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Core curricular elements of effective undergraduate technology management academic programs

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CORE CURRICULAR ELEMENTS OF EFFECTIVE UNDERGRADUATE TECHNOLOGY MANAGEMENT ACADEMIC PROGRAMS

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DEDICATION

This work is dedicated to my sons, Christopher and Zachary Smilo. Mere words cannot express the depth of my love for you both. I thank God for the opportunity and privilege of being your mother.

ABSTRACT

Technology management skills have become increasingly important to employers in today's rapidly changing technological environment; yet a scarcity of research exists regarding desired core competencies of undergraduate technology management majors. The purpose of this study was to determine the core curricular elements of an effective undergraduate technology management academic program.

A quantitative mixed-mode (Internet-based and paper-based) survey design using a 5-point Likert rating (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree) was used to solicit opinions from members of the sample population regarding core curricular elements of effective undergraduate technology management programs. Implementation of this research project included the following 5 phases: (a) identification of the sample population, (b) selection of survey software, (c) survey instrument design and pilot testing, (d) data gathering, and (e) data analysis. This exploratory descriptive study employed purposive expert sampling of 180 people with technology management expertise in four industry sectors (i.e., business services, education, government, and manufacturing); in addition, 18 executive board members of the Michigan Economic Development Corporation and 30 members of the Southern Wayne County Chamber of Commerce were queried.

Information regarding the relative perceived importance of each of the following eight core technology management competency areas was sought: (a) strategic management of technology, (b) management of innovation and product development, (c) management of technological change, (d) management of organizational change, (e) project management, (f) assessment and evaluation of technology, (g) quality management of technology, and (h) information and knowledge management. Significance was determined at the .05 level.

Key words: technology management, technology management education, undergraduate technology management, management of technological change, core competencies, employer assessment, survey methodology, electronic surveys, management of technology

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CHAPTER 1: INTRODUCTION AND BACKGROUND

Rapid technological change is occurring in all areas of business and industry; as Thamhain (2005) observed, "The magnitude and speed of technological advances over the past decades are stunning, reshaping our world and influencing virtually every aspect of life...as technology crosses virtually all levels and all disciplines of an enterprise" (p. xi). Technological progress is credited with generating approximately half of the economic growth seen in the U.S. in the last 50 years (U.S. National Science and Technology Council, Office of Technology Policy [NSTC], 1996, p. 1). Participants in a U.S. National Science Foundation-sponsored workshop, *Management of Technology: The Drivers of Technological Changes in the Twenty First Century,* recognized the necessity of technology management education ensuing from the occurrence of rapid technological change (Khalil & Yanez, 2006). The relentless changing of the technological arena has resulted in a pressing need for qualified employees who have technical, scientific, and professional skills, with employment growth projections of 28.4% and 1.9 million new jobs in these areas expected by 2014 (U.S. Department of Labor, Bureau of Labor Statistics, 2005).

Technology is the foundational basis of economic growth and competitiveness in all industrialized nations (U.S. National Science and Technology Council, 1996), and "technological change and globalization have increased the demand for higher-level skills" (Council for Adult and Experiential Learning, 2008, p. 18). Higher education is considered an essential component of state economic development initiatives in preparing a workforce for the "New Economy," which is now based on successful application of technology in all areas (Burke, 2003). Even in 1987, Herink et al. noted that management of the technologies used in business and industry was necessary for continued economic development. This situation is still true today, with growth projections of 60.5% in management, scientific, and technical consulting services being driven “by the increased use of new technology and computer software and the growing complexity of business” (U.S. Department of Labor, Bureau of Labor Statistics, 2005, para. 3).

The economy in the United States is driven by an educated workforce (National Commission on Adult Literacy, 2008). “The need for a useful and usable education has been a theme in American public policy at least since the launching of the land grant universities with the Morrill Act of 1862” (Kirp, 2003, p. 3). Career-focused educational programs that prepare graduates for productive positions in the workforce make up more than 60% of the baccalaureate degrees awarded (U.S. Department of Education, National Center for Education Statistics, 2005). Coordinators of educational programs in technology management seek to develop the necessary competencies required of program graduates by employers (Klingenberg & Lauria, 2007; Nambisan & Wilemon, 2004).

The hiring of employees with baccalaureate degrees is projected to increase, with almost 60% of companies expecting to increase hiring of these graduates (Casner-Lotto, & Barrington, 2006, p. 11). Enrollment in undergraduate and graduate programs is also anticipated to continue to increase during the next 10 years (U.S. Department of Education, National Center for Education Statistics, 2007). The fastest-growing area in higher education has been at the community college level (American Council on Education, 2004), where many students are considered nontraditional adult learners (Council for Adult and Experiential Learning, 2008). Because the fastest-growing occupations will require some post-secondary education, scores of adult learners are returning to the classroom to update their skills and increase their opportunities for gainful employment (Council for Adult and Experiential Learning, 2008). Graduates of technically focused associate degree programs may continue their education at the baccalaureate degree level and gain competencies sought by employers by pursuing educational programs in technology management. Most 72% (or 13) undergraduate technology management programs accept transfer credit from community colleges (Becker, 2007).

Widespread agreement exists on the need for technology management education (Badawy, 2004; Khalil & Yanez, 2006; van Wyk, 2004). Nambisan and Wilemon (2002) stressed that:

> university graduates who can operate effectively across the boundaries of engineering, science and business often have career opportunities superior to those not adept at extending themselves beyond their primary professional or technical domain. Indeed, new skills and knowledge in technology management are called for as companies and markets require managers to perceive and understand how the various technologies can provide the productive/competitive capabilities to the businesses (p. 108).

Researchers debate the formation dates of the technology management discipline (Chanaron & Jolly, 1999; Daim, Jetter, Kocaoglu, Maglio, & Demirkan, 2007; Fortino, 2006; Klingenberg & Lauria, 2007), yet strong evidence of high growth in the establishment of technology management programs during the 1990s and into the 21st century has been put forth by Kocaoglu, Sarihan, Sudrajat, and Hernandez (2003). Undergraduate technology management programs did not come into existence until after

1987, though some undergraduate courses were taught in the discipline prior to this date (Herink, et al., 1987).

Professor van Wyk (2004) stressed that a "*compelling need* for technologically informed management" (p. 5) exists resulting "from a significant gap in traditional management theory" (p. 5). Badawy (1998) concurred and identified these five contributing factors:

1. the necessity of understanding the complex problems of managing technology
2. the critical need for a broad vision of technology as an integral link in corporate strategy
3. managing technological innovation as a top-management responsibility
4. the context and core competence of technology-based organizations
5. the unique characteristics of the technical professional (p. 99).

The majority of the research on technology management education focuses on graduate-level studies (Badawy, 1998; Nambisan & Wilemon, 2002; van Wyk, 2004; Yanez, 2006; Yanez & Khalil, 2007). Nambisan and Wilemon (2003) noted that there has been an almost exclusive focus on technology management programs at the graduate level and went on to state "given the increasing demand for technology professionals in all areas of the society...we will need to start examining how technology management education can be incorporated at the undergraduate level too" (p. 962). Research at this level is becoming increasingly important as undergraduate technology management programs continue to be established to meet the needs of society and now make up more than 20% of all programs offered in this field (Becker, 2007, Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003).

Several of these researchers (i.e., Alvear, Rueda, Hernandez, Kocaoglu, 2006; Khalil & Yanez, 2006; van Wyk, 2004; Yanez, 2006) are attempting to define a body of knowledge for the technology management discipline. Much of this research has examined existing programs (Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003, Nambisan & Wilemon) and has been conducted under the auspices of professional associations in the technology management field, such as the International Association of Management of Technology (IAMOT; Yanez, 2006) and the Portland International Center for Engineering and Technology Management (PICMET; Kocaoglu et al., 2003).

Various approaches to curriculum development of technology management programs have been employed (Badawy, 1998; Klingenberg & Rothberg, 2006; Nambisan & Wilemon, 2002; van Wyk, 2004). Courses in these technology management programs could be grouped into four areas: (a) technology management, (b) corporate functionality, (c) technology specific, and (d) foundational. The core curriculum (technology management courses) included course titles such as change management, fundamentals of technology management, project management, and innovation management (Badawy, 1998; Becker, 2007; Hauck, 1999; Herink et al., 1987; Klingenberg & Rothberg, 2006; Nambisan & Wilemon, 2002; van Wyk, 2004; and Yanez, 2006).

The inclusion of the needs of industry when designing the curriculum for technology management programs is of the utmost importance (Nambisan & Wilemon, 2004). Programs in technology management are career-focused, and graduates of technology management programs should have competencies in areas that are deemed important by employers. This researcher found no studies that specifically focused on determining the needs of employers in the development of curricular programs in technology management; however, Yanez's study (2006) did focus on management of technology stakeholders who were members of IAMOT, including some industry members. As Nambisan and Wilemon (2004) emphasized, there is a critical need for increased involvement of industry in the curriculum development of technology management programs to help the discipline continue to grow and have greater relevance.

Very little information is available about the undergraduate aspect of technology management education, yet more than 20% of engineering management and technology management programs are offered at the undergraduate level (Becker, 2007; Kocaoglu et al., 2003). Moreover, Fortino (2006) suggested that the number of academic technology management programs at this level will continue to accelerate. Therefore, the need for accurate information about core curricular elements of undergraduate technology management programs is critical for program development and improvement.

Statement of the Problem

Employment positions requiring technology management skills are projected to continue to grow through 2014 (U.S. Department of Labor, Bureau of Labor Statistics, 2005); moreover, the number of new programs in technology management is also expected to increase during this time period (Fortino, 2006). Efforts to determine an identified body of knowledge for technology management programs continues (Alvear et al., 2006; Khalil & Yanez, 2006; van Wyk, 2004) and are of critical importance to the discipline (Yanez & Khalil, 2007); in addition, a cohesive, well-defined curriculum is necessary to sustain growth in the field. This need is especially important at the undergraduate level, where more than 20% of technology management programs are offered, and a significant lack of research on core curricular elements is evident.

Purpose of the Study

The primary purpose of this study was to determine the core curricular elements of effective undergraduate technology management academic programs. Specifically, the following four research questions were addressed:

Research Question 1: *What is the relative perceived importance of each of the eight core-competency areas (management of technological change, management of organizational change, project management, assessment and evaluation of technology, quality management of technology, information and knowledge management, innovation and product development, and strategic management of technology) in technology management?*

Research Question 2: *What is the relative perceived level of importance of each item within each of the eight core competency technology management scales?*

Research Question 3: *Do any differences exist between industry sectors (business services, education, government, and manufacturing) and their representatives' perceptions of the relative importance of the eight core competency areas?*

Research Question 4: *Do any differences exist between industry sectors and their representatives' perceptions of the items within each of the core competency areas?*

Significance of the Study

The establishment of a recognized core curriculum is critical for the technology management profession at both the undergraduate and graduate levels. Undergraduate technology management education has largely been ignored by researchers, and the results of this study highlighted the relative importance of undergraduate education in technology management within the profession.

