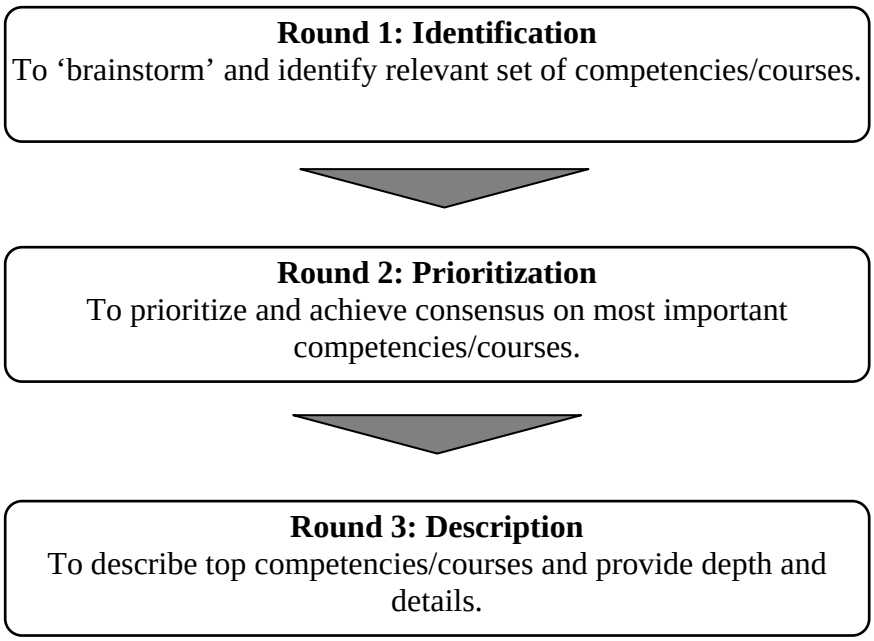


Figure 2. Purpose of Delphi rounds

The objective of Round 2 was to encourage consensus among participants and prioritize the competencies and courses for the master's level program in SSME. The literature does not provide any rigid standards for the consensus, however, every study should define what percentage of the participants' responses will be considered consensus (Murry & Hammons, 1995). Murry and Hammons (1995) defined consensus for their study as the agreement on a particular item by 75% of the participants by the second round or later. Likewise, for this study, consensus is reached when at least 75% of the participants rate any competency or course item as Very Important (4) or Important (3) on a four-point scale at the end of Round 2. The second round of the Delphi survey was developed based on the responses received from the first round. It comprised of an exhaustive list of competencies and courses available in the first round in addition to the new competencies and courses added by

the participants (see Appendix C & Appendix D). The additional competencies and courses that are suggested by at least three participants in Round 1 were included for Round 2. Descriptive statistics like mean and standard deviation for each competency and course were also reported along with the percentage of respondents rating each competency and course as Very Important (4) or Important (3) on a four-point scale. This allowed the participants to reconsider their previous responses of Round 1 in the light of the overall opinion of the panel.

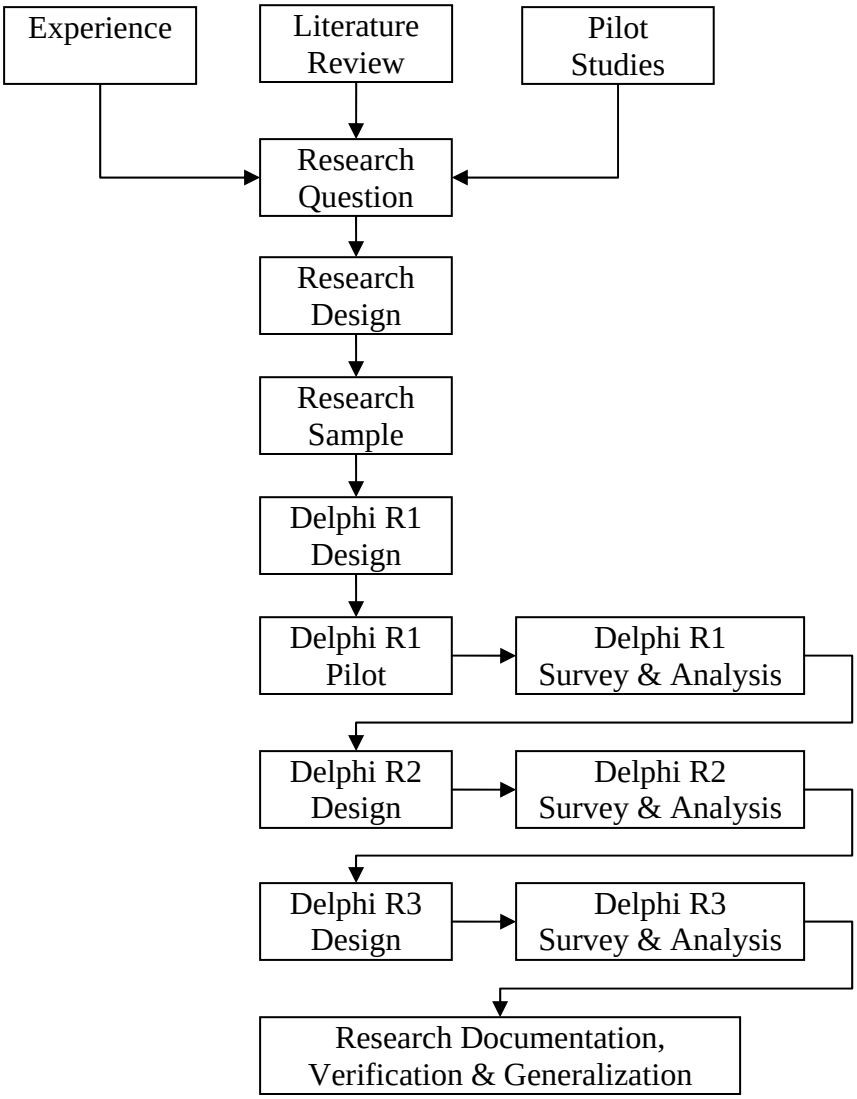
The objective of Round 3 was to provide depth and details to the top competencies and courses prioritized from previous two rounds. The survey comprised of top courses and competencies with a brief description, which was developed based on the responses received from open-ended sections of the previous two rounds and literature review. Specifically, participants were asked to rate their agreement with the description of the top competencies and courses, and provide suggestions for making them more relevant and inclusive (see Appendix E & Appendix F). The four-point Likert scale for degree of agreement with the definition ranged from Strongly Agree (4), Agree (3), Disagree (2) to Strongly Disagree (1). This final round aided in providing depth and details for designing the competency model and course descriptions.

3.5 Procedures

Murry & Hammons (1995) state that the modified Delphi method requires between two to four rounds to achieve desired consensus or stability in the results (see

Figure 3). The modified Delphi method has its first round as a structured questionnaire instead of a conventional open-ended questionnaire in traditional Delphi (Murry & Hammons, 1995). The structured questionnaire for Round 1 is developed based on the literature review or other secondary analysis and helps participants in organizing their thoughts (Eskandari et al., 2007; Franklin & Hart, 2007). As described earlier, Round 1 of the survey for this proposed study consisted of a preliminary list of competencies and courses that were found to be relevant based on the review of literature and review of the existing master's level program in SSME.

As explained earlier, the list of potential participants included presenters at the professional conferences related to the service science, authors of articles related to SSME, faculty of existing programs in SSME and references from IBM. Participants were invited to participate in the study by e-mail. The invitation email included the informed consent and Round 1 survey (see Appendix A). Panelists were provided 10 days time for completing the survey and returning it by email. A reminder was sent to the non-respondents after a week. Based on the responses received, data was analyzed and subsequent rounds were conducted. Only respondents of Round 1 were invited to participate in both Round 2 and Round 3. For Round 3, even non-respondents of Round 2 were invited to participate.



Adapted from Skulmoski, Hartman & Krahn (2007)

Figure 3. Delphi study administration process

3.6 Data Analysis

The Delphi method involves both quantitative and qualitative analyses at the end of each round so that feedback may be provided to the panel and a questionnaire for the next round may be prepared (Loo, 2002). Franklin and Hart (2007) state that in

a Delphi study “coupling panelists with strong feelings about a phenomenon with a broad and complex topic results in layers of data both quantitative and qualitative” (p. 243).

The data analysis for the study was also conducted after each of the three rounds. Content analysis technique was used as a data reduction process for identifying patterns or themes from the respondents’ open-ended comments (Patton, 2002). Content analysis uses coding and categorization to make rich and meaningful interpretations from data (Hsieh & Shannon, 2005; Weber, 1990). The use of content analysis approach varies with the focus and interests of the researcher and the research question being studied (Weber, 1990). For this study, content analysis was used for two primary reasons. First, to gain a deeper understanding of participants’ rationale for rating of competencies and courses. Second, to use the open-ended responses for modifying or adding competencies and courses for the SSME curriculum. The open-ended responses were put in an Excel sheet and analyzed for emergent themes for each round. Round 1 data was used to modify and add competencies and courses and develop Round 2 survey. Both Round 1 and Round 2 data was used to create descriptions for top courses and competencies for Round 3. Finally, Round 3 data was used to develop final descriptions for the competency model and curriculum blueprint.

For each round, descriptive statistics like mean and standard deviation for each competency and course were also reported along with the percentage of respondents rating each competency and course as Very Important (4) or Important (3) on a four-point scale. Results of the data analyses are reported in next chapter. Based on the data

analyses of this Delphi study, blueprint of a SSME curriculum was developed in conjunction with a competency model for a graduate of a master's level program in SSME.

3.7 Role of Researcher

Every researcher is influenced by life experiences that shape several aspects of the research including topic, design, data analysis, and its interpretation (Grbich, 2007). In particular, the role of researcher is critical to the credibility of the qualitative method as the researcher is the instrument of the study (Patton, 2002). The researcher should report any personal and professional background information that may influence the credibility of the study in terms of data collection, analysis, and interpretation (Patton, 2002). My interest in this topic was also shaped by my educational background and work experiences. I have over seven years of cross-functional experience in telecommunications, information technology and higher education sectors. All three sectors have a high component of knowledge work that is at the interface of technology and services. In terms of educational qualifications, I hold a bachelor's degree in Engineering and an MBA. The educational experiences helped me build my disciplinary foundations in engineering and management. My academic experiences encouraged me to investigate the need for a new education that may provide a unique blend of engineering and management competencies and add value to the knowledge-based service economy.

3.8 Limitations of the Method

This study, like any research study has some limitations. One set of limitations emerged from the use of the Delphi method. The purposeful sampling strategy and limited number of respondents restricted the generalizability of the results. This also restricted the possibility of conducting inferential statistical analysis. The online data collection process may be biased towards the inclusion of participants who are comfortable with Internet access and the online communication process. However, since the participants' profile is focusing on industry professionals and university faculty, it was assumed that participants were comfortable with the Internet communication channel.

The Delphi study consisted of three rounds, of which first round provided an initial list of competencies and courses to the participants. This list was generated from the literature to provide a starting point for the participants to rate and add more competencies and courses. It is possible that the initial list may have biased participants' thought process.

Multiple rounds of surveys to the same set of participants may have created response fatigue and also influenced some participants to drop in successive rounds. Thus, consistent number of participants and their quality of responses could not be guaranteed across all the rounds.

CHAPTER 4: RESULTS

The overarching purpose of this research was to provide theoretical and conceptual foundations for developing a competency-based curriculum for a master's program in SSME. Specifically, the objective was to ascertain the competencies and courses that are relevant for developing a competency model for a service scientist and a curriculum blueprint for SSME. A three round online Delphi survey was administered with the experts from industry and academia, who are already engaged with the field of SSME. The purpose of Round 1 was to identify courses and competencies that are considered important to be included in a master's program in SSME. Based on the results of Round 1 survey and descriptive responses to the open-ended comments, Round 2 survey was developed. The purpose of Round 2 survey was to prioritize and achieve consensus on the competencies and courses. Respondents were asked to retain or revise their Round 1 rating in the context of the overall panel responses. Respondents were provided with their Round 1 individual rating and overall panel rating for each course and competency to facilitate their rating decision for Round 2.

Competencies and courses that achieved consensus—rated Very Important (4) or Important (3) by at least 75% of the respondents—were used to develop Round 3 survey. The purpose of Round 3 was to gain a deeper insight into the description of the

competencies and courses identified and prioritized in the previous two rounds. A brief description for each of the consensual courses and competencies was provided and respondents were asked to rate their degree of agreement with the description. They were also asked to add suggestions for improving and clarifying the description.

This chapter presents the results and findings of the Delphi surveys conducted as per the methodology described in Chapter 3. The first section presents the profile of the Delphi panel. The second section discusses the results of the Delphi survey for each round and finally, the third section summarizes the results of this study.

4.1 Delphi Panel Profile

This section presents the profile of the Delphi panel. Round 1 of this study included a section soliciting participants' profiles in terms of primary disciplinary expertise, years of professional experience, highest educational degree, and profession. These profile questions were included to understand the expertise of the panel and also explore any subgroup differences in the responses.

A total of 159 e-mail invitations were sent to the potential participants, of which eleven e-mails were undelivered. Thus, 148 e-mails were delivered and 51 completed responses were received in Round 1, resulting in a response rate of 34 percent. For Round 2 and Round 3, all 51 respondents of Round 1 survey were invited to participate. A total of 40 and 39 completed responses were received in Round 2 and Round 3, resulting in a response rate of 78% and 76% respectively.

It is natural in a Delphi study that some participants will drop out in later rounds for several reasons including the timing of the survey and interest of the participants (Franklin & Hart, 2007). This study also noticed a drop out of participants across the three rounds. There was a drop out of 22% from Round 1 to Round 2 (11 participants) and 2.5% from Round 2 to Round 3 (1 participant), resulting in an overall drop out of 23.5% from Round 1 to Round 3 (12 participants). However, the overall number of respondents remained acceptable and in line with other research studies. For instance, Clark (2005) conducted a three round Delphi to develop a competency model and reported 16 and12 respondents in the first and third round respectively.

Table 3 presets the profile of the participants across the three Delphi rounds. In terms of professional experience, at least 90% of the respondents in all three rounds had 10 or more years of professional experience. Likewise, at least 80% of the respondents in all three rounds had a master's or doctoral degree. Nearly equal proportions of participants were represented from engineering and management disciplines in all three rounds. There was slightly more representation of industry professionals in Round 1 and Round 3 as compared to university faculty, however, the ratio was fairly even for the participants who responded to all three rounds. A total of 34 respondents were common in all three rounds, with 56% of them holding doctorate as their highest educational degree and 68% having professional experience of more than 20 years.

Table 3

Profile of Participants across Delphi Rounds

	Round 1		Round 2		Round 3		All Rounds[a]	
	f	%	f	%	f	%	f	%
Professional experience (years)								
0-4	1	2%	1	3%	1	3%	1	3%
5-9	2	4%	2	5%	1	3%	1	3%
10-14	11	22%	8	20%	9	23%	7	21%
15-19	5	10%	4	10%	3	8%	2	6%
20+	32	63%	25	63%	25	64%	23	68%
Highest educational degree								
Bachelor's	6	12%	4	10%	5	13%	4	12%
Master's	13	25%	11	28%	10	26%	9	26%
Doctorate	30	59%	23	58%	22	56%	19	56%
Others	2	4%	2	5%	2	5%	2	6%
Profession								
Industry Professional	26	51%	19	48%	20	51%	16	47%
University Faculty	22	43%	19	48%	17	44%	16	47%
Others	3	6%	2	5%	2	5%	2	6%
Disciplinary expertise								
Engineering	21	41%	18	45%	17	44%	16	47%
Management	22	43%	18	45%	16	41%	15	44%
Others	8	16%	4	10%	6	15%	3	9%
Total	51	100%	40	100%	39	100%	34	100%

Note. All Rounds[a] represents participants who responded to all three Delphi rounds.