In addition, hopefully, baccalaureate technology management degree holders will be better positioned for employment in well-paying jobs within business and industry if their degree is seen as relevant by prospective employers. The results of this study demonstrate that inclusion of technology management-specific core competencies in undergraduate technology management programs is essential.

Research Methodology

A survey research method was used to solicit responses from the sample population regarding core curricular competencies that should be included in undergraduate technology management programs. The use of surveys in curriculum development and design has been supported by many researchers, including Diamond (1998); Ehie (2002); Grier, (2005); Kung, Yang, & Zhang (2006); and Shin (1999). Rea and Parker (1997) stated that "survey research has derived considerable credibility from its widespread acceptance and use in academic institutions" (pp. 1-2), and Trochim (2001) concurred, affirming that "survey research is one of the most important areas of measurement in applied social research" (p. 107).

Research Design

The following five-phase process was used in this research study: (a) identification of the sample population, (b) selection of the software, (c) development of the survey instrument, (d) data gathering, and (e) data analysis. This exploratory descriptive study used a quantitative mixed-mode (Internet-based and paper-based survey) design. The survey was administered to 228 adult human subjects with expertise in technology management. Specifically, 40 employees in each of the following three industry sectors were asked to participate in this research study: (a) business services (b) education, and (c) manufacturing, as well as 60 employees from the government sector. Additionally, 18 executive board members of the Michigan Economic Development Corporation (MEDC) and 30 members of the Southern Wayne County Regional Chamber of Commerce (SWCCC) were invited to participate. A quantitative analysis of the survey results was completed. The use of a mixed-mode survey provided an additional opportunity for participants to complete the survey if they were reluctant or unwilling to respond to a Web-based survey or if they were unable to respond because of technical difficulties (Dillman, 2007).

A technology management curriculum inventory (TMCI) was developed based on the technology management literature and a review of textbooks used in the technology management discipline. The TMCI provided the basis for the survey instrument development and included the following eight areas: (a) strategic management of technology, (b) management of innovation and product development, (c) management of technological change, (d) management of organizational change, (e) technology project management, (f) assessment and evaluation of technology, (g) quality management of technology, and (h) information and knowledge management. A five-point Likert scale (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree) was used to measure the perceived level of importance respondents had regarding the inclusion of items within the eight areas in an undergraduate technology management program.

An email invitation was sent to survey participants three days before the distribution of the electronic survey. An Internet link included in the letter permitted participants to access the survey, which was developed using Survey Monkey software. A follow-up reminder was sent to survey participants who still had not responded to the survey within one week of receiving the survey, and a second reminder was distributed one week later. In addition to the surveys sent by email, participants from the government sector and members of the SWCCC received a paper-based survey; follow-up reminders were not sent to these participants. Participants from all four industry sectors (i.e., business services, education, government, and manufacturing) responded to the survey, as well as members of the MEDC and the SWCCC. There was an overall response rate of 55.7% (or 127 responses).

Data collected from the paper-based surveys were inputted into Survey Monkey, and then all data were exported into Microsoft Excel and then imported into Statistical Package for the Social Sciences (SPSS) for analysis. Descriptive statistics, including ranges, averages, and measures of central tendencies, were used to analyze data. Cronbach’s alpha was used to determine the reliability of the survey instrument, and statistical significance was determined using a one sample *t* test on the mean of each item. An analysis of variance procedure was used to determine if perceptions of technology management competencies varied by industry sector.

Delimitations of the Study

This study was delimited by its sole focus on undergraduate technology management education programs. In addition, the study was delimited by its attention to undergraduate technology management programs located in the United States versus international technology management undergraduate programs.

Definition of Relevant Terms

The following terms are operationally defined for specific use in this study:

Academic program: The combination of courses required to complete a degree or certificate program in a college or university; this term is also synonymous with the word *major*.

Core competencies: "The knowledge, skills, abilities and behaviors that contribute to an employee's job success" (Casner-Lotto & Barrington, 2006, p. 15).

Core curriculum: Required, discipline-specific courses included in a major or specialized program of study.

Curriculum: The subject matter or content included in an undergraduate technology management program or major.

Discipline: "A set of generalizations that explain the relationships among a body of facts and concepts" (Parkay & Hass, 2000, p. 218-219).

Engineering management: A program that focuses on the application of engineering principles to the planning and operational management of industrial and manufacturing operations and prepares individuals to plan and manage such operations. Includes instruction in accounting, engineering economy, financial management, industrial and human resources management, industrial psychology, management information systems, mathematical modeling and optimization, quality control, operations research, safety and health issues, and environmental programs (CIP code 15.1501: Engineering/Industrial Management, U.S. Department of Education, 2002).

Instructional programs: A combination of courses and experiences designed to accomplish a predetermined objective or set of allied objectives such as preparation for advanced study, qualification for an occupation or range of occupations, or simply the increase of knowledge and understanding (U.S. Department of Education, 2002, p. I-4).

Major: An academic field of study consisting of the courses necessary to complete a degree or certificate program in a college or university; this term is synonymous with “academic program”.

Program: “Any activity or collection of activities of the institution that consumes resources (dollars, people, space, equipment, and time)” (Dickeson, 1999, p. 45); a term frequently referred to as a “major” at the undergraduate level (Ornstein & Hunkins, 2004).

Technology management: “A field of study and a practice concerned with exploring and understanding technology as a corporate resource that determines both the strategic and operational capabilities of the firm in designing and developing products and services for maximum customer satisfaction, corporate productivity, profitability, and competitiveness (Badawy, 1998, p. 105).

Undergraduate program: The combination of courses, including general education requirements and discipline-specific requirements, necessary to complete a baccalaureate degree program at a college or university.

Organization of the Dissertation

This dissertation will be organized into the remaining four chapters: (a) technology management education literature review, (b) methodology, (c) presentation and analysis of data, and (d) summary, conclusions, inferences, and recommendations for further research and action. Chapter 2 will be a review of relevant literature on technology management education, including an overview of the discipline. In the third chapter, a description of the research methodology used in the study will be presented along with information about mixed-method research and the survey development process. The fourth chapter will present and analyze data collected in the study, and in the fifth chapter, the summary, conclusions, inferences, and recommendations for further research and action will be provided.

CHAPTER 2: TECHNOLOGY MANAGEMENT EDUCATION LITERATURE REVIEW

The relevance and need for technology management education have been well established in the past 20 years (Herink et al., 1987; Khalil & Yanez, 2006; van Wyk 2004). Technology management education is continuing to evolve and coalesce, and an identified body of knowledge is emerging at the graduate level (van Wyk, 2004; Yanez, 2006). Yet definitions of technology management still vary (Bellamy, Becker, & Kuwik, 2003; van Wyk, 2004), and a nebulous line of distinction often exists between the disciplines of technology management and engineering management in the minds of some researchers (Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Daim, Jetter, Kocaoglu, Maglio, & Demirkan, 2007). Several professional associations related to the field of technology management have been established in the past two decades (i.e., Engineering and Technology Management Education Research Council, International Association of Management of Technology, Portland International Center for Management of Engineering and Technology, and the Technology Management Education Association). Specialized accrediting bodies such as the Association to Advance Collegiate Schools of Business-International (AACSB International) and the National Association of Industrial Technology (NAIT) are granting professional accreditation to qualified technology management programs, and IAMOT is in the process of becoming an accrediting body for the discipline (IAMOT, 2007). An abundance of professional journals and publications focusing on the field of technology management exists, including the *International Journal of Technology Management*, *Research in Technology Management,* and the *International Journal of Technology and Innovation Management Education.*

More than 20% (Becker, 2007) of the technology management educational programs in the United States are offered at the undergraduate level, and Kocaoglu, Sarihan, Sudrajat, & Hernandez (2003) also found that more than 20% of engineering- and technology management (ETM) programs are offered at this level. Nambisan and Wilemon (2003), however, found that only about 9% of world-wide institutions who responded to their 2003 survey (53 responses from 170 surveys) offered an undergraduate technology management program, while 49% of these institutions offered undergraduate courses in technology management. There is, however, a dearth of research focused on undergraduate technology management education. The following six topics will be discussed in this chapter: (a) societal influences on curriculum, (b) problems in defining technology management, (c) overview of technology management education, (d) differentiation between engineering management programs and technology management programs, (e) the function of professional associations, accrediting agencies, and journals in technology management education, and (f) the current status of undergraduate technology management programs.

Societal Influences on Curriculum

Education is a driving force in the U.S. economy (National Commission on Adult Literacy, 2008). As Ratcliff (1997) noted, “Social conditions exert significant influence on the purpose, organization, and structure of the curriculum....[A]n important emerging social goal for undergraduate education is the transfer of technological knowledge and skill in an effort to further economic development” (p. 17). This goal has assumed an even greater level of importance as half (15 of 30) of the fastest-growing occupations require at least a bachelor’s degree (U.S. Department of Labor, Bureau of Labor

Statistics, 2007). “U.S. society is concerned about the development of human capital and how its investment in students’ education will pay off in terms of productive employment, economic growth, and international competitiveness” (Stark & Lattuca, 1997, p. 357). Technology management programs should be responsive to the needs of businesses and industries, and curriculum in these programs should be designed to meet these needs (Nambisan & Wilemon, 2004). As Dickeson (1999) underscored, programmatic curriculum in higher education is directly tied to societal influences, and the content of academic programs should be responsive to these societal pressures.

The curriculum offered by institutions of higher education is in a state of change, with new academic programs being added in a variety of areas, many of which are a result of technological innovations (U.S. Department of Education, 2002). Increasing complexity, technological change, and the degree of information generated have led to the development of sub-disciplines and specializations within academic fields (Gaff & Ratcliff, 1997). This movement toward increased specialization of the higher education curriculum was evidenced by the addition of approximately 750 new academic programs in the 2000 Classification of Instructional Programs (CIP) compiled by the National Center for Education Statistics (U.S. Department of Education, National Center for Education Statistics, 2002). In fact, 37 new programs with “management” in their titles were added to the CIP in 2000. Revisions to the CIP are infrequent, with revisions occurring in 1985, 1990, and 2000 (U.S. Department of Education, National Center for Education Statistics, 2002). Efforts are currently underway to revise the CIP in 2010 (Coon, June 13, 2008, personal communication). Although a taxonomic code for technology management programs was not included in the 2000 CIP Taxonomy, a proposal for inclusion has been made by both Becker (2007) and the President of IAMOT (Khalil, August 11, 2007, personal communication).

The majority of undergraduate degree programs are in areas that prepare students for gainful employment; more than 60% of bachelor's degrees are awarded in career-education programs (U.S. Department of Education, National Center for Education Statistics, *Trends in Undergraduate Career Education,* 2005). One of the primary goals of a college education is career training (Newman, Couturier, & Scurry, 2004, p. 71), and "external influences, originating in society, operate on collegiate career study programs directly and strongly" (Stark & Lattuca, 1997, p. 163). Academic programs in occupational fields (i.e., business, education, engineering, and nursing) are developed to prepare individuals for productive positions in the workforce (Brint, Riddle, Turk-Bicakci, & Levy, 2005). Jones (2002) affirmed that "ideally, an undergraduate education should provide students with the necessary skills, abilities, attitudes, and values that are critical to successfully navigate the dynamic complexities of the business world" (p. 1). With these words, he emphasized the importance of undergraduate majors obtaining technical knowledge in professional preparation programs.

Technology management education programs were developed in response to external needs originating in society (Badawy, 1998; Herink et al., 1987) and are career-focused programs. Consequently, the undergraduate technology management curriculum has to be responsive to the needs of businesses and industry, and a unified, relevant curriculum must be developed and maintained.

Problems in Defining Technology Management

In a 1986 workshop, the status of research, education, and practice in the management of technology was examined by members of the Task Force on Management of Technology, the Cross-Disciplinary Engineering Research Committee and Manufacturing Studies Board, and the Commission on Engineering and Technical Systems, along with academic and industrial participants. The seminal report, *Management of Technology: The Hidden Competitive Advantage* (Herink et al., 1987), was subsequently produced. In this report, management of technology was defined as linking "engineering, science, and management disciplines to address the planning, development, and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization" (p. 9). With this definition in place, practitioners and academics still cannot agree on a working definition of technology management some two decades later (Bellamy, Becker, & Kuwik, 2003, p. 1). Even in the third version of *A Credo for the Management of Technology (MOT),* van Wyk (2004) stated, "One important feature [that] has not been included, [is] a definition of MOT. We have left this out because of the difficulty of finding common ground" (p. 88). Thamhain (2005) concurred and noted that many definitions for management of technology exist. Yanez (2006) believed that the changing and evolving conditions associated with technology contribute to the changing definition of the discipline. Yet, according to Badawy (1998), MOT can:

> be defined as a field of study and a practice concerned with exploring and understanding technology as a corporate resource that determines both the strategic and operational capabilities of the firm in designing and developing products and

> services for maximum customer satisfaction, corporate productivity, profitability, and competitiveness (p. 105).

In 1987 the drivers of technology management were delineated by Herink et al. in the report *Management of Technology: The Hidden Competitive Advantage.* Environmental factors included increased global competition, rapid technological change, diversification, and decentralization of operations in business and industry. The traditional management functions that affected technology management needs were finance, marketing, research and development, production, and planning. The management of the technology knowledge base was influenced by traditional academic programs such as business, engineering, and social sciences, as well as emerging technology management education programs.

Overview of Technology Management Education

Some debate surrounds the date on which technology management education programs were established, with some researchers (Daim, Jetter, Kocaoglu, Maglio, & Demirkan, 2007) maintaining that academic roots were anchored in the early 1900s. According to Fortino (2006), while the discipline of technology management goes back 40 years, program development has been strong for the last 10 years and is projected to continue with the same or an even greater level of emphasis in the future. Chanaron and Jolly (1999) believed that technology management developed even later (i.e., in the mid-1980s). Technology management education programs were initially established to "enable technology-driven firms link [*sic*] strategic management goals to their technological capabilities and requirements" (Klingenberg & Lauria, 2007, p. 1484). In 1987 no undergraduate programs in technology management were identified, although courses in technology management were offered under the headings of science, technology, and society (Herink et al., 1987).

An undeniable need for technology management education exists (Herink et al., 1987; Khalil & Yanez, 2006; van Wyk, 2004). According to van Wyk (2004), the necessity for technology management education occurred as operations at many companies became technologically intensive and as graduates of traditional management education programs found they were not equipped with the expertise or skills required by employers. These deficits resulted because traditional management programs were functionally based and included study in the standardized disciplines of finance, marketing, and operations instead of any focus on the management of technology (van Wyk, 2004).

While one purpose of the report by Herink et al. (1987) was to identify specific areas (competencies and issues) leaders of effective technology management education programs should address, another purpose was to look at the needs of industry. The issues and responsibilities specific to the management of technology that were identified in the 1987 study included strategic issues (management of innovation, forecasting and assessment, managing for technological change, product conceptualization, design, and support), interfunctional policy issues relating to technology (technology transfer, sociotechnical system design, and the interfaces between marketing, manufacturing, administration, and research and development), and the management of projects, technical professionals, quality, and productivity. The authors also noted that the management and utilization of information systems, technological economics, human resource management, and the ethical and social impact of technology support services should be considered (Herink et al., 1987).

The authors (Herink et al., 1987) also emphasized that "education programs in MOT must be expanded as well as restructured, new programs initiated, and an integrated curriculum developed" (p. 21). Relatively slow growth in the establishment of engineering and technology management programs occurred during the 1980s, but program establishment accelerated after 1990 (Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003). In a comprehensive engineering and technology management study, *Educational Trends in Engineering and Technology Management (ETM;* 2003), personnel in 1,200 academic institutions were contacted and researchers identified the existence of 269 relevant programs internationally (Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003). Much of the published research (i.e., Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Aje, 2005; and Yanez, 2006) in technology management refers to the findings of this ETM study, which combined programs in engineering and technology management. It is important to note that Kocaoglu is the President of PICMET. Institutional representatives from 148 institutions (or approximately 12.3% of those surveyed) responded, representing 211 undergraduate, master's, and doctoral programs. Most of the participating ETM programs (136, or 64.45% of respondents) were offered at the master's level, 44 (20.85%) of the 211 academic programs identified were offered at the baccalaureate level, and 31 (14.69%) were doctoral.

Most technology management programs have been and still are offered at the master's level, and the majority of the literature on the technology management curriculum is dedicated to graduate programs (Badawy, 1998; Klingenberg & Lauria, 2007; Nambisan & Wilemon, 2004; van Wyk, 2004; Yanez & Khalil, 2007). A paucity of information exists on undergraduate technology management education programs, with the finding of only three articles specifically focused on the topic (i.e., Becker, 2007; Gruver & Stamos, Jr., 1997; Hauck, 1999).

Technology management education is an evolving academic discipline (Badawy, 1998), and researchers are attempting to identify a common body of knowledge for the discipline (Khalil & Yanez, 2006; van Wyk, 2004; Yanez, 2006). Several approaches to graduate curriculum development in technology management education have been suggested, including Badawy's (1998) alternative models, van Wyk's (2004) template for graduate programs in the management of technology, Yanez's (2006) body of knowledge for MOT graduate education, Nambisan and Wilemon's (2004) belief that industry involvement in curricular content is critical for technology management programs, and Klingenberg and Lauria's (2007) vision-driven approach to technology management curriculum development. Table 1 shows the major components of the curricular models/approaches to graduate-level technology management education programs.

Table 1

Curricular Models/Approaches to Graduate Technology Management Education

Author	Year	Name of Model/Approach	Curricular Components
Herink et al.	1987	Issues and Responsibilities Specific to Management of Technology	• Strategic Issues • Interfunctional Policy Issues • Research, Development, Operations • Technology Support
Badawy	1998	Alternative Model for Graduate Technology Management Education	• Core Courses/Topics • Foundational Courses/Topics • Elective Courses/Topics
Nambisan & Wilemon	2002	Key Management of Technology Program Themes	• Strategic Technology Management • Innovation Management • Manufacturing • New Product Development
van Wyke	2004	Template for Graduate Programs in the Management of Technology	• Technology-Centered Subjects • Technology-Related Management Procedures • Corporate Functions • Supporting Disciplines
Klingenberg & Rothberg	2006	Vision-Driven Approach	• Core Courses • Strategic Technology Management Track
Yanez	2006	Body of Knowledge Framework for Management of Technology Graduate Education	• Management of Technology-Centered Knowledge • Knowledge of Corporate Functions • Technology-Centered Knowledge • Knowledge of Supporting Disciplines • Special Requirements

Sources: Badawy, 1998; Herink et al., 1987; Klingenberg & Rothberg, 2006; Nambisan & Wilemon, 2002; van Wyk, 2004; Yanez, 2006.

"Because of the evolving nature of the field of MOT, there [were] no established models" (Badawy, 1998, p. 106); therefore, Badawy addressed content, foundational knowledge, and organizational structures in an alternative model for graduate technology management education. Badawy (1998) also recommended that the program be jointly sponsored by faculty members in both business and engineering colleges and that leaders from industry be heavily involved in curricular content and design.

A flexible format for a program of study related to the management of technology was advanced by van Wyk (2004) in a report to the education committee of IAMOT. This format included the following four areas: (a) technology-centered subjects, (b) technology-related management procedures, (c) corporate functions, and (d) supporting disciplines.

Alvear, Rueda, Hernandez, and Kocaoglu's analysis of ETM programs (2006) was based on 2003 ETM study data. This study by Alvear et al. (2006) of ETM programs had a 35% commonality criterion for inclusion of courses in ETM programs. Analysis was completed by the organizational location of the programs in either business schools or engineering schools. Technology management courses taught in both business and engineering schools included strategic planning, creativity management, change management, and technology management. Aje's analysis (2005) of catalog and syllabi content from 148 universities was also based on the institutions whose representatives responded to the ETM study. His analysis showed that none of the most commonly taught ETM courses achieved a 50% commonality criterion, though a course in project management was taught at 49 (33%) institutions, and both information technology and strategic management were taught at 41 (27.7%) institutions, quality management courses were included in 39 programs (26.3%), innovation management in 38 (25.7%) institutions, product development was addressed in 37 (25%) programs, and a course in change management was taught at only 34 institutions (23%).

Nambisan and Wilemon's (2002) global survey of academicians at 123 institutions focused on graduate management of technology programs; their findings were based on 67 responses (54.5% response rate). They found that strategic management, technology strategy, innovation management, and new product development were key in management of technology courses.