Overall, respondents had advanced educational credentials in management and engineering fields. They also possessed considerable professional and academic experiences in a wide range of business and academic organizations. This indicates that respondents had adequate disciplinary expertise, depth of experience, and diversity of view points for contributing to the trustworthiness of this study.

4.2 Delphi Survey Results

This section presents the results of each round of the Delphi survey and also explores differences by disciplinary expertise and profession of the respondents. The three rounds of the Delphi were respectively used to identify, prioritize, and describe competencies and courses for a master's program in SSME.

4.2.1 Round 1

This round of the study asked participants to rate the importance of courses and competencies on a four-point Likert scale ranging from Very Important (4), Important (3), Somewhat Important (2) to Not Important (1). They were encouraged to provide comments and rationale for their rating of each competency and course (see Appendix B). In addition, they were provided space to suggest new competencies and courses, and also add any overall comments. Fifty-one respondents completed Round 1 survey.

Courses

Table 4 summarizes the panel ratings of the courses using mean, standard deviation, and percentage of respondents rating course items as Important (3) or Very Important (4). Some of the highly technical courses like E-Commerce/Database Marketing and Datamining received the lowest mean ratings while courses emphasizing understanding of the service domain like Service Design, and Service Operations and Supply Chain received high mean rating.

Table 4

Panel Ratings of Courses in Round 1

	Courses	M	SD	% f(3/4)
1	Service Design	3.50	0.73	89%
2	Service Operations and Supply Chain	3.25	0.78	82%
3	Service Engineering	3.25	0.89	82%
4	Services Innovation Management	3.18	0.90	80%
5	Organizational Behavior	3.11	0.72	78%
6	Business and Technology Integration	3.25	0.94	78%
7	The Information and Services Economy	3.34	0.89	76%
8	Consumer Behavior	3.09	0.72	76%
9	Quality Management	2.98	0.76	73%
10	Customer Relationship Management	3.02	0.90	73%
11	Project Management	2.93	0.82	71%
12	Economics of Service	2.93	0.76	71%
13	Strategic Management	2.91	0.91	67%
14	Service Marketing	2.98	0.95	67%
15	Modeling and Simulation	2.95	0.83	67%
16	Knowledge Management	2.91	0.80	67%
17	Network Services and Systems	2.89	0.92	64%
18	Technology Management	2.75	0.84	58%
19	Market Analytics	2.57	0.82	53%
20	Financial Management	2.45	0.82	51%
21	Statistical Methods	2.64	0.89	49%
22	Management Science	2.55	0.85	44%
23	Forecasting and Demand Modeling	2.56	0.85	44%
24	Datamining	2.35	0.75	40%
25	E-Commerce/Database Marketing	2.09	0.83	29%

Note. N = 51. Mean (M) and Standard Deviation (SD) are calculated for a four-point Likert scale. % f(3/4) represents the percentage of respondents rating 3 or 4 on a four-point scale.

The data from open-ended comments were analyzed and recurring themes and categories were noted. Suggestion for additional course was accepted only if it was recommended by at least three respondents. Based, on the content analysis of the open-ended comments, titles of five courses were modified and three new courses were added (see Table 5). These changes were included in Round 2 survey.

Table 5

Changes made in the Courses based on Round 1 Responses

Round 1	Round 2
Courses Modified	
Customer Relationship Management	Enterprise Systems
Market Analytics	Decision Analytics and Business Intelligence
Modeling and Simulation	Business Process Modeling
Organizational Behavior	Leadership and Organizational Behavior
Service Innovation Management	Service Innovation
Courses Added	
	International Business
	Web services
	Financial and Managerial Accounting

Competencies

Table 6 summarizes the panel ratings of the competencies using mean, standard deviation, and percentage of respondents rating competency items as Important (3) or Very Important (4). Here broad interdisciplinary competencies seem to have received higher mean ratings as compared to narrow technical skills. For

example, Ability to work in interdisciplinary teams (*M*=3.58) as compared to Technology application (*M*=2.67).

Table 6

Panel Ratings of Competencies in Round 1

	Competencies	M	SD	% f(3/4)
1	Integrate engineering and management disciplines for solving service problems	3.56	0.66	96%
2	Ability to design a service system, component, or process	3.73	0.65	93%
3	Ability to work in interdisciplinary teams	3.58	0.62	93%
4	Demonstrate 'big picture' system based problem-solving approach	3.38	0.72	91%
5	Business and Technology Integration	3.33	0.83	87%
6	Demonstrate effective interpersonal communication skills	3.24	0.74	87%
7	Critical thinking	3.38	0.81	84%
8	Market and user needs assessment	3.22	0.79	82%
9	Information management	3.00	0.74	78%
10	Model building and analysis	2.89	0.93	73%
11	Recognize characteristics of knowledge-based service economy	3.09	0.92	71%
12	Collaborate with subject-matter expert	2.98	0.81	71%
13	Process analysis	2.93	0.84	71%
14	Ability to work with global teams	2.93	0.89	71%
15	Demonstrate disciplinary knowledge in management	2.91	0.73	69%
16	Project Management	2.82	0.81	62%
17	Manage risk and uncertainty	2.76	0.74	62%
18	Ability to learn new technology	2.73	0.86	60%
19	Cost effectiveness and efficiency orientation	2.60	0.78	60%
20	Demonstrate disciplinary knowledge in engineering	2.64	0.86	58%
21	Technology application	2.67	0.74	56%
22	Engage in life-long learning	2.58	0.87	56%
23	Knowledge of contemporary sociopolitical and economical issues	2.59	0.90	49%

Note. N = 51. Mean (M) and Standard Deviation (SD) are calculated for a four-point Likert scale. % f(3/4) represents the percentage of respondents rating 3 or 4 on a four-point scale.

The data from open-ended comments for the competencies section were also analyzed and recurring themes and categories were noted. Suggestion for additional competencies was accepted only if it was recommended by at least three respondents. Based, on the content analysis of open-ended comments, five competencies were modified and two new competencies were added (see Table 7). These changes were included in Round 2 survey.

Table 7

Changes made in the Competencies based on Round 1 Responses

Round 1	Round 2
Competencies Modified	
Demonstrate 'big picture' system based problem-solving approach	Apply systems based problem-solving approach
Information management	Information and technology management
Process analysis	Process analysis and design
Manage risk and uncertainty	Adaptability to unfamiliar situations, uncertainty, and complexity
Ability to work with global teams	Ability to work with global, multicultural teams
Competencies Added	
	Assess and learn from best and worst practices in services
	Complex communication involving interacting and persuading people

4.2.2 Round 2

The purpose of Round 2 survey was to prioritize the courses and competencies identified in Round 1 and achieve consensus. All 51 respondents of Round 1 were invited to participate in Round 2 and a total of 40 participants responded (78% response rate). The survey for Round 2 included old competencies and courses, along with the competencies and courses that were modified and added from Round 1 data analysis. Respondents received their individual rating from Round 1 along with the summary of panel responses in the form of mean, standard deviation and the percentage of respondents rating each competency item as 3 or 4 (see Appendix D). This allowed the participants to reconsider their previous responses of Round 1 in light of the overall opinion of the panel. They were encouraged to retain or revise their rating and also provide a rationale for any changes in the rating.

Courses

Table 8 shows the summary of participants' responses for the courses. Consensus was achieved for a particular item when it was rated as Very Important (4) or Important (3) by at least 75% of the respondents at the end of Round 2. A total of 13 courses achieved overall consensus. All three new courses which were added from the suggestions in Round 1 did not achieve consensus. These courses were International Business, Web services, and Financial and Managerial Accounting.

Table 8

Panel Ratings of Courses in Round 2

	Courses	M	SD	%f (3/4)
1	Service Design	3.63	0.67	95%
2	Service Innovation	3.35	0.74	90%
3	Service Operations and Supply Chain	3.25	0.81	88%
4	Leadership and Organizational Behavior	3.40	0.68	88%
5	The Information and Services Economy	3.28	0.78	88%
6	Consumer Behavior	3.15	0.74	85%
7	Project Management	3.10	0.71	85%
8	Service Engineering	3.23	0.80	83%
9	Business and Technology Integration	3.23	0.86	83%
10	Business Process Modeling	2.93	0.86	78%
11	Service Marketing	3.08	0.83	78%
12	Quality Management	2.93	0.73	75%
13	Enterprise Systems	3.08	0.89	75%
14	Economics of Service	2.83	0.70	68%
15	Knowledge Management	2.78	0.75	68%
16	Strategic Management	2.95	0.96	63%
17	Decision Analytics and Business Intelligence	2.60	0.71	58%
18	Network Services and Systems	2.70	0.85	55%
19	Technology Management	2.60	0.74	55%
20	Financial Management	2.55	0.75	55%
21	Statistical Methods	2.58	0.87	48%
22	Management Science	2.53	0.78	45%
23	Web services	2.48	0.94	45%
24	International Business	2.53	0.97	43%
25	Forecasting and Demand Modeling	2.41	0.68	40%
26	Datamining	2.20	0.76	30%
27	E-Commerce/Database Marketing	2.05	0.68	25%
28	Financial and Managerial Accounting	2.08	0.69	20%

Note. N = 40. Mean (M) and Standard Deviation (SD) are calculated for a four-point Likert scale. % f(3/4) represents the percentage of respondents rating 3 or 4 on a four-point scale.

Table 9 compares the courses that achieved consensus in Round 2 i.e. at least 75% of the respondents rating a particular course as 3 or 4 on a four-point scale, with their corresponding percentage of respondents rating courses as 3 or 4 in Round 1. In other words, it indicates the change in the ratings of the panelists and shift towards consensus for the courses that were rated 3 or 4 on a four-point scale by at least 75% of the respondents. Project Management and The Information and Services Economy noticed highest shift of 14% and 12% respectively, while Service Engineering, Quality Management and Enterprise Systems noticed minimal shift of 1%, 2% and 2% respectively.

Table 9

Shift in Panel Ratings of Courses in Round 2

Courses	Round 2	Round 1	% change
Service Design	95%	89%	6%
Service Innovation	90%	80%	10%
Service Operations and Supply Chain	88%	82%	6%
Leadership and Organizational Behavior	88%	78%	10%
The Information and Services Economy	88%	76%	12%
Consumer Behavior	85%	76%	9%
Project Management	85%	71%	14%
Service Engineering	83%	82%	1%
Business and Technology Integration	83%	78%	5%
Business Process Modeling	78%	67%	11%
Service Marketing	78%	67%	11%
Quality Management	75%	73%	2%
Enterprise Systems	75%	73%	2%

Note. Percentage of participants rating an item 3 or 4 on a four-point scale.

Table 10 shows the degree of consensus for the courses by the profession (university faculty or industry professionals) of Round 2 participants. Of the total 40 respondents in Round 2, 19 reported their professional background as university faculty and likewise, 19 other reported themselves as industry professionals. Overall, there seems to be a high degree of consensus by professional backgrounds, however, there were some sub group differences in terms of setting priorities for the courses. For example, Leadership and Organizational Behavior course was rated 3 or 4 on a four-point scale by 100% of the industry professionals, as compared to 79% of the university faculty. All the courses that achieved consensus from university faculty also achieved consensus from industry professionals, but, there were two courses (Business Process Modeling and Enterprise Systems) that achieved consensus from industry professionals only and not from university faculty (see Table 11).

Table 10

Degree of Consensus for Courses by Participants' Profession

Overall	% f(3/4)	Faculty	% f(3/4)	Industry Professionals	% f(3/4)
Service Design	95%	Service Design	100%	Leadership and Organizational Behavior	100%
Service Innovation	90%	Service Innovation	100%	Business and Technology Integration	95%
Service Operations and Supply Chain	88%	Service Operations and Supply Chain	89%	Service Design	89%
Information and Service Economy	88%	Information and Service Economy	89%	Service Operations and Supply Chain	89%
Leadership and Organizational Behavior	88%	Service Engineering	89%	Service Innovation	89%
Consumer Behavior	85%	Consumer Behavior	89%	Enterprise Systems	89%
Project Management	85%	Project Management	89%	Information and Service Economy	84%
Service Engineering	83%	Leadership and Organizational Behavior	79%	Service Engineering	79%
Business and Technology Integration	83%	Business and Technology Integration	79%	Consumer Behavior	79%
Service Marketing	78%	Quality Management	79%	Quality Management	79%
Business Process Modeling	78%	Service Marketing	79%	Project Management	79%
Quality Management	75%			Business Process Modeling	79%
Enterprise Systems	75%			Service Marketing	79%

Table 11

Comparison of Consensus for Courses by Participants' Profession

Both Faculty and Industry Professionals	Faculty only	Industry Professionals only
Business and Technology Integration	Nil	Business Process Modeling
Consumer Behavior		Enterprise Systems
Information and Service Economy		
Leadership and Organizational Behavior		
Project Management		
Quality Management		
Service Design		
Service Engineering		
Service Innovation		
Service Marketing		
Service Operations and Supply Chain		

Table 12 shows the degree of consensus for the courses by disciplinary background (engineering or management) of the participants. Of the total 40 respondents in Round 2, 18 reported their primary discipline as engineering and likewise, 18 other responded management as their primary discipline. Overall, there seems to be a high level of consensus by disciplines, however, there seem to be certain sub group differences in terms of setting priorities for the courses. For example, Leadership and Organizational Behavior course was rated 3 or 4 on a four-point scale by 94% of the respondents from the management discipline, as compared to 83% of the respondents from the engineering discipline.

There were few courses that did not achieve consensus by both the disciplines (see Table 13). For example, Service Engineering, Business Process Modeling, and Quality Management achieved consensus from the respondents representing the engineering discipline, but these courses did not achieved consensus from the respondents representing the management discipline. In particular, Service Engineering was rated 3 or 4 on a four-point scale by 94% of respondents from the engineering discipline, while it did not achieved consensus from the management discipline. Likewise, Service Marketing, Strategic Management, and Enterprise Systems achieved consensus from the respondents representing the management discipline, but these courses did not achieved consensus from the engineering discipline.

Table 12

Degree of Consensus for Courses by Participants' Disciplinary Expertise

Overall	% f(3/4)	Engineering	% f(3/4)	Management	% f(3/4)
Service Design	95%	Service Design	94%	Service Design	100%
Service Innovation	90%	Service Innovation	94%	Leadership and Organizational Behavior	94%
Leadership and Organizational Behavior	88%	Service Operations and Supply Chain	94%	The Information and Services Economy	94%
Information and Service Economy	88%	Business and Technology Integration	94%	Service Innovation	89%
Service Operations and Supply Chain	88%	Service Engineering	94%	Project Management	89%
Project Management	85%	Consumer Behavior	89%	Service Marketing	89%
Consumer Behavior	85%	Leadership and Organizational Behavior	83%	Service Operations and Supply Chain	83%
Business and Technology Integration	83%	The Information and Services Economy	83%	Consumer Behavior	83%
Service Engineering	83%	Project Management	83%	Enterprise Systems	83%
Service Marketing	78%	Business Process Modeling	83%	Strategic Management	83%
Business Process Modeling	78%	Quality Management	83%	Business and Technology Integration	78%
Enterprise Systems	75%				
Quality Management	75%				

Note. % f(3/4) represents the percentage of respondents rating 3 or 4.

Table 13

Comparison of Consensus for Courses by Participants' Disciplinary Expertise

Both Engineering and Management	Engineering only	Management only
Information & Service Economy	Service Engineering	Service Marketing
Leadership & Organizational Behavior	Business Process Modeling	Strategic Management
Consumer Behavior	Quality Management	Enterprise Systems
Project Management		
Service Design		
Service Operations and Supply Chain		
Services Innovation		
Business & Technology Integration		

The data from open-ended comments for courses were analyzed and recurring themes and categories were noted. Suggestions for changes in the courses were accepted only if they were recommended by at least three respondents. Based on data analysis, there were no suggestions that warranted changes in the course titles. However, SSME being an interdisciplinary field some important disciplinary differences were noted. Table 12 and Table 13 also illustrate the need to include disciplinary differences in curriculum offering. For instance, Strategic Management course was rated 3 or 4 on a four-point scale by 83% of the respondents from the management discipline, while it did not achieve consensus from the engineering discipline. Thus, the final list of courses for the SSME curriculum included courses that achieved consensus from only the engineering or management discipline only, along with the courses that achieved consensus from both of the disciplines (Table 13). This resulted in the final list of 14 courses, of which eight courses achieved consensus from both engineering and management disciplines and three courses each from engineering and management only.

The final 14 course titles were then expanded upon to create a brief course description. For example, Service Marketing course was given a course description of "Builds upon the course on Consumer Behavior and examines the marketing and managerial approaches for service offerings. Presents concepts and cases of service marketing including branding and pricing. Provides overview to customer relationship management and e-marketing." These course descriptions were developed based on

the open-ended comments from Round 1 and Round 2 and review of existing programs that offer similar courses.

In addition, the final 14 courses were logically classified into course modules. For example, Service Design, Service Operations and Supply Chain, and Service Innovation were categorized together as Service Core as these courses achieved consensus from both engineering and management disciplines and focused on the core theoretical and practical aspects of service economy. Likewise, the other modules were Contextual Foundation, Engineering or Management Concentration, and Integrative Capstone. The results from the data analysis of Round 2 were used to create Round 3 survey.

Competencies

Table 14 shows the summary of panel ratings of the competencies. Consensus was achieved for a particular competency item when it was rated as Very Important (4) or Important (3) by at least 75% of the respondents at the end of Round 2. A total of 12 competencies achieved overall consensus. Interestingly, both the new competencies which were added in Round 2 survey based on the Round 1 responses, did not achieved consensus. These two competencies were, “Assess and learn from best and worst practices in services” and “Complex communication involving interacting and persuading people”, and were rated 3 or 4 on a scale of four by only 55% of the total respondents.

Table 14

Panel Ratings of Competencies in Round 2

	Competency	M	SD	%f (3/4)
1	Ability to work in interdisciplinary teams	3.60	0.59	95%
2	Integrate engineering and management disciplines for solving service problems	3.48	0.72	93%
3	Ability to design a service system, component, or process	3.63	0.81	90%
4	Apply systems based problem-solving approach	3.50	0.68	90%
5	Demonstrate effective interpersonal communication skills	3.28	0.72	90%
6	Critical thinking	3.40	0.71	88%
7	Business and Technology Integration	3.28	0.78	85%
8	Market and user needs assessment	3.18	0.78	83%
9	Information and technology management	2.88	0.65	78%
10	Recognize characteristics of knowledge-based service economy	3.08	0.86	78%
11	Ability to work with global, multicultural teams	2.93	0.76	78%
12	Adaptability to unfamiliar situations, uncertainty, and complexity	2.95	0.64	78%
13	Process analysis and design	2.83	0.75	73%
14	Collaborate with subject-matter expert	2.93	0.83	73%
15	Model building and analysis	2.80	0.91	68%
16	Demonstrate disciplinary knowledge in management	2.80	0.72	68%
17	Project Management	2.87	0.77	68%
18	Technology application	2.70	0.72	60%
19	Ability to learn new technology	2.65	0.70	58%
20	Assess and learn from best and worst practices in services	2.82	0.68	55%
21	Complex communication involving interacting and persuading people	2.70	0.73	55%
22	Engage in life-long learning	2.60	0.90	53%
23	Knowledge of contemporary sociopolitical and economical issues	2.53	0.88	53%
24	Demonstrate disciplinary knowledge in engineering	2.48	0.85	50%
25	Cost effectiveness and efficiency orientation	2.43	0.68	48%

Note. N = 40. Mean (M) and Standard Deviation (SD) are calculated for a four-point Likert scale. % f(3/4) represents the percentage of respondents rating 3 or 4 on a four-point scale.

Table 15 compares the competencies that achieved consensus in Round 2 with their corresponding percentage of respondents rating 3 or 4 in Round 1. In other words, it indicates the change in the ratings of the panelists and shift towards consensus. Most of the competencies showed stability and there was minimal shift across two rounds. Competencies noticing highest shift were "Adaptability to unfamiliar situations, uncertainty, and complexity respectively" (14%), "Recognize characteristics of knowledge-based service economy" (7%), and "Ability to work with global, multicultural teams" (7%).

Table 15

Shift in Panel Ratings of Competencies in Round 2

Competency	R2	R1	% change
Ability to work in interdisciplinary teams	95%	93%	2%
Integrate engineering and management disciplines for solving service problems	93%	96%	-3%
Ability to design a service system, component, or process	90%	93%	-3%
Apply systems based problem-solving approach	90%	91%	-1%
Demonstrate effective interpersonal communication skills	90%	87%	3%
Critical thinking	88%	84%	4%
Business and Technology Integration	85%	87%	-2%
Market and user needs assessment	83%	82%	1%
Information and technology management	78%	78%	0%
Recognize characteristics of knowledge-based service economy	78%	71%	7%
Ability to work with global, multicultural teams	78%	71%	7%
Adaptability to unfamiliar situations, uncertainty, and complexity	78%	62%	16%

Note. Percentage of participants rating 3 or 4. R2: Round 2 and R1: Round 1.

Table 16 shows the degree of consensus for the competencies by the profession of the participants (university faculty or industry professionals). Overall, there seems to be a high degree of consensus by professional backgrounds, however, there were some sub group differences. For example, “Integrate engineering and management disciplines for solving service problems” was rated 3 or 4 on a scale of four by 100% of the university faculty as compared to 84% of the industry professionals.

All the competencies that achieved consensus from faculty also achieved consensus from industry professionals, but, there were four competencies that achieved consensus from industry professionals only and not from the university faculty (see Table 17). These competencies were “Collaborate with subject-matter expert”, “Process analysis and design”, “Complex communication involving interacting and persuading people”, and “Recognize characteristics of knowledge-based service economy.”

Table 16

Degree of Consensus for Competencies by Participants' Profession

Overall	%f (3/4)	Faculty	%f (3/4)	Industry	%f (3/4)
Ability to work in interdisciplinary teams	95%	Integrate engineering and management disciplines for solving service problems	100%	Ability to work in interdisciplinary teams	95%
Integrate engineering and management disciplines for solving service problems	93%	Ability to design a service system, component, or process	100%	Apply systems based problem-solving approach	89%
Ability to design a service system, component, or process	90%	Ability to work in interdisciplinary teams	95%	Critical thinking	89%
Apply systems based problem-solving approach	90%	Apply systems based problem-solving approach	95%	Business and Technology Integration	89%
Demonstrate effective interpersonal communication skills	90%	Demonstrate effective interpersonal communication skills	95%	Market and user needs assessment	89%
Critical thinking	88%	Critical thinking	84%	Integrate engineering and management disciplines for solving service problems	84%
Business and Technology Integration	85%	Business and Technology Integration	84%	Process analysis and design	84%
Market and user needs assessment	83%	Information and technology management	84%	Demonstrate effective interpersonal communication skills	84%
Information and technology management	78%	Market and user needs assessment	79%	Collaborate with subject-matter expert	84%
Recognize characteristics of knowledge-based service economy	78%	Ability to work with global, multicultural teams	79%	Ability to design a service system, component, or process	79%
Ability to work with global, multicultural teams	78%	Adaptability to unfamiliar situations, uncertainty, and complexity	79%	Information and technology management	79%
Adaptability to unfamiliar situations, uncertainty, and complexity	78%			Ability to work with global, multicultural teams	79%
				Adaptability to unfamiliar situations, uncertainty, and complexity	79%
				Recognize characteristics of knowledge-based service economy	79%
				Complex communication involving interacting and persuading people	79%

Table 17

Comparison of Consensus for Competencies by Participants' Profession

Both Faculty and Management	Faculty only	Industry only
Ability to design a service system, component, or process	Nil	Collaborate with subject-matter expert
Ability to work in interdisciplinary teams		Process analysis and design
Ability to work with global, multicultural teams		Complex communication involving interacting and persuading people
Adaptability to unfamiliar situations, uncertainty, and complexity		Recognize characteristics of knowledge-based service economy
Apply systems based problem-solving approach		
Business and Technology Integration		
Critical thinking		
Demonstrate effective interpersonal communication skills		
Information and technology management		
Integrate engineering and management disciplines for solving service problems		
Market and user needs assessment		

Table 18 shows the degree of consensus for the competencies by disciplinary background (engineering or management) of the participants. Of the total 40 respondents in Round 2, 18 were from engineering discipline and likewise, 18 other were from management. Overall, there seems to be a high level of consensus by disciplines, however, there were some sub group differences in terms of setting priorities for the competencies. For example, "Ability to work in interdisciplinary teams" was rated 3 or 4 by 100% of the respondents representing the management discipline, as compared to 89% of the respondents from the engineering discipline.

Table 18

Degree of Consensus for Competencies by Participants' Disciplinary Expertise

Overall	% f (3/4)	Engineering	%f (3/4)	Management	%f (3/4)
Ability to work in interdisciplinary teams	95%	Integrate engineering and management disciplines for solving service problems	100%	Ability to work in interdisciplinary teams	100%
Integrate engineering and management disciplines for solving service problems	93%	Ability to design a service system, component, or process	94%	Apply systems based problem-solving	100%
Ability to design a service system, component, or process	90%	Business and Technology Integration	94%	Demonstrate effective interpersonal communication skills	94%
Apply systems based problem-solving	90%	Adaptability to unfamiliar situations, uncertainty, and complexity	94%	Integrate engineering and management disciplines for solving service problems	89%
Demonstrate effective interpersonal communication skills	90%	Ability to work in interdisciplinary teams	89%	Ability to design a service system, component, or process	89%
Critical thinking	88%	Apply systems based problem-solving	89%	Critical thinking	89%
Business and Technology Integration	85%	Demonstrate effective interpersonal communication skills	83%	Market and user needs assessment	89%
Market and user needs assessment	83%	Critical thinking	83%	Recognize characteristics of knowledge-based service economy	89%
Information and technology management	78%	Market and user needs assessment	83%	Business and Technology Integration	83%
Recognize characteristics of knowledge-based service economy	78%	Process analysis and design	83%	Information and technology management	83%
Ability to work with global, multicultural teams	78%	Complex communication involving interacting and persuading people		Ability to work with global, multicultural teams	78%
Adaptability to unfamiliar situations, uncertainty, and complexity	78%	Model building and analysis	78%	Project Management	78%
		Information and technology management	78%		

There were some competencies that did not achieve consensus by both the disciplines (see Table 19). For example, “Adaptability to unfamiliar situations, uncertainty, and complexity”, “Complex communication involving interacting and persuading people”, “Model building and analysis”, and “Process analysis and design” achieved consensus from the respondents representing the engineering discipline only and not from the management discipline. Likewise, “Ability to work with global, multicultural teams”, “Project Management”, “Recognize characteristics of knowledge-based service economy” achieved consensus from the respondents representing the management discipline only and not from the engineering discipline. In particular, “Recognize characteristics of knowledge-based service economy” was rated 3 or 4 on a scale of four by 89% of respondents from the management discipline, while it did not achieved consensus from the engineering discipline.

Table 19

Comparison of Consensus for Competencies by Participants' Disciplinary Expertise

Both Engineering and Management	Engineering only	Management only
Ability to design a service system, component, or process	Adaptability to unfamiliar situations, uncertainty, and complexity	Ability to work with global, multicultural teams
Ability to work in interdisciplinary teams	Complex communication involving interacting and persuading people	Project Management
Ability to work with global, multicultural teams	Model building and analysis	Recognize characteristics of knowledge-based service economy
Apply systems based problem-solving approach	Process analysis and design	
Business and Technology Integration		
Critical thinking		
Demonstrate effective interpersonal communication skills		
Information and technology management		
Integrate engineering and management disciplines for solving service problems		
Market and user needs assessment		

The data from open-ended comments were also analyzed for competencies and recurring themes and categories were noted. Suggestions for a change in the competencies were accepted only if they were recommended by at least three respondents. Based, on the content analysis of open-ended comments, "Ability to work in interdisciplinary teams" and "Integrate engineering and management disciplines for solving service problems", were merged to form one competency

entitled “Interdisciplinary collaboration.” Likewise, “Information and technology management” was merged into “Business and technology integration.” This resulted in reduction of competencies that achieved overall consensus, from 12 to the final list of 10 competencies.

The final 10 competencies were then further logically classified at two levels. First, an easy to understand competency title was created and second, a brief description for each competency title was developed. For example, “Market and user needs assessment” was give competency title of “Needs assessment” with a competency description of “Understands the value of identifying and fulfilling customer needs and its implications on long term success of the service organization. Works to understand the market needs for opportunity spotting and customer needs for value creation. Contributes towards creating positive interactions between the customer and the organization.” These descriptions were developed based on the open-ended comments from Round 1 and Round 2 and literature review.

In addition, the final ten competencies were classified into broader competency clusters. For example, Problem-solving, Needs assessment, Contextualize service science, and Conceptualize service system were categorized together as Service mindset. Likewise, two other competency clusters were Integrative competence, and Meta-competence. The results from the data analysis of Round 2 were used to create Round 3 survey.

4.2.3 Round 3

The purpose of Round 3 was to gain a deeper insight into the competencies and courses that achieved consensus in Round 2. The Round 3 survey comprised of top competencies and courses prioritized from Round 2, along with a brief description for each of them (see Appendix F). Participants were asked to rate their degree of agreement with the description and also suggest any changes to make the descriptions more inclusive and relevant. All 51 respondents of Round 1 survey were invited for Round 3. Thus, 11 non-respondents of Round 2 were also invited. A total of 39 participants responded in Round 3, resulting in a response rate of 76%.

Courses

Table 20 summarizes the participants' rating of their agreement with the courses and course descriptions. Project Management had a low mean and high standard deviation indicating an overall variability of the degree of agreement. Two other courses receiving low mean ratings were Consumer Behavior and Leadership & Organizational Behavior. In contrast, Integrative Capstone had the highest mean and the lowest standard deviation indicating an overall consistency of the degree of agreement. Likewise, Service Innovation received a high mean score.