A body-of-knowledge framework for MOT was proposed by Yanez (2006). His dissertation research study included two surveys; one (2005) surveyed MOT stakeholders who were members of IAMOT and the members of an electronic newsgroup maintained by the Management of Innovation and New Technology (MINT) Research Centre at McMaster University. This first survey sought opinions of stakeholders regarding validity of the template for MOT graduate programs as a framework for the MOT body of knowledge. This survey was sent to approximately 1,200 people, and 106 responses were received (approximate response rate of 8.8%). Yanez's second survey was also sent to the 1,200 members of IAMOT (2006) and to editorial boards of technology-innovation management and management of technology journals; this survey sought input on the MOT body of knowledge initiative. A total of 129 responses (approximate response rate of 10.8%) to this survey were received; the majority (66%) came from academia and only 27% from industry. Requests to participate in both of these studies were sent by Khalil, President of IAMOT (Yanez, 2006). The proposed MOT body of knowledge framework that resulted from the research included the following five knowledge groups with associated disciplines/courses: (a) management of technology-centered knowledge, (b) knowledge of corporate functions, (c) technology-centered knowledge, (d) special requirements/assignments, and (e) knowledge of supporting disciplines.

Klingenberg and Lauria (2007) recommended a vision-driven approach for course and program development in a technology management master of science program. They viewed the technology management program objectives as ensuing from the program vision, which should be derived from the mission and capabilities of the organization. They, like Badawy (1998), also sought input from industry leaders in developing the program of study components. Industry representatives helped define the skill sets and learning outcomes of the program, which then became program learning objectives. Klingenberg and Rothberg (2006) developed program, skills, knowledge, and ability objectives for a master of science in a technology-management program. Structurally, Klingenberg and Lauria (2007) viewed technology management as a system, with education as the mediator among business, society, and government.

A curriculum reform process was used by Hauck (1999) to develop *A Model Undergraduate Curriculum in Technology Management* at Colorado State University in the Department of Manufacturing Technology and Construction Management. Three majors (construction management, industrial technology management, and technology education and training) were housed in this department. A common core in technology management was developed to "accommodate the objective of emphasizing the common purposes noted for all three programs [and] to establish a common core of departmental requirements" (Hauck, 1999, p. 833). The following six technology management core courses resulted from the integration of research and from departmental faculty discussions: (a) team problem solving and leadership, (b) graphic communications/computer-aided design, (c) trends in energy and transportation, (d) introduction to manufacturing and construction, (e) energy control systems, and (f) materials testing and processing. Gruver and Stamos (1997) promoted the inclusion of a two-summer program for undergraduates majoring in business or engineering, where students spent the time between their sophomore and junior years studying technology management, and during the following summer they completed an internship at selected organizations.

Based on a literature review related to technology management education, these four primary areas surfaced as the ones in which courses/topics should be grouped: (a) technology management, (b) corporate functionality, (c) technology specific, and (d) foundational. Courses related to technology management included innovation management, management of technological change, and strategic management of technology. The corporate functionality area consisted of courses such as accounting, finance, law, and marketing. Technology-specific courses focused on emerging technologies, technical specializations, and technology theory. Foundational courses/topics included quantitative reasoning, communication, and economics among others. See Table 2 for a list of courses/topics related to each primary area of technology management education.

Table 2

Primary Areas and Courses/Topics included in Technology Management Education

Area	**Courses/Topics**
Technology Management Courses/Topics	• Change management • Emerging technology management models • Entrepreneurship • Fundamentals of technology management • Global aspects of technology management • Innovation management • Knowledge management • Leadership in technical organizations • Managing cross-functional teams • Management of information technology • Managing organizational change • Managing product, information, and process technology • New product development • Project management • Quality management • Research and development management • Strategic management of technology • Technology and organizational systems • Technology forecasting • Technology policy
Corporate Functionality Courses/Topics	• Accounting • Business and strategic management • Finance • Information systems policy • Leadership and organizational behavior • Marketing • Operations • Personnel/human resource management • Supply chain management • Systems and information concepts in organizations
Technology-Specific Courses/Topics	• Emerging technologies • Technical/engineering specialty • Technology analysis • Technology theory • Technology transfer
Foundational Courses/Topics	• Communication skills • Computer-based applications and management support systems • Economics • Ethics

	• Problem solving • Quantitative methods • Research methods and statistics

Sources: Afuah, 2003; Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Angus, Gundersen, & Cullinan, 2000; Arnold, & Holler, 1995; Badawy, 1995; Badiru, 1996; Bennett, 1996; Dorf, 1999; Durham, & Kennedy, 1997; Ettlie, 2006; Evans & Lindsay, 2008; Gehani, 1998; Gerwin, & Kolodny, 1992; Haag, Cummings, & McCubbrey, 2005; Haddad, 2002; Hammer, & Champy, 2003; Herink et al., 1987; Hitt, Costa, & Nixon, 1998; Jain, & Triandis, 1997; Katz, 2004; Khalil, 2000; Laudon, & Laudon, 2001; McGrath, 1995; Mintzberg, Lampel, Quinn, & Ghoshal, 2003; Morel-Guimaraes, Khalil, & Hosni, 2005; Narayanan, 2001; Porter, Roper, Mason, Rossini, & Banks, 1991; Rosenau, Jr., 1992; Sherif, & Khalil, 2007; Thamhain, 2005; Tushman, & Anderson, 2004; Van Wyk, 2004; Warren, 2002; Yanez, 2006; Yanez & Khalil, 2007.

In addition, the increased use of information-based technologies has influenced the organizational structure of many higher education institutions, with more than half of all postsecondary institutions now offering distance-education courses (U.S. Department of Education, National Center for Education Statistics, 2005). Alvear, Rueda, Hernandez, & Kocaoglu (2006) reported that 36% of ETM programs use Web-based course delivery formats in conjunction with classroom teaching. Yet “academic institutions are still slow in embracing change both in curricula and in methods of delivery of education” (Khalil, 2001, p. 16).

Differentiation between Engineering Management Programs and Technology Management Programs

Technology management and engineering management are sometimes considered to be the same field (Alvear et al., 2006; Daim et al., 2007); although Herink et al. (1987) agreed that similarities exist between the two fields, they maintained that “engineering management is not the same as technology management” (p. 12). Nambisan and Wilemon (2003) concurred and noted that the distinction between technology management and engineering management is becoming progressively apparent. Thamhain (2005) posited that engineering management is a subset of technology management, while Badawy (1998) supposed that engineering management is narrower in scope than technology management and that engineering management is primarily concerned with the management of the engineering function. The American Society for Engineering Management (ASEM; 2007) defined engineering management as:

> the art and science of planning, organizing, allocating resources, and directing and controlling activities which have a technological component.... Engineering managers are distinguished from other managers by the fact that they possess both an ability to apply engineering principles and a skill in organizing and directing technical projects and people in technical jobs (p. 1).

Problems in defining distinct technology management degree programs, at both the undergraduate and graduate levels, have primarily resulted from the lack of a code for technology management programs in the taxonomic scheme developed and used by the U.S. Department of Education's National Center for Education Statistics (NCES) in the CIP. Most technology management program coordinators use the combined CIP code (15.1501) for engineering/industrial management programs, which defines these programs as follows:

> A program that focuses on the application of engineering principles to the planning and operational management of industrial and manufacturing operations, and prepares individuals to plan and manage such operations. Includes instruction in accounting, engineering economy, financial management, industrial and human resources management, industrial psychology, management information systems, mathematical modeling and optimization, quality control, operations research, safety and health issues, and environmental program management (U.S.

Department of Education, National Center for Education Statistics, 2002, para. 86).

The establishment of a CIP code is essential if the field of technology management is to be recognized and validated as a formal discipline. The creation of a dedicated CIP code will structurally focus technology management programs by delineating curricular principles and content. Graduates of technology management programs do not require the ability to apply engineering principles. Several researchers (Becker, 2007; Herink et al., 1987; Nambisan & Wilemon, 2003; Thamhain, 2005) believe that engineering management and technology management academic programs are unique entities and should be addressed as such.

Function of Professional Associations, Accrediting Agencies, and Journals in Technology Management Education

External influences, such as those exerted by members of professional organizations and accrediting bodies, have a direct bearing on technology management education. Members of professional associations also provide forums such as conferences at which topics related to technology management education may be discussed (IAMOT, n.d.; PICMET, n.d.). The associations also act as information resource centers for faculty members and researchers in the technology management discipline (ETMERC, n.d.; IAMOT, n.d.). Accrediting bodies validate the content taught in technology management programs and ensure that quality standards are met by accredited programs (AACSB International, n.d.). Publications and journals focused on technology management also provide an important means of disseminating information relevant to technology management education.

Professional Associations

Professional associations are important to the development of the discipline of technology management and provide a forum for sharing knowledge in the field through conferences, meetings, and publications (IAMOT, n.d.; PICMET, n.d.). Several professional associations are dedicated to the technology management field, including IAMOT, the Portland International Center for the Management of Engineering and Technology (PICMET), the Technology Management Education Association (TMEDA), the Academy of Management (AOM) Division of Technology and Innovation Management (TIM), and the Engineering and Technology Management Education and Research Council (ETMERC). Associations and organizations devoted to technology management continue to be established, and even regional associations such as the Technology Management Association of Chicago (TMAC; 2005) are now in place.

Members of IAMOT actively promote education in the field of technology management and act as an "information resource center in the field" (IAMOT, n.d., para. 1). IAMOT staff members also sponsor an annual international conference on the management of technology and publish the conference proceedings; in addition, IAMOT members advocate research and application projects in the field of technology management (IAMOT, Bylaws, n.d.).

Members of PICMET also actively support technology management education and act as information resources for both engineering and technology management. In 1989 PICMET was "established as a non-profit organization to disseminate information on technology management through an international conference" (PICMET, n.d., para. 1). The first conference was held in 1991, and biennial conferences were held until 2004, when the conference became an annual event (PICMET, n.d.). “PICMET’s focus is on bringing together the experts on technology management to address the issues involved in managing current and emerging technologies” (PICMET, n.d., para. 3). A wide variety of content areas related to technology management is addressed at the conferences and includes topics such as decision-making in technology management, disruptive technologies, emerging technologies, environmental issues, intellectual capital, management of engineers and scientists, manufacturing management, project management, technology forecasting, technology management education, and technological change (PICMET, n.d.).

In 1987 the Academy of Management formed the Technology and Innovation Management (TIM) Division to “bring together scholars interested in innovation, research and development, and the management of technology-based organizations” (Academy of Management, 2008, para. 1). The domain of the TIM Division includes management of technological change and innovation, innovation process management, technology implementation and use, the effects of technology on organizations, and project management (Academy of Management, 2008).

The Technology Management Education Association (TMEDA) is “a community of higher education and industry professionals dedicated to improving the effectiveness of technology management education” (TMEDA, n.d., para. 1). The association’s leaders host an annual workshop focused on technology management education where members have an opportunity to interact with other technology management professionals and learn about recent developments in the field of technology management education. The first annual workshop hosted by TMEDA was held in 2003 (TMEDA, 2007). Technology management resources, such as links to other related professional associations and conferences, educational programs, and research centers, are also available to members.