Table 20

Panel Ratings of Courses in Round 3

Courses	M	SD	f(1)	f(2)	f(3)	f(4)	% f(3/4)
Module 1: Contextual Foundation	3.77	0.54	0	2	5	32	95%
Information & Service Economy	3.67	0.66	0	4	5	30	90%
Consumer Behavior	3.44	0.75	1	3	13	22	90%
Leadership & Organizational Behavior	3.46	0.72	0	5	11	23	87%
Project Management	3.38	0.78	0	7	10	22	82%
Module 2: Service Core	3.87	0.41	0	1	3	35	97%
Service Innovation	3.67	0.70	1	2	6	30	92%
Service Design	3.62	0.78	1	4	4	30	87%
Service Operations and Supply Chain	3.54	0.82	1	5	5	28	85%
Module 3(a): Engineering Concentration	3.79	0.66	1	2	1	35	92%
Business Process Modeling	3.74	0.64	1	1	5	32	95%
Service Engineering	3.67	0.70	1	2	6	30	92%
Quality Management	3.72	0.60	0	3	5	31	92%
Module 3(b): Management Concentration	3.74	0.75	2	1	2	34	92%
Strategic Management	3.74	0.55	0	2	6	31	95%
Service Marketing	3.64	0.71	1	2	7	29	92%
Enterprise Systems	3.59	0.82	2	2	6	29	90%
Module 4: Integrative Capstone	3.90	0.38	0	1	2	36	97%

Note. N = 39. Mean (M) and Standard Deviation (SD) are calculated for a four-point Likert scale. f(1), f(2), f(3), and f(4) indicate frequency of participants rating a particular item as 1, 2, 3, or 4 respectively. % f(3/4) represents the percentage of respondents rating 3 or 4.

Figure 4 shows the frequency distribution of the degree of agreement with the courses and their descriptions. It indicates a high level of agreement among the respondents. For each of the course at least 80% of the respondents agreed (3) or strongly agreed (4) with the description provided.

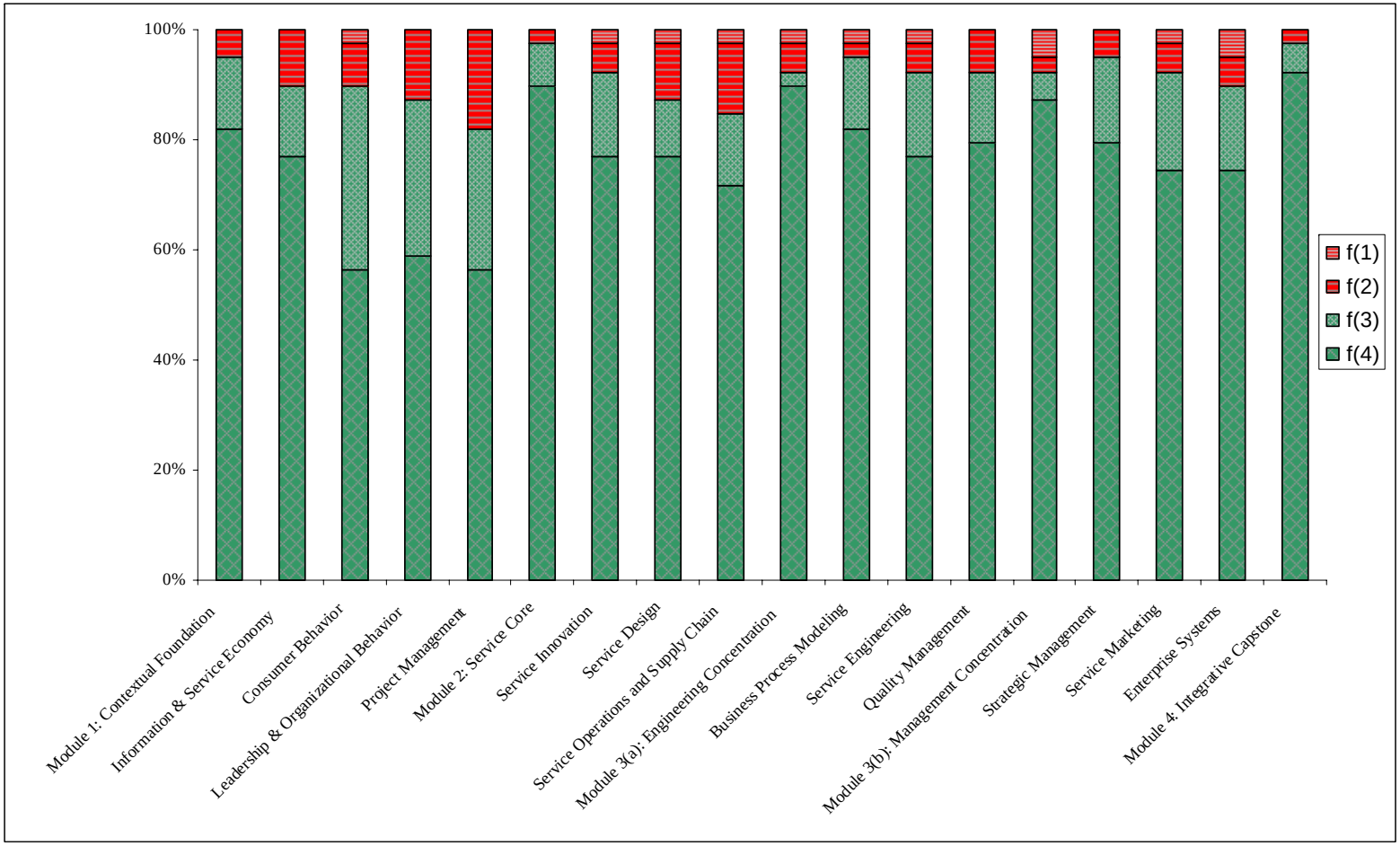


Figure 4. Frequency distribution of degree of agreement with courses in R3

As observed from the descriptive statistics of the participants' ratings, there appears to be a high level of consensus about the description of the courses. The participants' responses to the open-ended part of the survey were analyzed and interpreted to develop the final description of the courses (see Table 21).

Table 21

Description of Courses in Round 3

Course Title	Course Description
Module 1: Contextual Foundation	This is the required set of courses that provide theoretical and practical understanding of customers, organizations, processes, and external environment by situating them within the larger context of the service systems.
Information & Service Economy	Presents characteristics and concepts related to the service economy from social, economic, technological, legal and global perspectives. Aims at understanding of the uniqueness of the service economy at the interface of information technology and globalization and its influence on service organizations.
Consumer Behavior	Provides a framework for analyzing consumer behavior for offering co-creating value and delivering services. Discusses concepts of marketing research and data driven decision making for better understanding organizations and individuals as the consumers of services.
Leadership & Organizational Behavior	Focuses on theory and practice of leadership for building effective, adaptable, and innovative service organizations. Provides overview of organizational behavior, organizational change, knowledge management and organizational learning for a variety of organizational contexts including local, global and virtual.
Project Management	Discusses tools and techniques for resource utilization and effective management of service projects. Integrates the challenges and opportunities of financial management, risk management and people management. Presents the role of contracts and service level agreements in project management.
Module 2: Service Core	This is the required set of courses that focus on developing expertise in the domain of service science. It develops competence in innovating and improving service systems using specialized theory, concepts, and techniques.

Service Innovation	Covers approaches to infuse innovative thinking into organizations for identifying opportunities and creating new service solutions. Introduces systematic, integrated and holistic approach to conceive, create, launch, and support innovative service solutions. Emphasizes inclusion of internal and external stakeholders in transforming service propositions.
Service Design	Explores the process and components of service design within the given business constraints and objectives. Develops skills to integrate user needs, define functionality, and design service system for integrating contextual, functional and experiential aspects of the service. Uses tools and techniques for conceiving, designing and prototyping a service systems.
Service Operations and Supply Chain	Explores the differences and complementariness between the service and manufacturing operations. Develops a distinct set of skills required in designing, planning and managing service supply chains. Overviews technology tools and techniques for managing and improving supply chain performance.
Module 3(a): Engineering Concentration	This is the set of courses for students with engineering background who are aiming to become experts in design, engineering, and process aspects of service science. The primary objective of the concentration is to leverage and build on the students' existing disciplinary expertise in engineering domain.
Business Process Modeling	Examines theory, practice and tools of business process modeling. Focuses on defining, simulating, measuring, re-engineering and improving processes in service systems. Emphasizes process orientation as fundamental for simulating and managing the complexity, interactivity and dynamism associated with service systems.
Service Engineering	Focuses on translation of business needs into technical elements to achieve optimum performance from the dynamic and complex service systems. Integrates concepts from systems engineering and operations research as well as provides an overview of technological potential of web services, and network systems and services.
Quality Management	Investigates the underlying management and engineering principles of quality management and its applications for service systems. Focuses on the use of tools and techniques for process and productivity improvement to achieve customer satisfaction.

Module 3(b): Management Concentration	This is the set of courses for students with non-engineering background who are aiming to become experts in innovation, customer, and management aspects of service science. The primary objective of the concentration is to leverage and build on the students' diverse background from non-engineering disciplines.
Strategic Management	Explores strategic management for service organizations, with focus on industry structure and organizational capabilities, issues of strategic change, and influence of customer experiences on strategic directions. Introduces frameworks and methodologies for strategy formulation and implementation in an increasingly dynamic and interconnected external environment.
Service Marketing	Builds upon the course on Consumer Behavior and examines the marketing and managerial approaches for offerings services to individual and organizational customers. Presents concepts and cases of service marketing including branding and pricing. Provides overview to customer relationship management and e-marketing.
Enterprise Systems	Presents concepts and practices of enterprise wide systems and their applications in managing service organizations. Investigates the challenges and opportunities in implementing and managing enterprise systems. Emphasizes the role of strategic alignment between business processes, organizational capabilities and information resources.
Module 4: Integrative Capstone	This capstone module aims at providing an experiential learning opportunity to students for integrating business (management) and technology (engineering) perspectives. Engages students to conceptualize, and solve service science issues within an organization and provide appropriate solutions, prototypes or recommendations. Emphasizes interdisciplinary team work, use of theories and tools learned, and application of competencies developed through out the curriculum.

Competencies

Table 22 summarizes the panel ratings of their agreement with the competencies and competency descriptions. "Contextualize service science" received the lowest mean and the highest standard deviation indicating variability of the degree of agreement. In contrast, "Adaptability" received the highest mean and the lowest standard deviation indicating a high degree of agreement.

Table 22

Panel Ratings of Competencies in Round 3

Competencies	M	SD	f(1)	f(2)	f(3)	F(4)	% f(3/4)
Cluster 1: Service Mindset	3.38	0.88	2	4	10	23	85%
Conceptualize service system	3.54	0.79	2	1	10	26	92%
Needs assessment	3.54	0.72	0	5	8	26	87%
Problem-solving	3.41	0.75	0	6	11	22	85%
Contextualize service science	3.21	0.95	3	5	12	19	79%
Cluster 2: Integrative Competence	3.82	0.60	1	1	2	35	95%
Business and technology integration	3.62	0.59	0	2	11	26	95%
Interdisciplinary collaboration	3.56	0.82	2	2	7	28	90%
Diversity orientation	3.36	0.74	1	3	16	19	90%
Cluster 3: Meta-competence	3.62	0.54	0	1	13	25	97%
Adaptability	3.67	0.48	0	0	13	26	100%
Critical thinking	3.67	0.70	1	2	6	30	92%
Interpersonal communication	3.67	0.62	0	3	7	29	92%

Note. N = 39. Mean (M) and Standard Deviation (SD). f(1), f(2), f(3), and f(4) indicate frequency of participants rating a particular item as 1, 2, 3, or 4 respectively.

Figure 5 shows the frequency distribution of the degree of agreement with the competencies and their descriptions. Overall, it indicates a high level of agreement among the respondents. For each of the competency except "Contextualize service science", at least 80% of the respondents agreed (3) or strongly agreed (4) with the description provided. Two competencies—"Problem-solving" and "Contextualize service science" had a relatively higher level of disagreement with the description.

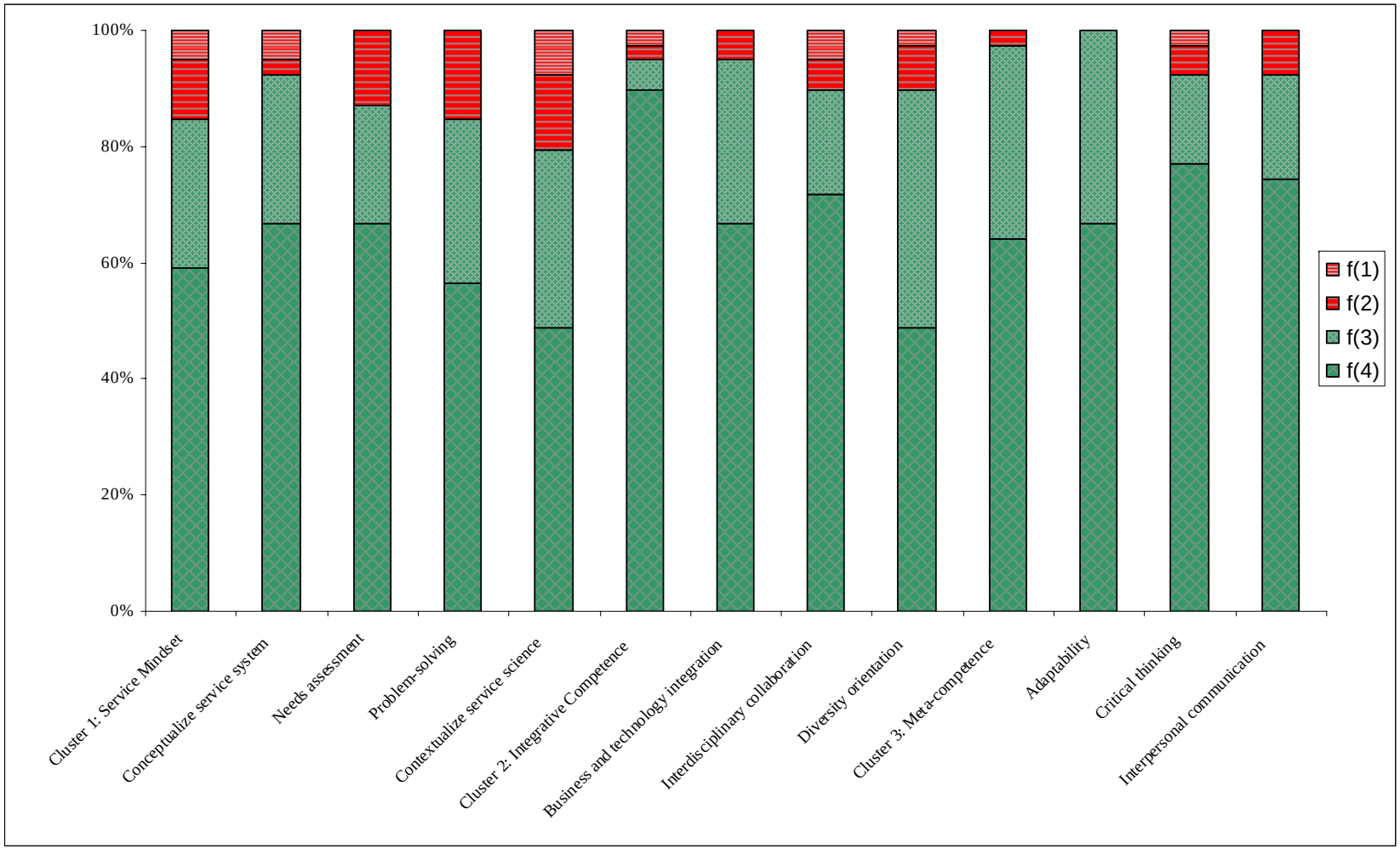


Figure 5. Frequency distribution of degree of agreement with competencies in R3

As observed from the descriptive statistics of the participants' ratings, there appears to be a high level of consensus about the description of the competencies. Participants' responses to the open-ended part of the survey were analyzed and interpreted to develop the final description of the competencies (see Table 23).

Table 23

Description of Competencies in Round 3

Competency Title	Competency Description
Cluster 1: Service Mindset	An orientation towards value creation in a customer-provider relationship enabled by systematic assessment, improvement and innovation of service systems.
Conceptualize service system	The ability to conceptualize, design and implement service system using specialized tools and techniques. Demonstrates expertise in configuring service systems, integrating resources, and managing customer interactions for effective decision making.
Needs assessment	Understands the value of identifying and fulfilling customer needs and its implications on the long term success of the service organization. Applies appropriate tools and techniques to assess the needs of end users and the intermediaries involved in the service value chain.
Problem-solving	Exhibits an integrated system based approach in framing, prioritizing, and solving problems. The ability to assess complex interrelationships of various facets of the problem including technical, managerial, or interpersonal to deliver value proposition. The ability to define root causes and propose alternative solutions.
Contextualize service science	Demonstrates a deep and wide understanding of the characteristics of the service economy and its relationship with other aspects of the economy. Understands relevant theories, literature, and philosophies on which to base rigorous professional practice of service scientist.
Cluster 2: Integrative Competence	The ability to integrate ideas, concepts, and strategies emerging as a result of interaction among disciplines, people, and business processes to deliver a value proposition. Exhibits complex communication or interactional expertise.

Business and technology integration	Identifies and prioritizes information needed to conceptualize the situation and seeks that information from appropriate sources. Integrates information from a number of diverse sources and applies it for improving customer value propositions and operational efficiencies.
Interdisciplinary collaboration	Integrates disciplinary foundations from engineering and management to co-create value for customers and service organizations. Collaborates with subject-matter experts to understand business implications and conveys it to a variety of participants in the service system. Functions as a cross-functional liaison and effectively coordinates across stakeholders.
Diversity orientation	The ability to collaborate and communicate with a diverse set of people in a global and local context. Appreciates differences in cultural perspectives and communication styles and adapts to work towards common goal.
Cluster 3: Meta-competence	The ability to locate, analyze, and adapt existing competencies depending on the contexts and complexities. Meta-competence includes generic capacities like adaptability, critical thinking, and interpersonal communication that enhance and enable other competencies.
Adaptability	Adaptability to unfamiliar situations, uncertainty, and complexity. Ability to innovate and reconceptualize problems in response to changing market demands and risks.
Critical thinking	Ability to analyze multiple perspectives and establish appropriate criteria for choosing among competing perspectives. Exhibits inductive and deductive thinking capacity of analyzing, evaluating, and constructing components of the service system.
Interpersonal communication	Recognizes the value of interactions in co-creating value and possess interactional expertise. Communicate effectively across disciplinary, geographical, technological and cultural barriers in both oral and written forms using multiple channels.

4.3 Summary of Results

This section presented the results of the online Delphi survey to identify, prioritize, and describe the most important competencies and courses for a master's program in SSME. Industry professionals and university faculty who are engaged with the field of SSME were invited to participate as expert panel. Of the total 148 emails delivered to the potential participants, 51 responded in Round 1. For Round 2 and Round 3 all 51 respondents from Round 1 were invited, and a total of 40 and 39 responses were received in Round 2 and Round 3 respectively. The profile of the participants indicated that they had adequate disciplinary expertise, depth of experience and diversity of view points.

Round 1 survey allowed participants to rate and also suggest additional competencies and courses to be included in the list of relevant courses and competencies for SSME. Based on data analysis of Round 1 survey, Round 2 survey was developed. Round 2 comprised of 28 courses and 25 competencies. Participants for Round 2 rated their responses again in the light of the group responses from Round 1. Consensus—defined as at least 75% of the respondents rating any item as Very Important (4) or Important (3)—was achieved for a total 12 competencies. Based on the data analysis of the respondents' suggestions, two of the 12 competencies were merged to develop a final list of 10 competencies. Similarly, consensus was achieved for eight courses by respondents from both engineering and management disciplines, and three courses each achieved consensus by engineering and management

disciplines only. This resulted in a final list of 14 courses. An overall shift towards consensus was observed from Round 1 to Round 2.

The purpose of Round 3 survey was to gain a deeper insight into the description of the competencies and courses. Round 3 survey comprised of 10 competencies and 14 courses that achieved consensus from Round 2, along with a brief description for each of them. Participants were asked to rate their degree of agreement with the description and also suggest any changes to make the descriptions more inclusive and relevant. A high degree of consensus was observed for the description of the competencies and courses. For each competency and course at least 75% of the respondents agreed (3) or strongly agreed (4) with the description provided.

The final 14 courses were categorized into four modules, Module 1: Contextual Foundation (Information & Service Economy, Consumer Behavior, , Leadership & Organizational Behavior, Project Management); Module 2: Service Core (Service Innovation, Service Design, Service Operations and Supply Chain); Module 3(a): Engineering Concentration (Business Process Modeling, Service Engineering, Quality Management); Module 3(b): Management Concentration, Strategic Management, Service Marketing, Enterprise Systems) and; Module 4: Integrative Capstone (Business and Technology Integration).

The final 10 competencies were categorized into three clusters; Cluster 1: Service Mindset (Needs assessment, Conceptualize service system, Problem-solving, Contextualize service science); Cluster 2: Integrative Competence (Business and

technology integration, Interdisciplinary collaboration, Diversity orientation) and; Cluster 3: Meta-competence (Adaptability, Interpersonal communication, and Critical thinking).

To sum up, the expert panel engaged in three rounds of the online Delphi survey and reached an overall consensus for the most important competencies and courses for a master's program in SSME. There were also some differences noted in terms of priorities for the courses and competencies by disciplinary expertise and professional background of the respondents.

CHAPTER 5: DISCUSSION

This chapter builds on the results presented in Chapter 4 and discusses the key implications and contributions of this study. It presents a competency model for a service scientist, a blueprint of the SSME curriculum, offers recommendations for higher education institutions and other stakeholders, and provides future directions of research.

The overarching purpose of this research was to provide theoretical and conceptual foundations for developing a competency-based curriculum for a master's program in SSME. Specifically, the research questions guiding this study were:

1) What are the most important competencies required for a graduate of the master's level interdisciplinary program in SSME?
2) What courses/content domains may provide the most important competencies required for a graduate of the master's level interdisciplinary program in SSME?

The researcher administered three rounds of the online Delphi method to address the above research questions. In particular, the three rounds were respectively used to identify, prioritize, and describe the most important competencies and courses. Industry professionals and university faculty who are engaged with the field of SSME were invited to participate as experts. Based on the consensus of the study participants,

a final list of 10 competencies and 14 courses was generated. These competencies were used to develop a competency model and the courses were used to create a curriculum blueprint as discussed in the next two sub-sections.

5.1 Curriculum Blueprint for SSME

Based on the results discussed in the previous chapter, a curriculum blueprint for a master's program in SSME is developed. Detailed descriptions of the courses and modules of the curriculum were presented earlier in Table 21. The blueprint of SSME curriculum is visually presented in Figure 6. The four primary modules of curriculum are: Contextual foundation, Service core, Engineering concentration or Management concentration, and Integrative capstone. Contextual foundation and Service core are the required set of courses which achieved consensus by the respondents from both engineering and management disciplines and focus on developing a deeper understanding of theory and practice of service science.

Integrative capstone is proposed for two primary reasons. First, several participants recommended inclusion of a project based course in the curriculum and, second, Business and Technology Integration course achieved consensus by the respondents from both engineering and management disciplines. A university faculty reported that "Service systems are composed of business process and technology-based process, thus it [Business and Technology Integration] is fundamental."

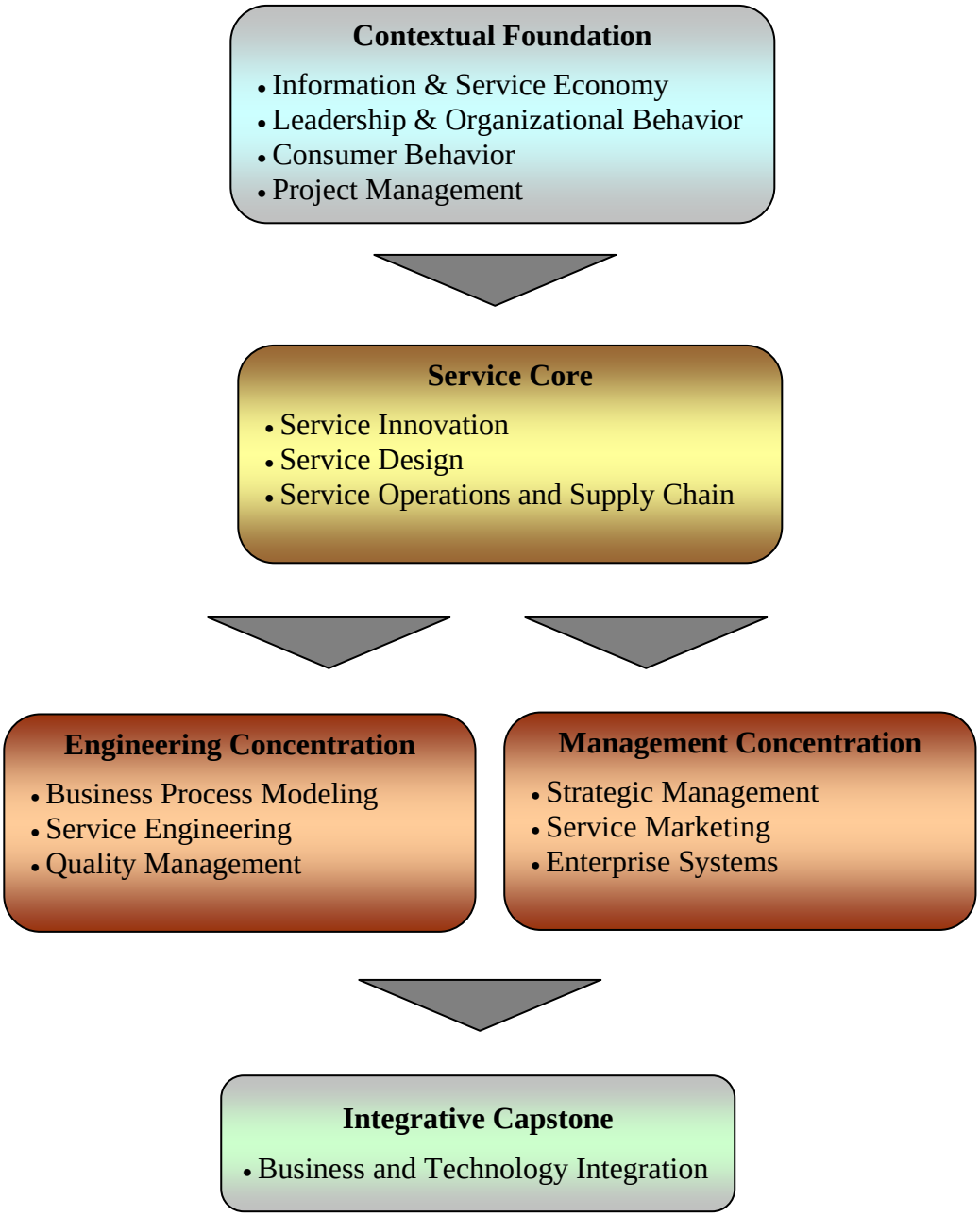


Figure 6. Curriculum blueprint for a master's program in SSME

Concentration courses in engineering and management included courses that achieved consensus by the respondents from only engineering or management disciplines but not both. For example, Information & Service Economy course achieved consensus from both engineering and management disciplines, where as, Service Marketing achieved consensus by the respondents from management discipline only and not from engineering discipline. This need for concentration tracks was highlighted by several respondents. One university faculty mentioned "I see that at least two streams are needed for a SSME graduate program: engineering and managerial." The concentration track in engineering is primarily for engineers and develops expertise in design, engineering, and process aspects of service science, while the management concentration is for non-engineers and develops expertise on customers, innovation, and management aspects of service science.

Overall there was a high degree of consensus among the participants for the SSME courses and their descriptions. One of the industry professionals noted "I think your courses and course descriptions are excellent" and other university faculty stated that "The courses are well defined and complete service scientists need of knowledge for their future market and job placement."

While there was an overall consensus among the participants, there were some expressions of reservation and disagreement. For example, one of the engineering faculty objected to the division of students into engineering and management concentration and noted that "I strongly disagree with partitioning the students into 2 groups. Engineers should also be exposed to these [management concentration

courses] materials." Another industry professional from engineering background had a contrasting view and stated that "I like the idea to have courses for students with different backgrounds!" These polarized views may be a result of differences in disciplinary and professional background.

The study noted indications of curricular tensions between stakeholders (university faculty and industry professionals) and disciplines (management and engineering). Stark et al. (1986) stated that curricular tensions may be expressed in the form of debate about instructional and evaluation methodologies, balance of theory and practice, choice of core courses and sequencing, and even evolve from interaction with an external professional community. The differences in priorities of courses were noticed between industry professionals and university faculty. For example, Leadership and Organizational Behavior was rated 3 or 4 on a scale of four by 100% of the industry professionals as compared to 79% of the university faculty. Likewise, while Enterprise Systems achieved consensus (89%) by the industry professionals, only 63% of the university faculty rated it 3 or 4 on a four-point scale.

Several researchers have noted the influence of disciplinary differences on curriculum and program planning (Stark, Lowther, Sharp & Arnold, 1997). SSME being an interdisciplinary program, tensions were also noticed in terms of setting priorities for the courses by the disciplinary expertise of the respondents. For example, Service Operations was rated 3 or 4 on a scale of four by 94% of the respondents from the engineering discipline as compared to 83% of the respondents from the management discipline. Likewise, Service Marketing achieved consensus (89%)

solely by the respondents from management discipline and only 67% of the respondents from the engineering discipline rated it 3 or 4 on a scale of four.

As highlighted in Chapter 1, existing Engineering Management and Systems Engineering programs are still offered from a manufacturing paradigm and have not integrated the characteristics of the service economy in its curriculum. Similarly, some of the initial programs related to SSME have built service concentrations as add-ons to their existing programs and have not undertaken a fresh slate approach to embrace interdisciplinarity and service innovation. Van der Klink and Boon (2003) stated that "Competency-based education does not imply the redesign of a single course but it does require a major curriculum transformation" (p. 133). The proposed competency-based curriculum undertakes this transformative approach and moves away from service as an "add-on" concentration to service as foundation and core of the curriculum. Thus, this blueprint encourages building on the core theoretical and scientific principles of service innovation with a true interdisciplinary and competency-based approach.