In 2003 the Engineering and Technology Management Education and Research Council (ETMERC) was founded. The council aims to advance the fields of engineering management and technology management through education and research activities. These activities include development of program curriculum, creation of accreditation guidelines for departments or programs, conducting benchmarking studies for the establishment of norms and standards in engineering and technology management, and raising the awareness of engineering and technology management in both academia and industry (ETMERC, n.d.).

The Technology Management Association of Chicago (TMAC) holds monthly meetings that include a networking period and presentations by experts in the field of technology management. For example, the May 5, 2008, meeting topic was “Enterprise Attention Management: Addressing Info-Stress and Information Overload” (TMAC, n.d.). The association’s membership includes managers, entrepreneurs, and other leaders interested in emerging technologies (TMAC, 2005).

Professional associations related to technology management (i.e., IAMOT, PICMET, TMEDA, AOM Division of TIM, and ETMERC) provide invaluable resources, contacts, and information in this dynamic, growing discipline.

Specialized Accrediting Bodies

Increasing emphasis is being placed on accreditation, assessment (Diamond, 1998; Dickeson, 1999; Wholey, Hatry, & Newcomer, 2004), learner outcomes (Jacobi, Astin, & Ayala, Jr., 1987), and accountability (Burke, 2005) in higher education. “The purposes or goals of accountability programs for higher education have shifted over time from system efficiency, to educational quality, to organizational productivity, and to external responsiveness to public priorities or market demands" (Burke, 2005, p. 4).

Accreditation has become progressively more important in higher education (Whittlesey, 2005). Political constituents and legislators require institutions of higher education be accredited. "The goal of accreditation is to ensure that education provided by institutions of higher education meets acceptable levels of quality" (U.S. Department of Education, 2005, National Center for Education Statistics, p. 1). Curry and Wergin (1997) argued that "the criteria for accreditation are only loosely related to the outcomes society demands in competent professionals; most professional associations and agencies have considerable input into, if not sole control over, which schools achieve and maintain their professional accreditation" (p. 349).

Accreditation of academic institutions and programs functions through national, regional, and specialized agencies that focus on programmatic areas (Burke, 2005). Recognition by specialized accrediting bodies is important for academic programs, including those in the technology management discipline (Burke, 2005; Dickeson, 1999). Accredited academic programs are viewed as those providing a quality education (Burke, 2005; Dickeson, 1999) and emphasizing learner outcomes; such results have become increasingly important in the accrediting process (Burke, 2005; Dickeson, 1999; Newman, Couturier, & Scurry, 2004).

Accreditation is awarded to academic courses of study through "a process of voluntary, non-governmental review of educational institutions and programs….Specialized agencies award accreditation for professional programs and academic units in particular fields of study" (AACSB International, n.d., para. 2). Technology management degree programs are typically located organizationally in schools and colleges of business, engineering, and technology; specialized accreditation is generally associated with the school or college in which the program resides. Currently, only two accrediting bodies award specialized accreditation to technology management programs: the Association to Advance Collegiate Schools of Business International (AACSB International) and the National Association of Industrial Technology (NAIT). IAMOT is in the process of becoming an accrediting body for technology management programs (IAMOT, 2007). The Accreditation Board for Engineering and Technology (ABET) grants accreditation to engineering management programs.

AACSB International 2008 accredits both undergraduate and graduate programs in business and accounting. Accreditation is linked to the mission of the institution, and a peer-review process is used to ensure compliance with standards set by the AACSB International (AACSB International, n.d.). Accreditation for AACSB International includes strategic management standards, participant standards, and assurance of learning standards (AACSB International, 2008). Only two programs (11% of the undergraduate technology management programs identified by Becker [2007]) had achieved specialized accreditation by AACSB International (2007): Clarkson University (Clarkson University, 2006) and Texas A&M University – Commerce (Texas A&M University – Commerce, 2005). Clarkson University's business and technology management major is housed in the School of Business and Texas A&M University's technology management program is located organizationally in the College of Business and Technology.

Accreditation is awarded to industrial technology programs in colleges, universities, and technical institutes by NAIT. The association also promotes industrial technology and provides certification to industrial technologists (NAIT, n.d.). Only three (16.7%) undergraduate technology management programs were granted accreditation by NAIT, and one of these programs (Texas A& M University – Commerce, [2005]) was also accredited by AACSB International (Becker, 2007).

NAIT is transitioning to an outcome-assessment accreditation model as part of the requirements established by the Council for Higher Education Accreditation (CHEA), the organization from which NAIT received its authority to accredit programs (NAIT, 2007). The outcome-assessment accreditation model is made up of these three areas: (a) program inputs, (b) program operation criteria, and (c) outcomes measures that focus on program improvement (NAIT, 2007).

IAMOT is working to become an accrediting body. In 2007, IAMOT leaders disseminated the organization's proposed accreditation/certification guidelines for management of technology (MOT) graduate-level programs (IAMOT, 2007). The guidelines will be used in conjunction with accreditation from AACSB International and ABET (Walsh, 2004). Four knowledge groups (management of technology-centered knowledge, knowledge of corporate functions, technology-centered knowledge, and knowledge of supporting disciplines) are promoted in the IAMOT program guidelines for certification in addition to an area devoted to special topics. The assessment process will include evaluation of "program objectives; program structure and contents; instructors/faculty qualifications; program administration; knowledge delivery system and facilities; participant qualifications at the entry and exit levels; program outcome/graduates accomplishments; and the institution commitment and support to the program" (IAMOT, 2007, p. 3).

The increasing emphasis on accountability and accreditation (Burke, 2005) of academic programs warrants the development of specialized accreditation of technology management programs at both the undergraduate and graduate levels. IAMOT's proposed development of a specialized accreditation agency is critical for continued growth of the discipline and for quality assurance of programs. Given the growing importance of undergraduate academic offerings, any accrediting effort should also be focused on the standards and quality of undergraduate as well as graduate technology management education programs.

Technology Management Publications and Journals

Numerous publications are dedicated to the topic of technology management. These magazines, journals, and newsletters provide an invaluable forum for the dissemination of knowledge related to the technology management discipline. Publications range from documents providing general coverage of technology management topics, such as *Research in Technology Management* and the *Technology Management Newsletter*, to specialized publications that narrowly focus on only one aspect of technology management, such as the *Journal of Technology Transfer* or the *International Journal of Technology Marketing*.

Two of the professional associations related to technology management sponsor publications. PICMET sponsors the *Technology Management Newsletter* (TMN), which was established in 2004 and is published online on a quarterly basis. TMN contributors report on and promote the field of technology management and the content serves as a resource for technology managers, educators, and researchers (*Technology Management Newsletter*, 2004). The recently established (2006) *International Journal of Technology and Innovation Management Education* (IJTIME) is sponsored by the (Technology Management Education Association (TMEDA; Technology Management Education Association, n.d.). "The key aim for this journal is to become a forum for the development and sharing of best practices in technology and innovation management education" (Maital & Horwitch, 2006). See Appendix A for a list of selected technology management publications and journals.

Current Status of Undergraduate Technology Management Education

Technology management education is a dynamic academic field, with program development rapidly increasing at the undergraduate, graduate, and doctoral levels (Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003) over the last 30 years (Alvear, Rueda, Hernandez, & Kocaoglu, 2006). *Engineering, Technology, and Management* survey respondents (Kocaoglu et al., 2003) identified 26 titles of undergraduate engineering management and technology management programs (e.g., bachelor of applied science in engineering management; bachelor of business in operations management, engineering science, industrial engineering, and management; and bachelor of technology in technology management); a complete list of program titles can be found in Appendix B. Use of a wide variety of program titles and the combining of engineering and technology management programs in research articles by some authors (Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Daim et al., 2007) have contributed to the ambiguity surrounding technology management education.

In 2007 Becker completed a comparative analysis of undergraduate technology and engineering management programs in the U.S.. In this analysis, 18 undergraduate technology management programs were identified as operational in the U.S. between spring 2005 and winter 2007. More than half (10, or 56%) of the institutions offering technology management programs conferred bachelor of science degrees, and three (17%) awarded a bachelor of applied science degree, while only two (11%) awarded a bachelor of arts degree. A bachelor of applied technology was awarded by one (6%) institution, a bachelor of industrial technology was awarded by another institution, and the other institution did not specify the degree type (Becker, 2007). Only the following five courses in the undergraduate technology management program analysis met a 50% commonality criterion: (a) statistics (11, or 61% of programs required), (b) accounting (10, or 56% of programs required), (c) quality (9, or 50%), (d) marketing (9, or 50%), and (e) organizational behavior (9, or 50%; Becker, 2007). Most (13, or 72%) of the technology management programs accepted transfer coursework from community colleges, which primarily consisted of general education and technical courses (Becker, 2007).

As noted, most technology management academic programs are offered at the master's level; however, undergraduate programs in technology-management education continue to be established and make up an increasingly greater percentage of overall programs in the discipline (0% in 1987 and more than 20% in 2007; Becker, 2007; Herink et al., 1987). The lack of literature on curriculum development in undergraduate academic programs has, in part, led to a wide variety of coursework and a lack of a unified curriculum in undergraduate technology management majors. Courses in statistics, accounting, quality, marketing, and organizational behavior do not constitute a unified body of knowledge in technology management programs at the undergraduate level. Unpublished results of Becker's (2007) study also indicated that very few (5, or 28%) of the technology management programs even offered a course in technology management.

The organizational structure of units offering technology management and applied technology management programs differed. Five of the technology management programs were housed in colleges or schools of technology, but only one of the applied technology management programs was located in a college of technology and management. Three of the applied technology management programs were located in a college of business. Two of the applied technology management programs were the only baccalaureate programs offered at their institutions (Brazosport College and Midland College), with both of these colleges having received initial authorization to offer baccalaureate degrees in 2005. The establishment of baccalaureate completion programs, which have an applied and workplace focus, at two-year community colleges is an emerging trend occurring in higher education and warrants further research because the highest growth area in higher education is at the community college level (American Council of Education, 2004).

A survey of legislation in all 50 states by Levin (2004) indicated that legislators in the following five states authorized community colleges to offer baccalaureate degrees: Arkansas, Florida, Idaho, Nevada, and Utah. Texas legislators also allowed community colleges to offer baccalaureate degrees (Brazosport, 2005). Undergraduate technology management education may be adversely affected by community colleges that offer baccalaureate degrees (Mills, 2003).