5.2 Competency Model for a Service Scientist

IfM and IBM (2008) define the T-shaped professional or service scientist as an individual with deep problem-solving and expert thinking skills in their home discipline coupled with complex communication skills to interact with specialists across a wide range of disciplines. As SSME is an emerging field, there is some level of ambiguity and vagueness about the conceptualization of the T-shaped professional

(Glushko, 2008). The competency model presented here attempts to explicate the key competencies expected from a service scientist and integrate them with the curriculum presented earlier.

Based on the results presented in the previous chapter, 10 competencies that achieved overall consensus were included in the model (see Figure 7). Detailed descriptions of the competencies were presented earlier in Table 23. The horizontal component of the model describes the skills and attitudes required from a service scientist and comprises of three primary clusters of competencies, Integrative competence, Service mindset, and Meta-competence. The descriptions of these competency clusters are in consonance with other definitions noticed in the literature. Stark et al. (1986) defined integrative competence as "the ability to meld conceptual and technical competences in order to practice effectively and efficiently" (p. 245). Service mindset is "An orientation geared towards the innovation of customer-provider interactions (service systems and value propositions), combined with interactional skills to enable teamwork across academic disciplines and business functions" (IfM & IBM, 2008, p. 18). According to Cheetham and Chivers (1998) meta-competencies are beyond other competencies and support individual to analyze their existing competencies, locate them and improve upon them.

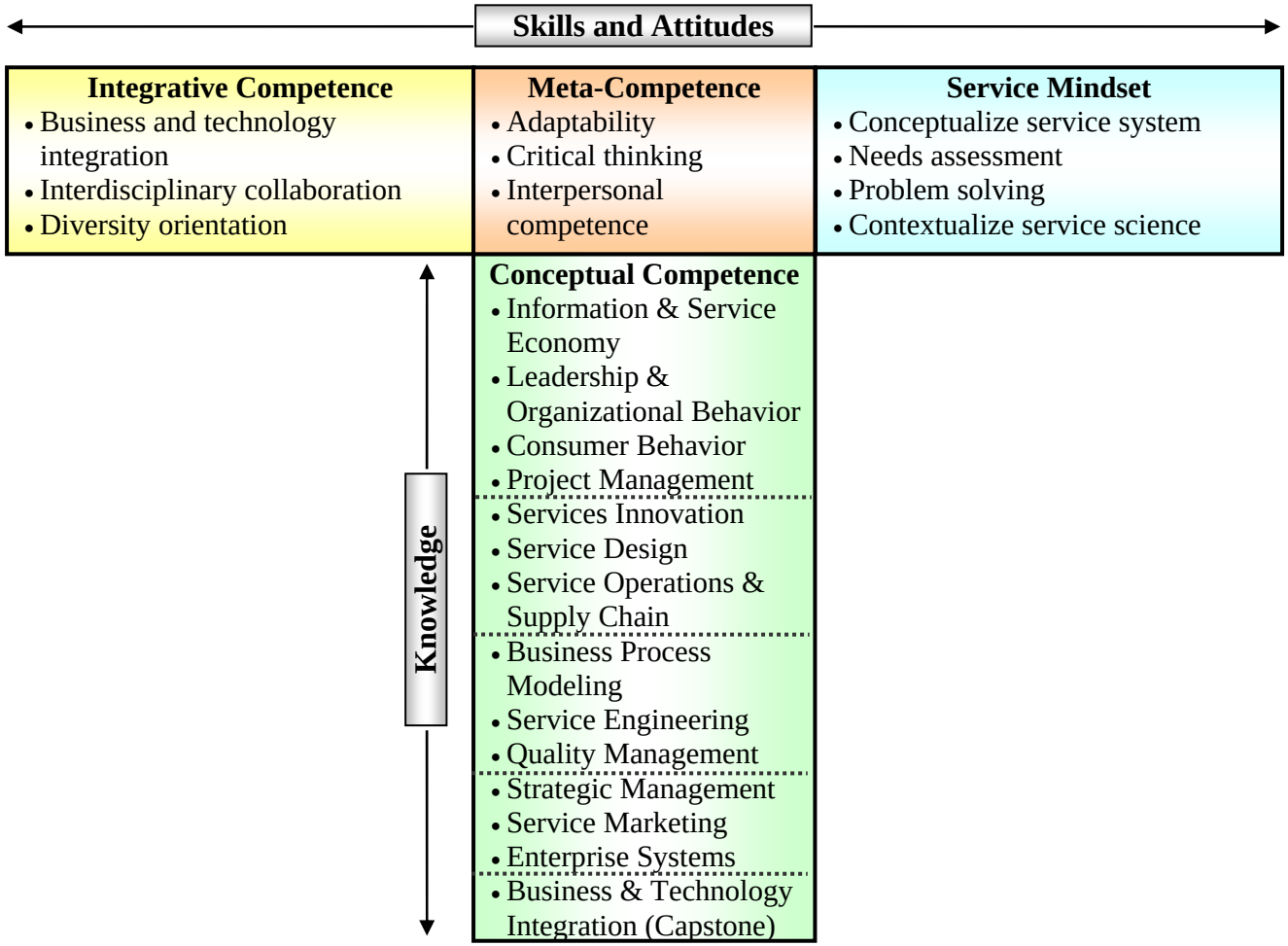


Figure 7. Competency model for a service scientist

The vertical component of the model describes the knowledge or conceptual competence required by a service scientist. It includes 14 courses or content domains that achieved consensus. The dotted lines represent the four primary course modules which indicate the content domain expertise. Stark et al. (1986) state that "Graduates are conceptually competent if they have acquired the theoretical foundations or generally accepted knowledge upon which professional practice is based" (p. 244). The knowledge or conceptual competence complements the behavioral (skills and attitudes) aspects of a service scientist to create an integrated competency model.

Thus, the competency model represents knowledge, skills and attitudes that a graduate of the master's program in SSME needs to possess and exhibit. This model attempts to address incoherence in the directions of SSME education by providing a theoretical and conceptual foundation for understanding the expectations from a service science professional. As Voorhees (2001) noted that the challenge for higher education system is to "…determine which competencies can be bundled together to provide different types of learners with the optimal combination of skills and knowledge needed to perform a specific task" (p. 9).

Overall there seems to be a high degree of consensus among the participants on the competencies and their descriptions. For example, one university faculty from the management field noted that "It sound[s] complete to me. The identified competencies seem to fulfill the goal of a service scientist." Another industry professional from the management discipline stated "this is a good list with very good descriptions."

However, there were some respondents who have reported disagreements. For example, one university faculty disagreed with several competencies and commented that the overall description of competencies “Demonstrates a closed view of systems. Ignores the role of customer as arbiter of value.” Similarly, one industry professional expressed reservation with the use of the term service scientist and noted that “I am not sure I want ‘service scientists’ as graduates, but technology and business savvy services employees and leaders.”

There were some differences in conceptualization of the competencies between stakeholders—university faculty and industry professionals, and between disciplines—management and engineering. For example, “Ability to design a service system, component, or process” was rated 3 or 4 on a four-point scale by 100% of the university faculty as compared to 84% of the industry professionals. Likewise, “Business and technology integration” was rated 3 or 4 on by 94% of the respondents representing the engineering discipline as compared to 83% of the respondents from the management discipline.

These differences in the priorities for competencies and views on the description of the competencies indicate that there are some differences in the expectations and interpretations of competencies by the panelists. This may be influenced by several factors including the emerging nature of the SSME field, differential level of panelists’ engagement with the field, differences in professional background and disciplines, and finally the challenges of defining competencies.

Overall, the competencies section of the study appeared to have relatively more disagreements among participants as compared to the courses section. This is also expressed in the comments of a university faculty member "As categories I have found these [courses] more agreeable than the competencies section."

Competencies are contextual in nature and the combination of knowledge and skills required varies by the context (Voorhees, 2001). Consequently, the competency model presented here is in the context of a service scientist who is working in a service economy. The T-shaped competency model presented here is not definitive. There are certain competencies which surprisingly did not achieve consensus. For example, "Engage in life-long learning" achieved an overall rank of 22 out of 25 competencies with only 53% of the respondents rating it 3 or 4 on a scale of four. Several respondents noted that this competency overlaps with other competencies and few others highlighted the universal nature of the competency.

Several researchers have noted that competencies are some times ambiguous, and unclear (Van der Klink & Boon, 2002), and other times they are mechanistic and uninformative (Ashworth & Saxton, 1990). The competency model presented here also has its limitations. There seems to be a certain degree of overlap among competencies, while few other competencies appear generic. However, based on the findings of this study, the competencies defined in this model provide a conceptual framework to advance the discussion about the unique capacities and characteristics of a service scientist. This conceptual framework is also important as it engaged stakeholders and provided a common language for developing SSME curricula.

5.3 Recommendations

The National Center on Education and the Economy (2007) suggests that America has to adapt its education system to prepare talent for the most creative work and transition them from low skill routine work to high skill creative work. The results of this study have implications for contributing towards the long terms competitiveness of the economy. It provided conceptual and theoretical foundations for developing a competency-based curriculum for a master's program in SSME. These competency-based programs may aid in developing innovators for the service economy and in turn contribute towards the national competitiveness.

This study fills a gap of creating a competency-based curriculum for the evolving service economy. The context of this study is the rapidly changing nature of the work and role of professional master's education in fulfilling the need. The nature of work will continue to transform and hence the needs of the economy and the competencies will also continue to change. Professional higher education needs to consistently revisit its offerings so that it is developing talent that is prepared to meet the changing needs of the society and the economy.

In particular, the two most significant outputs of this study are in the form of a competency model for a service scientist and a curriculum blueprint for a master's programs in SSME. The blueprint of the competency-based curriculum developed in this study may be used to develop new program in SSME. The blueprint also serves as a tool to assess the gaps in the existing programs so that they may be better aligned

with the evolving needs of the SSME field. Thus, higher education institutions may adapt the blueprint of SSME in line with their program mission and focus.

The curriculum blueprint developed in this study was designed with the interdisciplinary integration of engineering and management disciplines. In this curriculum it was assumed that both disciplines have an equitable emphasis. However, higher education institutions offering new programs in SSME or redesigning their existing programs may want to adapt this emphasis on engineering or management according to the needs, missions and goals of the program. For example, an Engineering Management program that wants to redesign its curriculum for SSME may have a higher engineering emphasis as compared to an MS in Management program that may have a higher management emphasis. In addition, as the SSME field evolves, other disciplines like social sciences may also gain more emphasis. Consequently, higher education institutions offering SSME programs need to constantly evaluate their program offering in line with the advancement of the SSME field and the underlying disciplines.

Given the strong relationship between the employee competencies and the productivity and performance of the organization, corporate employers need to take a more proactive role in supporting development of new programs in SSME. This support may directly come in the form of tuition support, flexible schedule, and sabbaticals to employees. Business organizations should engage in offering Integrative capstone projects for students and also support faculty for course designing opportunities. They should also consider providing funding support to universities for

developing new programs or realigning existing programs. At another level, industry should consider revising job descriptions for service scientist roles in collaboration with higher education institutions (Davis & Berdrow, 2008). The T-shaped competency model for a service scientist presented in this study may be adapted by business organizations to design job descriptions. This will also bring coherence in expectations between higher education institutions and business organizations.

In line with the conceptual framework, this study engaged industry professionals and university faculty to virtually brainstorm and arrive at a consensus for a competency-based curriculum for SSME. This study exemplifies and encourages more collaboration between industry and university to create win-win situations. The university-industry collaboration is highly pertinent in the case of master's level programs because of its professional focus. Industry may bring insights about the changing needs of the work so that university may effectively balance theoretical and practical components in the curriculum. More than three decades ago, Clark Kerr (1974) highlighted that university and industry need to collaborate without losing their respective identities and noted that "Some tension is inevitable, even desirable, provided it occurs within reasonable rules of conduct" (p. 24). More recently, Carnevale (2008) concluded that there is a need to "strike a pragmatic balance between education's growing economic role and its traditional cultural and political independence from economic forces" (p. 29). Therefore in spite of a risk of too much interference by industry in academia, both university and industry stakeholders should attempt to maximize the interdependency of their relationship. This study presented

one unique collaborative approach of developing a competency-based curriculum for a master's program in SSME.

Given the recurring challenge of assessing effectiveness of student learning, proposed competency-based curricula may offer some promise. Jones (2001) states that "competencies can have a stronger impact on student learning when they are linked and embedded within specific courses" (p. 23). Voorhees (2001) adds that competency-based learning helps in establishing common standards and language and provides students with a clear and logical sense of direction. Likewise, the competency model and the blueprint of the SSME curriculum may aid setting clear expectations among students about the purpose and direction of the curriculum. Students may also engage in a more purposeful learning.

The master's degree in general is given lower priority and respect as compared to the doctoral degree in the research universities (Conrad et al., 1993). This is primarily because of the prestige associated with research and disciplinary affiliation of faculty. University administrators and faculty need to take a more holistic view about the contributions of the master's degree not only at the university level but also at the societal and national level. As Conrad et al. (1993) asserted that "Perhaps more than any level of education, master's education is directly serving important societal needs and, in doing so, significantly enhancing overall relations between higher education and society" (p. 318). Policy makers at state and federal levels need to collaborate with industry and higher education institutions to foster development of innovative professional master's program like SSME. Government should provide

more funding support to higher education institutions for developing SSME programs that may directly contribute to innovation and competitiveness at the state and national levels.

Professional associations and accrediting bodies need to take a more proactive role in catalyzing the visibility and adoption of interdisciplinary competency-based curriculum in SSME. In addition to organizing conferences and disseminating the value of SSME, professional associations need to further emphasize the need for competency-based approaches and interdisciplinary collaboration in learning outcomes. Curriculum development approach presented in this study, may serve as a case study to be used by professional and disciplinary associations to highlight the need and relevance of competency-based curriculum that attempts to bridge not only disciplinary gaps but also gaps between theory and practice.

Slaughter (2002) noted that "For new curricula to become widely institutionalized, curriculum planners must be able to ensure that programs will lead to prestige and resources for faculty and well-paid professional careers for students" (p. 283). Recognition and reputation building of both faculty and students is critical for the acceptance and growth of SSME. This requires a strong collaborative approach between corporates, universities, government, and professional associations. The curriculum development process presented in this study exemplified one way of encouraging collaboration among stakeholders. More avenues of collaboration should be explored that may lead to prestige and visibility of the new SSME curriculum.

5.4 Implications for Future Research

This study has several implications for future research. In terms of the study design, Delphi method was found to be highly appropriate for the exploratory nature of this study where SSME experts were geographically dispersed and little research was available on the topic of investigation. Future studies for curriculum development are encouraged to use the Delphi method. This study used Microsoft Excel to conduct the survey, which had its benefits and limitations. The benefits included the ability to add open-ended comments for each item and also include participants' individual responses along with the statistical summary of the group responses in Round 2 survey. The primary limitation of using Excel was higher time involvement of the researcher in organizing multiple files for each respondent across three rounds and compiling data. Future studies may explore developing better web-based survey instruments to specifically meet the needs of the Delphi method.

One important research area is to further describe the components of the individual courses. This study identified 14 courses that signify the broad content domains required for the SSME program at the master's level. However, significant differences in emphasis may exist within each course. Future studies may involve deeper investigation of the specific components of the courses. In addition, other aspects of the curriculum like the nature of the internship or capstone project, distribution of core and elective courses, identification of program concentrations, academic and work experience requirements of incoming students may also be investigated.