An array of technical coursework from associate degrees may be accepted as transfer credit in undergraduate technology management degree programs. For example, Clarkson University accepts technical coursework in the specialization areas of entrepreneurship, human resource management, international business, and project management. In addition, students can customize their technical concentration with the assistance of an adviser. St. Petersburg College accepts technical coursework from the following areas: computer engineering technology, computer information technology, computer programming, computer service technology, electrical distribution technology, manufacturing technology, network services technology, plastics engineering technology, telecommunications technology, electronics engineering technology, and database technology. The acceptance of technical credits from community colleges is common (Becker, 2007) in undergraduate technology management programs.

Summary

In reviewing the related literature on technology management education, the need for both undergraduate and graduate programs in the disciplinary area is apparent (Badawy, 1998; Becker, 2007; Hauck, 1999; Herink et al., 1987; Khalil & Yanez, 2006; van Wyk, 2004). The need for technology management education has resulted from rapidly changing technologies, increased complexity of business operations, and global competition (Herink et al., 1987; Thamhain, 2005). Various definitions exist for technology management (Bellamy, Becker, & Kuwik, 2003; Herink et al., 1987; Thamhain, 2005; van Wyk, 2004), and the lack of a formal CIP code designated by the

NCES exasperates the problem of defining technology management as a discipline. Differentiation between engineering management programs and technology management programs also should be addressed, and boundaries between the two disciplines should be formalized (Becker, 2007; Nambisan & Wilemon, 2003).

Growth in the establishment of technology management programs has been strong since the 1990s and is expected to continue (Fortino, 2006; Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003; Nambisan & Wilemon, 2003). In 1987 no undergraduate technology management education programs existed, and these programs now make up more than 20% of all technology management academic offerings (Becker, 2007; Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003). However, very little research has been focused on curricular issues related to undergraduate technology management education. Instead, researchers have focused on graduate education in technology management (Badawy, 1998; Klingenberg & Lauria, 2007; van Wyk, 2004; Yanez, 2006). Four primary coursework areas in technology management programs emerged from this review: (a) technology management courses/topics, (b) corporate functionality courses/topics, (c) technology-specific courses/topics, and (d) foundational courses/topics.

Several external influences on the discipline of technology management exist, including professional associations, specialized accreditation agencies, and publications and journals. Professional association members promote the field of technology management and provide an avenue for members of the association to discuss and disseminate information related to the field. Numerous publications and journals also provide a means to share knowledge about the technology management discipline.

Specialized accrediting agencies assist in assuring that quality educational standards are being promoted in the discipline of technology management. Currently, two agencies (AACSB International and NAIT) grant accreditation to technology management programs, and IAMOT is working to become an accrediting organization in this field.

Undergraduate technology management education programs are evolving in the discipline; at this point, very little consistency exists in the curricular content taught within these programs (Becker, 2007). Clearly, the lack of research devoted to the topic of undergraduate technology management education has adversely affected the quality and consistency of these programs.

CHAPTER 3: RESEARCH METHODOLOGY

In this section of the document, research design, research questions, and the following five phases used in implementing research procedures will be discussed: (a) identification of the sample population, (b) selection of the survey software, (c) survey instrument design and pilot testing, (d) data gathering, and (e) data analysis. Data integrity will also be discussed.

A survey method was used by the researcher to seek the opinions of the sample population regarding core curriculum competencies in undergraduate technology management education programs. Many researchers (i.e., Diamond, 1998; Ehie 2002; Grier, 2005; Kung, Yang, and Zhang 2006; and Shin 1999) have used survey research in designing and developing curriculum. The use of surveys by faculty in academic institutions is widely accepted (Rea & Parker, 1997). A flowchart of the five phases used in this research process is included in Figure 1.

Research Design

In this exploratory descriptive research study, the purpose of the investigation was to determine the core curricular components of an undergraduate technology management education program. After an extensive survey of available literature, the researcher found no research studies that addressed this specific topical area. Use of a descriptive study approach (Trochim, 2001) allows the investigator to "describe phenomena in detail...in contrast to *explanatory* studies, which generally attempt to explain a social phenomenon by specifying why or how it happened" (Bailey, 1994, p. 40). While no formal hypothesis will be presented, which is common in exploratory research studies (Bailey, 1994), research questions will be considered.

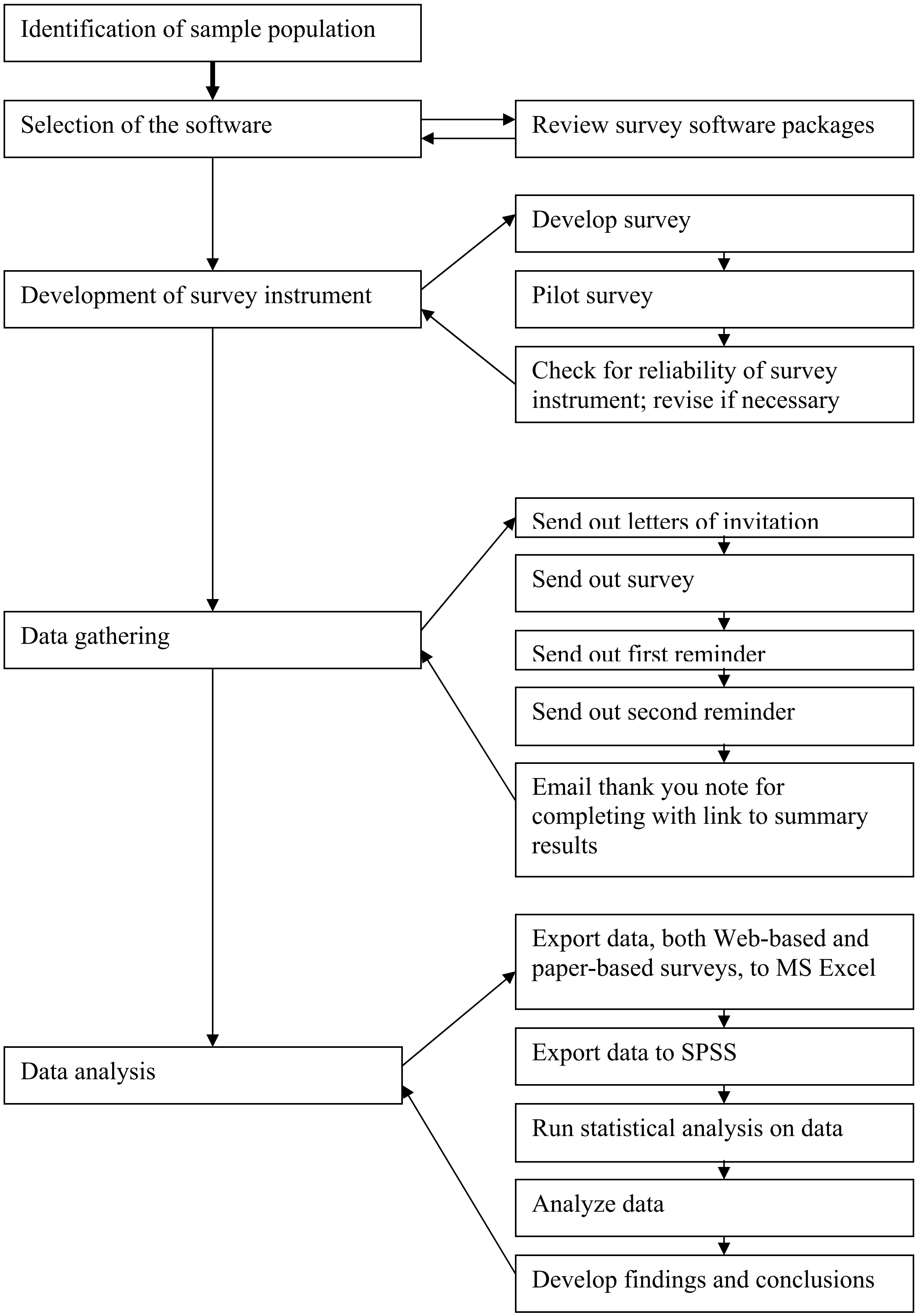

Figure 1: Research Methodology Process

A quantitative mixed-mode (Internet-based and paper-based survey) design was used in this exploratory study. The survey was administered to 228 adult human subjects with expertise in the field of technology management. Specifically, 180 employees in the following four industry sectors were asked to participate: (a) business services, 40 employees; (b) education, 40 employees; (c) government, 60 employees; and (d) manufacturing, 40 employees. In addition, 18 executive board members of the MEDC and 30 members of the SWCCC were invited to participate in the survey. A quantitative analysis of the results was completed.

The use of a mixed-mode survey should improve response rates (Dillman, 2007) and provided an additional opportunity for participants to complete the survey if they were reluctant or unwilling to respond to a Web-based survey or if they were unable to respond because of technical difficulties (Dillman, 2007). A paper-based survey was administered to participants in the government sector and to members of the SWCCC. In order to minimize any measurement differences as a result of using mixed-mode surveys, the survey instrument was developed using the unimode construction approach (Dillman, 2007, p. 244). A copy of the Web-based survey was saved and printed as a PDF file (Survey Monkey, n.d.) to assure "receipt by respondents of a common mental stimulus" (p. 232), as recommended by Dillman (2007).

Research Questions

The current lack of research on the undergraduate technology management curriculum compelled this investigation, and the results of the study will be used to determine an optimal core curriculum for undergraduate technology management academic programs. The overarching question for this study is: What core competencies are necessary for undergraduate technology management majors to be successful when they enter the workplace? "Core competencies refer to the knowledge, skills, abilities and behaviors that contribute to an employee's job success" (Casner-Lotto & Barrington, 2006, p. 15).

A review of the technology management literature is indicative of the following eight categories on which undergraduate technology management education should focus: (a) strategic management of technology, (b) management of innovation and product development, (c) management of technological change, (d) management of organizational change, (e) project management, (f) assessment and evaluation of technology, (g) quality management of technology, and (h) information/knowledge management (Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Angus, Gundersen, & Cullinan, 2000; Evans & Lindsay, 2008; Haag, Cummings, & McCubbrey, 2005; Herink et al., 1987; Porter, Roper, Mason, Rossini, & Banks, 1991; Thamhain, 2005; Yanez, 2006; Yanez & Khalil, 2007). These categories were included in the survey, and items representative of the domain for each of these eight categories were incorporated into the survey. Participants were asked to indicate their level of agreement or disagreement that graduates of undergraduate technology management academic programs should have competencies in the eight areas through the use of a Technology Management Curriculum Inventory (see Appendix C).

Specifically, the following four research questions were addressed in this study:

Research Question 1: *What is the relative perceived importance of each of the eight core competency areas (management of technological change, management of organizational change, project management, assessment and* *evaluation of technology, quality management of technology, information and knowledge management, innovation and product development, and strategic management of technology) in technology management academic programs?*

Research Question 2: *What is the relative perceived importance of each item within each of the eight core competency technology management scales?*

Research Question 3: *Do any differences exist between industry sectors (i.e., business services, education, government, and manufacturing) and their representatives' perceptions of the relative importance of the eight core competency areas?*

Research Question 4: *Do any differences exist between industry sectors and their representatives' perceptions of the items within each of the core competency areas?*

This research study was approved by Eastern Michigan University's Institutional Review Board before the pilot study was administered. A copy of the approval form and informed consent document is located in Appendix D.