The competency model developed in this study needs to be expanded to include the definition of standards and assessment methods for each competency. This study focused on identification, prioritization and description of the competencies that may be expected from a future service scientist. Future studies may build on the results of this study to develop the proficiency and assessment standards for the key competencies.

Professional education at the master's level should be a collaborative process that includes various stakeholders. The master's degree is uniquely positioned to meet the needs of the individual, corporate, economy, and society. This study included both university faculty and industry professionals as the participants. Future studies may include policy makers and students to bring a more holistic perspective in the curriculum development process.

Researchers are encouraged to test the blueprint of SSME curriculum and competency model using both qualitative and quantitative approaches. Qualitative methods like focus groups and individual interviews may be conducted to gain deeper insights about the rationale for the competencies and courses identified in this study. Quantitative survey of a large random sample of faculty and professionals may be undertaken to identify statistically significant differences in the perceptions about the findings of this study.

Interdisciplinary curriculum is the core of SSME program, however, realizing the vision of the interdisciplinary program is infested with several obstacles. These obstacles may include program culture and disciplinary differences of faculty, unclear

definition of interdisciplinary goals, unsatisfactory reward system, lower recognition for tenure and promotion, and institutional policies. Future studies may investigate the opportunities and challenges of developing an interdisciplinary curriculum in SSME and identifying its critical success factors.

Influence of accreditation standards from engineering and management accreditors may also be investigated. Specifically, a deeper analysis is required to understand the alignment of the curriculum within the accreditors' expectations and the nature of changes that may be required.

Overall methodology implemented in this study may be used by other disciplines to develop master's program that are in alignment with the profession's needs. For example, the field of higher education may engage university administrators and faculty to develop a competency-based curriculum for a master's program in higher education administration.

5.5 Limitations of the Study

In addition to the limitations explained in section 3.5 concerning the Delphi method, this study has few additional limitations.

First, given the interdisciplinary and evolving nature of the SSME field, there is a possibility of misinterpretation of some of the key terms among the participants. Since the participants had different disciplinary backgrounds in management or engineering disciplines, their interpretations and understanding of operational definitions of the competencies and courses may also not be consistent. In addition,

this study engaged two primary stakeholders—industry professionals and university faculty—as study participants. Although this diversity of perspective added to the content validity of this study, it may have also resulted in a lack of coherence in the directions for the SSME education.

Second, this study used competency and course titles in the first two rounds for setting the curricular priorities. The limited information provided by competency and course titles may have restricted the capacity of participants to interpret and effectively respond. However, given the professional expertise and active engagement of the participants, misinterpretation of constructs is expected to be limited. Further, Round 3 of the study provided ample opportunity to the participants to go beyond competency and course titles to provide depth and details.

Finally, the researcher's background, assumptions, and perspectives on the topic may have also influenced the interpretation of data. The researcher assumed that the selected expert panelists have a deep and wide understanding about the issues related to the service science field.

Despite these limitations, the study offers several theoretical and practical implications for the evolution of SSME field. It also suggested future directions of research to fill some of the limitations discussed here. The study contributed to the theory and practice of competency-based curriculum development in higher education and aids in advancing the SSME field.

5.6 Conclusions

Curriculum development for professional programs should not only measure the relative importance of knowledge and skills required for the profession, but should also assess the congruence between practitioners and academicians (Mallick & Chaudhury, 2000). This study engaged university faculty and industry professionals to identify, prioritize, and describe competencies and courses that are considered important to be included in a competency-based curriculum for a master's program in SSME.

Robert Glushko (2008) described the experiences of developing SSME curriculum at the University of California, Berkeley and noted that "It has not been easy, and the fit between where we are and where we want to be is not perfect, but we now have a clearer view of how to proceed" (p. 19). On a similar note, in spite of the limitations, this study lays the theoretical and conceptual foundations for future studies and stakeholders to systematically advance SSME education.

Stark and Lattuca (2002) highlight the interactive and complex process of curriculum change in American higher education. They argue that the debate about curriculum change has been recurring over the years and that "[t] most significant undulations in the intensity of debate about the change have been produced by external influences" (p. 68). SSME is an emerging field that has its origins in external forces. Glushko (2008) found that it is very difficult for one institution to develop a comprehensive curriculum in SSME. This study contributes to the development of

shared framework and common language for the SSME education at the master's level by bringing together stakeholders from several institutions.

Building a new academic field requires a confluence of demand for new knowledge and willingness and ability of producers to meet the demand (Berry & Parasuraman, 1993). A recent report by the Council on Competitiveness asserts that "Although the knowledge-intensive service economy is a principle driver of economic growth, there is a dearth of research, funding, and educational curriculum to accelerate America's capacity for service innovation and productivity" (Van Opstal, Evans, Bates & Knuckles, 2008. p. 24). Thus, there seems to be an urgent demand for education that may aid in developing talent for the new knowledge-based service economy. This study supports the development of SSME as an academic field as it provides a conceptual and theoretical background for developing the competency-based curriculum for the master's program in SSME.

The rise of academic field is not only a result of intellectual advances but more importantly influenced by its sociopolitical context (Hambrick & Chen, 2008). There are three primary sociopolitical components that enhance an aspiring community's likelihood of acceptance as an academic field: (1) differentiation—asserts that proposed field is distinct from existing fields and worthy of separate focus; (2) mobilization—consists of a favorable political opportunity structure, shared interests to establish group identity, and social infrastructure for consolidating resources; and (3) legitimacy building—attempts intellectual persuasion and emulation of existing adjacent and closely related fields. The results of this study found influence of all three

forces in shaping the future of SSME. Respondents seem to have strongly agreed for building a new and different curriculum for SSME; they encouraged mobilization of collaboration among stakeholders; and they seem to find their source of legitimacy from the existing fields of engineering and management.

While there is an increasing momentum for SSME with more than one hundred universities across the world working on establishing SSME related programs, there are also few dissenting voices (Spohrer, 2008). Some people are questioning if "…this emerging area can really succeed in creating a unique and deep body of knowledge, sets of tools, and profession that is not already addressed by existing discipline or profession" (Spohrer, 2008). This study found strong agreement among the respondents about SSME and none of the respondents questioned the need and relevance of the SSME. However, there were some differences in terms of the priorities and directions for the SSME field in general and curriculum in particular. For an emerging field like SSME, this is a healthy debate and would lead to a more informed and rigorous development of the field.

Shiela Slaughter (2002) in her article *Political Economy of Curriculum-Making in American Universities* concluded, "To implement new curricula successfully, faculty and administrators will have to position programs in the dense web of organizations that surround the disciplines and professions" (p. 282). The SSME curriculum development process also needs to acknowledge the interdependency and interconnectedness of disciplines and stakeholders to produce talent for this evolving service economy.

According to Maglio & Spohrer (2008) “service systems engage in knowledge-based interactions to co-create value, meaning that advances in service innovation are only possible when a service system has information about the capabilities and the needs of its clients, its competitors, and itself” (p. 19). They add that service innovation and improvement of service systems requires development of provider side competence. Consequently, it is critical to understand and cultivate the relevant competencies for a service scientist or a T-shaped professional, who may innovate and improve the service systems.

The term knowledge worker was coined by Peter Drucker in 1959 “to describe people who add value to their organization through their ability to process existing information to create new information which could be exploited to define and solve problems” (Cheese, Thomas & Craig, 2008, p. 41). With the change in the “knowledge” and the context of the “work”, there is a need for a new professional to address the challenges of service productivity and innovation. The T-shaped competency model developed in this study, explicates the characteristics of a service scientist and the proposed curriculum blueprint aids in developing the required competencies. To conclude, the competency-based curriculum presented in this study adds to the theoretical and conceptual foundations for developing professionals who will lead innovation and productivity improvement in the service economy.

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Appendices

Appendix A

Round 1 Email Invitation

Dear _____,

I am writing to you with reference to my Ph.D. dissertation that aims to develop a competency-based curriculum for a master's program in Service Science, Management and Engineering (SSME).

I am inviting you to participate in this study as you are an experienced professional engaged with the emerging field of SSME. Your expertise and knowledge will provide valuable insights and information for the study and in turn will contribute towards the advancement and development of SSME. The results of this study will aid universities in developing new programs and aligning existing programs for preparing competent service scientists.

The study comprises of three rounds of the Delphi survey to identify, prioritize and describe competencies with the courses for the SSME curricula. Each round of survey would not take more than 20 minutes of your time. You are provided 10 days time to respond to the survey. The entire process will be completed in approximately eight weeks. The success and validity of the Delphi study is highly dependent on the "expertise" of the panel and response rate at each round.

Attached with this email is Round 1 survey as Excel sheet. I request your participation in the study by filling the survey and sending it back to me via e-mail at rahul.choudaha@du.edu by <date>.

Participation in this study is strictly voluntary and your responses are confidential. The risks associated with this study are minimal. If, however, you experience discomfort you may discontinue your participation at any time. I respect your right to choose not to answer any questions that may make you feel uncomfortable. Refusal to participate or withdrawal from participation will involve no penalty or loss of benefits to which you are otherwise entitled. Your return of this survey will imply your consent to participate in the study.

If you have any concerns or complaints about how you were treated during the study, please contact Dr. Susan Sadler, Chair, Institutional Review Board for the Protection of Human Subjects, at (303) 871-3454 or Sylk Sotto-Santiago, Office of Sponsored Programs at (303) 871-4052 or write to either at the University of Denver, Office of

Sponsored Programs, 2199 S. University Blvd., Denver, CO 80208-2121. This study was approved by the University of Denver's Institutional Review Board for the Protection of Human Subjects in Research on June 10, 2008.

I understand that as a senior professional there are multiple demands on your time, and I sincerely appreciate your time and contribution. If you have any questions or concerns about the study please feel free to contact me at rahul.choudaha@du.edu or 1-720-314-0586. Thank you for your time, expertise and support. I look forward to receiving your Round 1 survey response.

Sincerely,

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Appendix B

Round 1 Delphi Survey

Delphi Survey Round 1: Identification of competencies and courses for a master's level program in SSME.

The Delphi survey allows for group communication among experts using feedback mechanism, multiple rounds, and anonymity of participants. This study will consist of three rounds of survey--Round 1 (Identification), Round 2 (Prioritization), and Round 3 (Description). Each round would not take more than 20 minutes of your time. Round 2 survey will be designed based on responses received from this Round 1.

This is Round 1 of survey and consists of three parts. Please read the instructions for each part and indicate your responses. Once you have completed the survey, save the file and email it to rahul.choudaha@du.edu . I appreciate your time and expertise in participating in this study.

	PART-I Participant Profile:	
1	Full Name (First, Middle, Last)	
2	Title	
3	Organization	
4	Email address	
5	Profession (select from drop down)	
6	Professional experience in years (select from drop down)	
7	Primary disciplinary expertise (select from drop down)	
8	Highest educational degree (select from drop down)	

PART-II: Competencies

- Please rate the importance of the competencies required for a graduate of master's level program in SSME from drop down options. In other words, identify and rate the competencies that a "service scientist" is expected to exhibit for superior performance.
- You are encouraged to describe the competency with example or add comments/reasons for assigning particular rating to the competency. There is no restriction of word limit. Please add any overall/general comments at the bottom of the green table.
- You may also suggest additional competencies in the space provided at the bottom of the green table. Incase, you wish to modify an existing competency, please type the modified competency and its rationale under "description" column.

	Competencies	**Rating**	**Description/Comments/Reasons**
1	Ability to design a service system, component, or process	(4) Very Important	
2	Information management	(3) Important	
3	Technology application	(2) Somewhat Important	
4	Model building and analysis	(1) Not Important	
5	Market and user needs assessment		
6	Manage risk and uncertainty		
7	Ability to learn new technology		
8	Project Management		
9	Knowledge of contemporary sociopolitical and economical issues		
10	Business and Technology Integration		
11	Demonstrate disciplinary knowledge in engineering		
12	Demonstrate disciplinary knowledge in management		
13	Recognize characteristics of knowledge-based service economy		
14	Integrate engineering and management disciplines for solving service problems		
15	Critical thinking		
16	Demonstrate 'big picture' system based problem-solving approach		
17	Process analysis		
18	Engage in life-long learning		
19	Collaborate with subject-matter expert		
20	Ability to work in interdisciplinary teams		
21	Ability to work with global teams		
22	Cost effectiveness and efficiency orientation		
23	Demonstrate effective interpersonal communication skills		
24	**Add Competency 1**		
25	**Add Competency 2**		
26	**Add Competency 3**		
27	***Overall Comments about Competencies:***		

PART-III: Courses/Content Domains

- Please rate the importance of the courses or content domains that may develop the most important competencies required for a graduate of the master's level program in SSME from drop down options. In other words, identify and rate the content domains that an ideal SSME program at the master's level should include.
- You are encouraged to describe the course with example or add comments/reasons for assigning particular rating to the courses. There is no restriction of word limit. Please add any overall/general comments at the bottom of the yellow table.
- You may also suggest additional courses/content domains in the space provided at the bottom of the yellow table. Incase, you wish to modify an existing course, please type the modified course and its rationale under "description" column.

	Course Titles	**Rating**	**Description/Comments/Reasons**
1	The Information and Services Economy		
2	Modeling and Simulation		
3	Network Services and Systems		
4	Project Management		
5	Quality Management		
6	Service Engineering		
7	Service Operations and Supply Chain		
8	Service Design		
9	Services Innovation Management		
10	Statistical Methods		
11	Market Analytics		
12	Economics of Service		
13	E-Commerce/Database Marketing		
14	Forecasting and Demand Modeling		
15	Business and Technology Integration		
16	Customer Relationship Management		
17	Datamining		
18	Technology Management		
19	Knowledge Management		
20	Service Marketing		
21	Financial Management		

22	Management Science		
23	Strategic Management		
24	Organizational Behavior		
25	Consumer Behavior		
26	**Add Course 1**		
27	**Add Course 2**		
28	**Add Course 3**		
30	***Overall Comments about Courses:***		
	Please email the completed survey to ***rahul.choudaha@du.edu***		

Appendix C

Round 2 Email Invitation

Dear_____

Thank you for participating in Round 1 the Delphi study on competency-based curriculum development for the master's level program in Service Science, Management and Engineering (SSME).

Attached with this email is Round 2 survey and I request your continued participation in the study by filling the survey and sending it to me via e-mail at rahul.choudaha@du.edu by <date>.

The purpose of this Round 2 survey is to prioritize the competencies and courses and arrive at a consensus. Based on the responses and comments received from 51 participants in Round 1 survey, I have reported descriptive statistics like mean and standard deviation along with percentage of respondents rating a particular competency or course as 3 or 4 on a four-point scale. It includes your individual response and the response of the panel. In light of this information, you are requested to re-rate the competencies and courses. You are encouraged to provide reasons for retaining or revising any of the ratings.

If you have any questions or concerns about the study or survey please feel free to contact me at rahul.choudaha@du.edu or 1-720-314-0586. Thank you for your time, expertise and support. I look forward to your response.