Phase I: Identification of Sample Population

Purposive expert sampling (Bailey, 1994; Trochim, 2001) was used in this research study to identify participants. Purposive sampling is useful when researching "one or more specific predefined groups...Expert sampling involves the assembling of a sample of persons with known or demonstrable experience and expertise in some area" (Trochim, 2001, pp. 56-57). People with expertise in technology management from each of the following industry sectors were asked to participate in this research study: business services, education, government, and manufacturing. Specifically, these groups of individuals were surveyed:

- Business services employees and technology managers from Blue Cross Blue Shield of Michigan, IBM, and Schneider Logistics; these administrative professionals manage technology in their respective organizations.
- Technology managers and information technology managers from Eastern Michigan University, Utah Valley State College, and the University of Michigan made up the members of the education sector. Graduates of technology management programs are employed at all three of these institutions; in addition, Utah Valley State College has an undergraduate technology management program.
- The government sector was represented in this research study by law enforcement officials from the Detroit (Michigan) Police Department and emergency management professionals from southeastern Michigan. These officials occupied leadership positions in their respective institutions and are required to manage technologies.
- Employees from Robert Bosch, LLC; Integral Vision; Sypris Test and Measurement; Brooks Global; and Visteon Corporation, working at various facilities in Michigan, represented the manufacturing sector. These respondents were responsible for managing technologies at their respective organizations.

In addition, 18 members of the executive board of directors of the MEDC and 30 members of the SWCCC were queried. MEDC represents more than 10,500 business and industrial organizations in 46 specialty areas within the state of Michigan; moreover, MEDC is the state's leading economic development authority (Granholm, 2008). The business and specialty areas of MEDC include, but are not limited to, automotive, advanced manufacturing, construction, financial services, information technology, retail, and Web design. The SWCCC represents businesses and industries from 21 communities in southeastern Michigan, including business services, education, and manufacturing (SWCCC, *Member Directory*, n.d.). Technologies are used in all of the member businesses and organizations associated with the MEDC and SWCCC; therefore, the need to manage technologies is critical for the economic success of these enterprises (Khalil & Yanez, 2006).

Phase II: Selection of the Software

Many different Internet-based survey software packages are available for use by researchers (Burke & James, 2006). Features and options in the survey software packages vary significantly, as does cost, with some of the basic packages being available for free. Some of the features and options of survey software packages include, but are not limited to, data collection and coding; data analysis; layout and design options; and the ability to include graphics, skip patterns, answer verification, customize, and vary question types (Burke & James, 2006). The ease with which surveys can be developed and distributed also varies significantly, with some survey software packages having templates for question development that can be modified and some packages requiring the ability to perform HTML coding.

This researcher reviewed the following three survey software packages: (a) Snap, (b) Survey Monkey, and (c) Survey Methods. Each of the survey software packages offered different levels of features and support. Survey Methods offers a free basic package, an advanced package ($9 per month), and a professional package ($39 per month; Survey Methods, n.d.). The Snap Professional Edition costs $1,145 and has questionnaire design, publication data collection, and analysis for paper as well as telephone surveys; the Snap ProNet Edition costs $1,995 and has the same features as the Snap Professional Edition plus add-ons for paper, telephone, scanner, Web, and email surveys (Snap Surveys, n.d.). While Eastern Michigan University has a site license for Snap software, a location restriction exists, and the software can only be accessed from a university computer. Survey Monkey is the lowest-priced solution, with a free basic package and a monthly rate of $19.95 for the professional version. A paper-based survey can also be generated using Survey Monkey (Survey Monkey, n.d.). Survey Methods (Survey Methods, n.d.) does have automatic reminders and custom thank you greetings. Confidentiality can be assured with all of the software packages, and each one has the ability to export data to an Excel spreadsheet application for analysis.

Survey Monkey was chosen as the survey software for use in this research study. The primary advantage was the ability to generate a PDF file of the survey instrument, which allowed the use of a mixed-mode research instrument.

Phase III: Survey Instrument Design and Pilot Testing

The TMCI was developed after an analysis of the research in the technology management field and a review of textbooks used in the discipline. See Appendix E for a list of the textbooks reviewed in the development of this instrument. The TMCI was then used to develop the items in each of the eight scales used in the pilot survey.

Content validity of the TMCI inventory categories and items was ensured because each appears to be representative of the domain of items for each concept and was based on the researcher's review of the technology management literature. The pilot survey was divided into the following 10 categories: (a) informed consent, (b) demographic information, (c) strategic management of technology, (d) management of innovation and product development, (e) management of technological change, (f) management of organizational change, (g) project management, (h) assessment and evaluation of technology, (9) quality management of technology, and (10) information/knowledge management. A copy of the pilot test survey instrument is included in Appendix F.

A Likert scale consisting of a five-point rating (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree) was used to solicit opinions from members of the sample population. A Likert scale is used to measure the attitude of the respondent on a "continuum from highly favorable to highly unfavorable, or vice versa, with an equal number of positive and negative response possibilities and one middle or neutral category" (Rea & Parker, 1997, p. 59). When a series of questions related to a specific subject is included, and attitudinal information is sought, the Likert scale is applicable.

The pilot study was electronically administered to 30 upper-division undergraduate technology management students, and a paper-based survey was administered to 15 master of science in technology studies students at Eastern Michigan University. From the 45-member pilot test group, a total of 33 respondents (or 73.3%) of the pilot sample population responded to the survey. All of the respondents indicated their gender (21 [63.6%] males and 12 [36.4%] females). The mean age of the respondents was 35 years, with a median age of 33.

Respondents representing all industry sectors were involved in the pilot study (see Figure 2). Based on feedback from pilot study participants and analysis of the industry sector variable, it was determined that respondents from Web design and health care should be incorporated into the business services area. The resulting four industry sectors were included in the survey instrument: (a) business services, (b) education, (c) government, and (d) manufacturing.

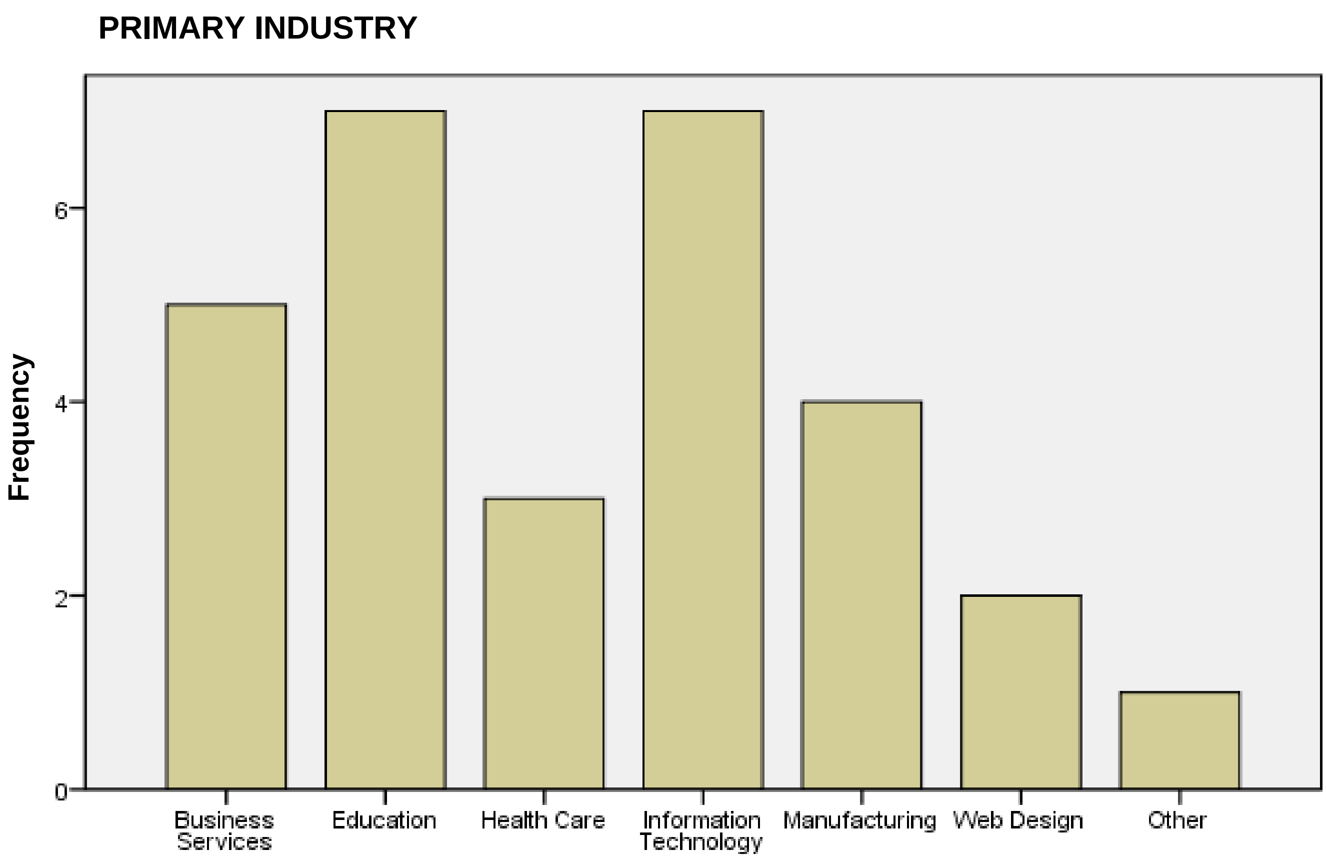

Figure 2: Pilot Test Respondents by Primary Industry

Primary Industry

Results of the pilot test were analyzed, and alpha reliability was tested for each of the eight scales and the items within the scales using Cronbach's alpha. Statistical significance was determined by performing a one sample *t* test for the mean of each scale and for each item within each scale.

Minor revisions to the pilot test survey were made based on feedback received from pilot survey participants to increase the reliability of the instrument. One item was removed from the project-management scale because it was considered redundant. These revisions also included changing the order of the questionnaire by moving the strategic management of technology scale and the management of innovation and product development scale to the end of the survey as a result of the lower Cronbach's alpha reported on these two scales.

Thirty total cases were included (three were excluded) in the reliability analysis. The reliability analysis of each of the scales is noted in Table 3, and the reliability analysis of each of the items within each scale is included in Appendix G.