Sincerely,
Rahul Choudaha (B.Engg., MBA)
Ph.D. Candidate in Higher Education
University of Denver
2390 S. University Blvd. #102
Denver CO 80210
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1-720-314-0586

Appendix D

Round 2 Delphi Survey

Delphi Survey Round 2: Prioritization of competencies and courses for a master's level program in SSME.
This is Round 2 of Delphi survey and consists of two parts. The purpose of this round is to incorporate the feedback received in Round 1 survey and prioritize the competencies and courses to be included in the master's level program. Please read the instructions given below to indicate your responses. Once you have completed the survey, save the file and kindly email it to rahul.choudaha@du.edu. Your continued participation is very critical for the validity of this study and setting future directions for SSME. I appreciate your time and expertise.

Instructions:

- Given below are the Competencies (Part-1) and Courses (Part-2) along with your individual rating and the statistical summary of responses by the panel from Round 1.
- Competencies and Courses highlighted in Red (No. 4, 9, 12, 14, 16, 24, and 25) indicate that they have been modified from Round 1 or added as new competencies/courses.
- Competencies and Courses are sorted by % of participants rating them as 3 (Important) or 4 (Very Important).
- Please re-rate the importance of the competencies and courses required for a master's level program in SSME from drop down options under the column "Your R2 Rating."
- Feel free to revise or retain your responses from the Round 1 in the context of the rating by the panel.
- You are requested to add comments or reasons for assigning particular rating to the competencies/courses. There is no restriction of word limit.

PART-I: Competencies		**Panel R1 (Mean)**	**Panel R1 (Std. Dev.)**	**Panel R1 (% 3/4)**	**Your R1 Rating**	**Your R2 Rating**	**Comments/ Reasons**
1	Integrate engineering and management disciplines for solving service problems	3.56	0.66	96%			
2	Ability to design a service system, component, or process	3.73	0.65	93%			
3	Ability to work in interdisciplinary teams	3.58	0.62	93%			
4	Apply systems based problem-solving approach	3.38	0.72	91%			

5	Demonstrate effective interpersonal communication skills	3.24	0.74	87%			
6	Business and Technology Integration	3.33	0.83	87%			
7	Critical thinking	3.38	0.81	84%			
8	Market and user needs assessment	3.22	0.79	82%			
9	Information and technology management	3.00	0.74	78%			
10	Model building and analysis	2.89	0.93	73%			
11	Recognize characteristics of knowledge-based service economy	3.09	0.92	71%			
12	Process analysis and design	2.93	0.84	71%			
13	Collaborate with subject-matter expert	2.98	0.81	71%			
14	Ability to work with global, multicultural teams	2.93	0.89	71%			
15	Demonstrate disciplinary knowledge in management	2.91	0.73	69%			
16	Adaptability to unfamiliar situations, uncertainty, and complexity	2.76	0.74	62%			
17	Project Management	2.82	0.81	62%			
18	Ability to learn new technology	2.73	0.86	60%			
19	Cost effectiveness and efficiency orientation	2.60	0.78	60%			
20	Demonstrate disciplinary knowledge in engineering	2.64	0.86	58%			
21	Technology application	2.67	0.74	56%			
22	Engage in life-long learning	2.58	0.87	56%			
23	Knowledge of contemporary sociopolitical and economical issues	2.59	0.90	49%			
24	Assess and learn from best and worst practices in services	NEW ADDED					
25	Complex communication involving interacting and persuading people	NEW ADDED					
	Overall Comments about Competencies:						

PART-II: Courses/Content Domains		Panel R1 (Mean)	Panel R1 (Std. Dev.)	Panel R1 (% 3/4)	Your R1 Rating	Your R2 Rating	Comments/ Reasons
1	Service Design	3.50	0.73	89%			
2	Service Engineering	3.25	0.89	82%			
3	Service Operations and Supply Chain	3.25	0.78	82%			
4	Service Innovation	3.18	0.90	80%			
5	Business and Technology Integration	3.25	0.94	78%			
6	Leadership and Organizational Behavior	3.11	0.72	78%			
7	The Information and Services Economy	3.34	0.89	76%			
8	Consumer Behavior	3.09	0.72	76%			
9	Quality Management	2.98	0.76	73%			
10	Enterprise Systems	3.02	0.90	73%			
11	Project Management	2.93	0.82	71%			
12	Economics of Service	2.93	0.76	71%			
13	Business Process Modeling	2.95	0.83	67%			
14	Knowledge Management	2.91	0.80	67%			
15	Service Marketing	2.98	0.95	67%			
16	Strategic Management	2.91	0.91	67%			
17	Network Services and Systems	2.89	0.92	64%			
18	Technology Management	2.75	0.84	58%			
19	Decision Analytics and Business Intelligence	2.57	0.82	53%			
20	Financial Management	2.45	0.82	51%			
21	Statistical Methods	2.64	0.89	49%			
22	Forecasting and Demand Modeling	2.56	0.85	44%			
23	Management Science	2.55	0.85	44%			
24	Datamining	2.35	0.75	40%			
25	E-Commerce/Database Marketing	2.09	0.83	29%			
26	International Business	NEW ADDED					
27	Web services	NEW ADDED					
28	Financial and Managerial Accounting	NEW ADDED					
	Overall Comments about Courses:						

Appendix E

Round 3 Email Invitation

Dear_____

Thank you for participating in the Delphi study on competency-based curriculum development for the master's level program in Service Science, Management and Engineering (SSME).

Attached with this email is the Round 3 survey and I request your continued participation in the study by filling the survey and sending it to me via e-mail at rahul.choudaha@du.edu by <date>.

The purpose of this final round is to provide depth and details to the top competencies and courses prioritized from previous two rounds. Specifically, I am asking you to rate your agreement with the definition/description of the competencies and courses identified, and provide your suggestions for making them more relevant.

Based on the responses and comments received from 40 respondents in the Round 2 survey, I have reported top competencies and courses that have been identified as "important" or "very important" by at least 75% of the respondents.

I sincerely appreciate your time and contribution despite your busy schedule. If you have any questions or concerns about the study or survey please feel free to contact me at rahul.choudaha@du.edu or 1-720-314-0586. I look forward to your response.

Sincerely,
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1-720-314-0586

Appendix F

Round 3 Delphi Survey

Delphi Survey Round 3: Defining competencies and courses for a master's level program in SSME.
This is Round 3 (final round) of the Delphi survey and consists of two parts (competencies and courses). Once you have completed the survey, save the file and email it to rahul.choudaha@du.edu .
In this round of survey, I am asking you to respond on two primary aspects:
1) Rate your degree of agreement with the definition of competencies/description of courses on a scale of 1-4 (1-Strongly disagree to 4-Strongly agree) from the drop-down menu.
2) Provide suggestions and comments for improving the relevancy and inclusiveness of each definition/description.

PART-I: Competencies

- Expected output: Competency model for a service scientist.
- Given below are the top 10 competencies identified and prioritized by the panel from previous two rounds.

Competency	**Competency Definition**	**Rating of Definition**	**Suggestions for Changes**
Category: Service Mindset	An orientation towards service innovation and productivity improvement, facilitated by the ability to holistically solve problems by assessing needs, contextualizing service science and conceptualizing service systems.	(4) Strongly Agree	
Problem-solving	Exhibits a holistic system based approach in identifying, prioritizing, and solving problem. The ability to assess interrelationships of various facets of the problem including technical, managerial, or interpersonal. The ability to ask the right questions and propose alternative solutions.	(3) Agree	
Needs assessment	Understands the value of identifying and fulfilling customer needs and its implications on long term success of the service organization. Works to understand the market needs for opportunity spotting and customer needs for value creation. Contributes towards creating positive interactions between the customer and the organization.	(2) Disagree	
Contextualize service science	Demonstrates a deep and wide understanding of the characteristics of service economy and the context of service science. Understands relevant theories, literature, and philosophies on which to base informed professional practice of service scientist.	(1) Strongly Disagree	

Conceptualize service system	The ability to conceptualize, design and implement service system using specialized tools and techniques. Demonstrates expertise in configuring service systems for making appropriate technical and managerial decisions.		
Category:Integrative Competence	The ability to integrate ideas, concepts, and strategies emerging as a result of interaction among disciplines, people, and business processes.		
Interdisciplinary collaboration	Integrates disciplinary foundations from engineering and management to scientifically solve service problems. Collaborates with subject-matter experts to understand business implications and conveys it to a different set of audience. Functions as a cross-functional liaison and effectively coordinates across stakeholders.		
Diversity orientation	The ability to collaborate and communicate with a diverse set of people in a global and local context. Appreciates differences in cultural perspectives and communication styles and adapts to work towards common goal.		
Business and technology integration	Identifies and prioritizes information needed to conceptualize the situation and seeks that information from appropriate sources. Integrates information from a number of technical sources and applies the information for improving business operations.		
Category: Meta-competence	The ability to locate, analyze, and adapt existing competencies depending on the contexts and complexities. Meta-competence includes generic capacities like adaptability, critical thinking, and interpersonal communication.		
Adaptability	Adaptability to unfamiliar situations, uncertainty, and complexity. Ability to innovate and reconceptualize problems in response to changing demands and risks.		
Critical thinking	Exhibits inductive and deductive thinking process of analyzing, evaluating, and constructing information and situations. Ability to critically review components of service systems and determine its implications on innovation and productivity improvement.		
Interpersonal communication	Demonstrates capacity to effectively interact with a variety of individuals and groups to facilitate communication in both oral and written forms using multiple channels. Possesses interactional expertise to communicate across disciplinary, geographical and cultural barriers.		
Overall Comments about Competencies:			

PART-II: Courses

- Expected output: Blueprint of a Master's program in SSME (1 -year MS program, 10 courses + capstone).
- Given below are the top courses identified and prioritized by the panel from previous two rounds.

Course	Course Description	Rating of Definition	Suggestions for changes
Category: Contextual Foundation	This is the required set of courses that focus on providing contextual foundations in understanding customers, organizations, processes, and external environment.		
Information & Service Economy	Presents characteristics and concepts related to the service economy from social, economic, technological, legal and global perspectives. Aims at understanding of the uniqueness of the service economy at the interface of information technology and globalization and its influence on service organizations.		
Leadership & Organizational Behavior	Focuses on theory and practice of leadership development for building efficient and innovate service organizations. Provides overview of organizational behavior and its relationship with leadership and teamwork.		
Consumer Behavior	Provides a framework for analyzing consumer behavior for offering superior services. Discusses concepts of marketing research and data driven decision making.		
Project Management	Presents the role of contracts and service level agreements in project management. Discusses tools and techniques for various stages of project management. Emphasizes the importance of resource management and organization design in effective project management.		
Category: Service Core	This is the required set of courses that focus on developing expertise in the domain of service science. It develops competence in innovating and improving service systems using specialized theory, concepts, and techniques.		
Service Design	Explores the process service design within the given business constraints and objectives. Aims at developing skills to integrate user needs, define functionality, and design service system. Uses tools and techniques for conceiving, designing and prototyping a service blueprint.		
Service Operations and Supply Chain	Explores the difference between service and manufacturing operations. Develops the distinct set of skills and tools required in designing, planning and managing service supply chains.		
Service Innovation	Covers approaches to infuse innovative thinking into organizations for identifying opportunities and creating new service solutions. Emphasizes systematic, integrated and holistic approach to conceive, create, launch, and support innovative service solutions.		

Category: Engineering Concentration	This is the set of courses for students with engineering background who are aiming to become experts in design, engineering, and process aspects of service science.		
Service Engineering	Focuses on translation of business needs into technical elements to achieve optimum performance from the service system. Provides an overview of web services, and network systems and services.		
Business Process Modeling	Examines theory, practice and tools of business process modeling. Emphasizes problem formulation, model building, and data analysis for improving processes in service systems.		
Quality Management	Investigates the underlying management and engineering principles of quality management and its applications for service systems. Focuses on process and productivity improvement.		
Category: Management Concentration	This is the set of courses for students with non-engineering background who are aiming to become experts in innovation, customer, and management aspects of service science.		
Service Marketing	Builds upon the course on Consumer Behavior and examines the marketing and managerial approaches for service offerings. Presents concepts and cases of service marketing including branding and pricing. Provides overview to customer relationship management and e-marketing.		
Strategic Management	Explores strategic management for service organizations, with focus on industry structure and organizational capabilities, issues of strategic change, and relationship between implementation and performance. Introduces frameworks and methodologies for strategy formulation and implementation.		
Enterprise Systems	Presents concepts and practices of enterprise wide systems and applications in managing service organizations. Investigates the challenges and opportunities in implementing and managing enterprise systems. Emphasizes the role of strategic alignment between business processes and IT architecture.		
Category: Integrative Capstone	Business and Technology Integration: This capstone course aims at providing a real-life experience for students to integrate their learning from foundational, core, and concentration courses. Engages students to conceptualize, and solve a service science issue with an organization and provide appropriate recommendations. Emphasizes interdisciplinary team work, use of theories and tools learned, and application of competencies developed through out the curriculum.		
Overall Comments about Courses:			

VITA

Rahul Choudaha
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Education :

Ph.D. (Higher Education)	Nov'08
Morgridge College of Education, University of Denver, USA	www.du.edu
MBA (Post Graduate Diploma in Industrial Management)	May'02
National Institute of Industrial Engineering (NITIE), Mumbai, India	www.nitie.edu
Bachelor of Engineering (Electronics & Telecom)	July'99
Government Engineering College, Jabalpur, India	www.jec-jabalpur.org

Work Experience in Education Sector:

Associate Director (Innovation & Development)	09/08 – Present
World Education Services, New York, USA	www.wes.org
Graduate Teaching Assistant	09/06 – 06/08
Morgridge College of Education, University of Denver, USA	www.du.edu
Manager - Admissions	09/04 - 08/06
Indian School of Business (ISB), Hyderabad, India	www.isb.edu
Associate Vice President	05/03 - 09/04
International College of Financial Planning, Mumbai, India	www.icfpindia.org

Honors, Awards & Grants:

NAGAP Enrollment Management Research Grant ($2500)	2008-09
Pat McCartney Research Merit Award ($5,500 joint award by McREL and DU).	2006-07
Outstanding Doctoral Student, HESA, University of Denver	2007-08
International Graduate Student Ambassador for Leadership, University of Denver	2006-07
Morgridge College of Education Dean's Scholarship	2006-08
Graduate Studies Doctoral Fellowship, University of Denver	2006-07
Member, International Relations Committee, NAGAP	2008-10
On-site Chair, NAGAP Annual Conference 2008, Denver CO.	2007-08

Selected Presentations & Papers:

• 'Embracing the connection between signals and strategies: Envisioning new theory and practice of recruiting graduate students of color' (with Dr. Frank Tuitt & Stephanie Krusemark), ASHE Annual Conference 2008, Jacksonville, FL.
•'Open my eyes to the new world: 3I's framework for higher education curriculum' at HGSE SRC, Harvard University, 2008.
• 'TIE it together for the new world: Innovation in doctoral programs in higher education', CAHEP, ASHE Annual Conference 2007, Louisville, KY.
• 'Service encounters with international students: Can America win the war for talent?' International Forum, ASHE Annual Conference 2007, Louisville, KY.
• 'Adding an Indonesia to India: Sustaining the recruitment momentum' on IIE Network 2008.
• 'Partnering for global success: Case of Asian business schools' on IIE Network, 2007.
• 'Moving from quantity to quality: Aligning strategies for attracting Indian talent' (with Shevanti Narayan) at NAGAP Annual Conference 2008, Denver CO.