Table 3

Pilot Test: Instrument Reliability Analysis of Scales

Scale	Number of Items in Scale	Cronbach's Alpha
Strategic Management of Technology	5	.564
Management of Innovation and Product Development	4	.762
Management of Technological Change	4	.782
Management of Organizational Change	6	.887
Technology Project Management	8	.870
Assessment and Evaluation of Technology	8	.790
Quality Management of Technology	9	.905
Information/Knowledge Management	9	.877

Analysis of the pilot test results confirmed reliability of the pilot test instrument. A copy of the final version of the survey instrument used in the study is located in Appendix H.

Phase IV: Data Gathering

On May 12, 2008, three days prior to the email distribution of the final survey instrument, an email invitation (first contact) was sent to survey participants requesting their participation in the study (see Appendix I for a copy of the email invitation). The survey instrument was then distributed by email (second contact) on May 15, 2008, and was accessible through an Internet link included in the email. Respondents had the option of completing a Web-based survey or requesting a paper-based survey through the U.S. mail. If the participant completed a paper-based survey, responses were electronically entered into the database by the researcher (see Appendix J). A follow-up reminder (third contact) was sent on May 21, 2008, to members of the sample population who had not responded within one week (seven days) after receiving the emailed survey (see Appendix K). A second reminder (fourth contact) was sent on May 27, 2008, to those participants who still had not responded to the survey within six days of the first reminder (see Appendix L). The survey closed on June 7, 2008.

Phase V: Data Analysis

Survey data were imported from Survey Monkey into Microsoft Excel and then imported into Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to analyze data, including ranges, averages, and measures of central tendencies. A mean for each item within each category was calculated to determine the relative importance of each item to the other. The relative importance of each item within each category was based on mean values and statistical significance.

A Likert scale consisting of five scale points and five anchors was used to measure the items within each of the technology management categories. Each of the category items was tested for its alpha reliability. A one sample *t* test was performed for the mean of each item to determine statistical significance.

Upon review of the returned questionnaires, the investigator determined that sufficient numbers of responses existed to make categorization by industry type possible. An analysis of variance procedure was used to determine if perceptions of technology management curriculum competencies varied according to industry type. In order to perform this procedure, items within each technology management category were summed to form eight separate scales. Each scale was tested for its alpha reliability. A one-way ANOVA procedure was completed and two post-hoc tests (Hochberg's GT2 and the Games-Howell) were also completed. Hochberg's GT2 is a multiple comparison procedure developed to deal with conditions in which different sample sizes exist (Fields, 2005). The Games-Howell procedure is used when there is uncertainty in the equivalence of population variances and is "also accurate when sample sizes are unequal" (Fields, 2005, p. 341).

Measures to Ensure Integrity

The research study did not involve any deception or punishment of the research participants. Moreover, the information collected was held confidentially and only presented in aggregate form. Participant surveys were coded so the names of the organizations/participants cannot be revealed; names and codes were kept under lock and key at the researcher's home until the study was completed, at which time the names, codes, and research data were destroyed. The aggregate results of the research will be disseminated in this dissertation, in future publications, and in national/international presentations. Participants were informed that they could request a copy of the research results when submitting their survey responses and were also reminded of their right to withdraw from the study at any time during the process (i.e., participation in the study was voluntary). A copy of the Informed Consent document is included in Appendix M.

CHAPTER 4: PRESENTATION AND ANALYSIS OF DATA

In this chapter, data collected during this investigation are presented and analyzed by the author. As noted in this document, the primary purpose of the study was to determine the core competencies required of undergraduate technology management program graduates in the following eight areas: (a) management of technological change (b) management of organizational change, (c) project management, (d) assessment and evaluation of technology, (e) quality management, (f) information and knowledge management, (g) product and innovation management, and (h) strategic management of technology. In addition, the investigator sought to determine whether differences existed between the four industry sector categories (business services, education, government, and manufacturing) and the eight core competency areas.

Descriptive statistics were used to analyze data, including the range, averages, and measures of central tendencies. Averages for each item within each of the eight categories were calculated to determine the relative importance of each item to the other items. The overall participant response rates for the study and for each of the industry sectors (business services, education, government, and manufacturing), the respondent demographic information, and the following four specific research questions will be addressed in this chapter:

Research Question 1: *What is the relative perceived importance of each of the eight core competency areas (management of technological change, management of organizational change, project management, assessment and evaluation of technology, quality management of technology, information and knowledge* *management, innovation and product development, and strategic management of technology) in technology management?*

Research Question 2: *What is the relative perceived level of importance of each item within each of the eight core competency technology management scales?*

Research Question 3: *Do any differences exist between industry sectors (business services, education, government, and manufacturing) and their representatives' perceptions of the relative importance of the eight core competency areas?*

Research Question 4: *Do any differences exist between industry sectors and their representatives' perceptions of the items within each of the core competency areas?*

Response Rate

The survey instrument was administered to 228 people; 127 responses were received for an overall response rate of 55.7%. Employees from the government sector had an 85% response rate, which represented the highest level of involvement by participants in any one industry sector in this study. The high response rate by representatives of the government sector may have resulted from the personal distribution and collection of a paper-based survey by the researcher. Table 4 contains specific information about the response rates from each of the participating groups.

Table 4

Survey Response Rate by Industry Sector

Industry Sector	Number of Invitations	Number of Responses	Response Rate %	Survey Distribution Method	Data Collection Method
Business Services	40	29	72.5%	Electronic mail	Web-based
Education	40	23	57.5%	Electronic mail	Web-based
Government	60	51	85.0%	Paper-based	Collected at point of administration
Manufacturing	40	21	52.5%	Electronic mail	Web-based
*MEDC	18	2	11.1%	Electronic mail	Web-based
*SWCCC	30	6	20.0%	Paper-based	U.S. Mail
Total	228	127	55.7%		

Note: Respondents from MEDC and SWCCC identified their primary industry sector affiliation when they completed the survey instrument.

Demographic Information

The provision of demographic information including position titles and the name of the organization at which the participant was employed was optional. The positions represented in the business services category included titles such as business analyst, business operations manager, logistics manager, project manager, and senior analyst. The respondents' position titles in the education sector included director of information technology, director of project management, executive director of human resources, interim chief information officer, and manager of academic information systems. In the government sector, individuals were employed in positions with titles of captain, fire chief, fire marshal, lieutenant, sergeant, and supervisor. Participants from the manufacturing sector were in positions such as chief executive officer, director of sales engineering, production supervisor, senior design engineer, unit manager, and vice-president of operations. Based on the variety of positions held by the respondents, the investigator believes to have collected a sample that is representative of the population under study.

Of the 127 survey respondents, 124 indicated their gender. The majority (92, or 74.2%) of the respondents was male, and 32, or 25.8%, were female. A total of 116 (91.3%) people reported their age, but 11 of the respondents chose not to answer this particular question. The range was from age 23 to 71, with the mean age of respondents being 44.83 or 45 years old and a median age of 38. See Figure 3 for the frequency distribution of the respondents' ages.

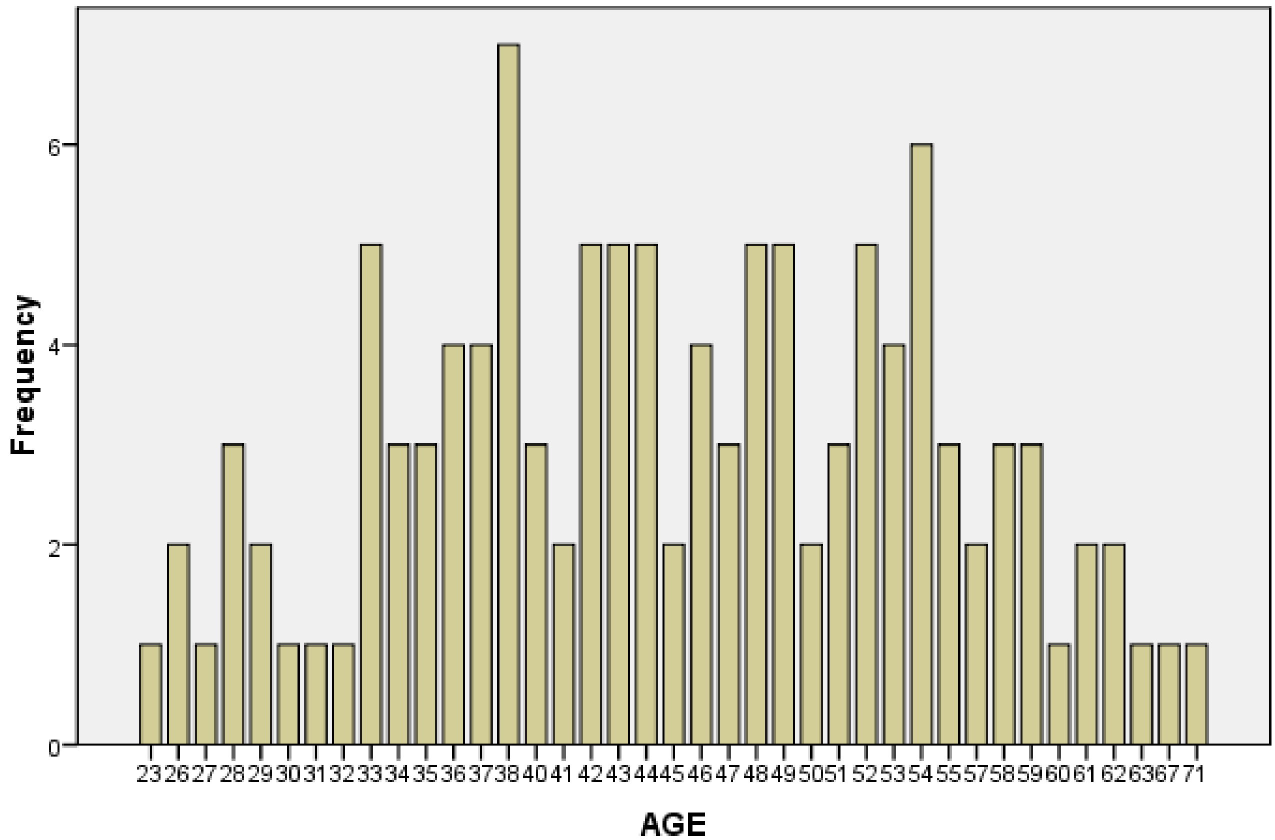

Figure 3: Frequency Distribution of the Respondents' Ages

The majority of respondents (124, or 97.6%) indicated the industry sector in which their employer was categorized. Most of the respondents were from the government sector (51 respondents, or 40.1%), followed by the business services sector (29, or 22.8%), education (23, or 18.1%), and manufacturing (21, or 16.5%). See Figure 4 for details.

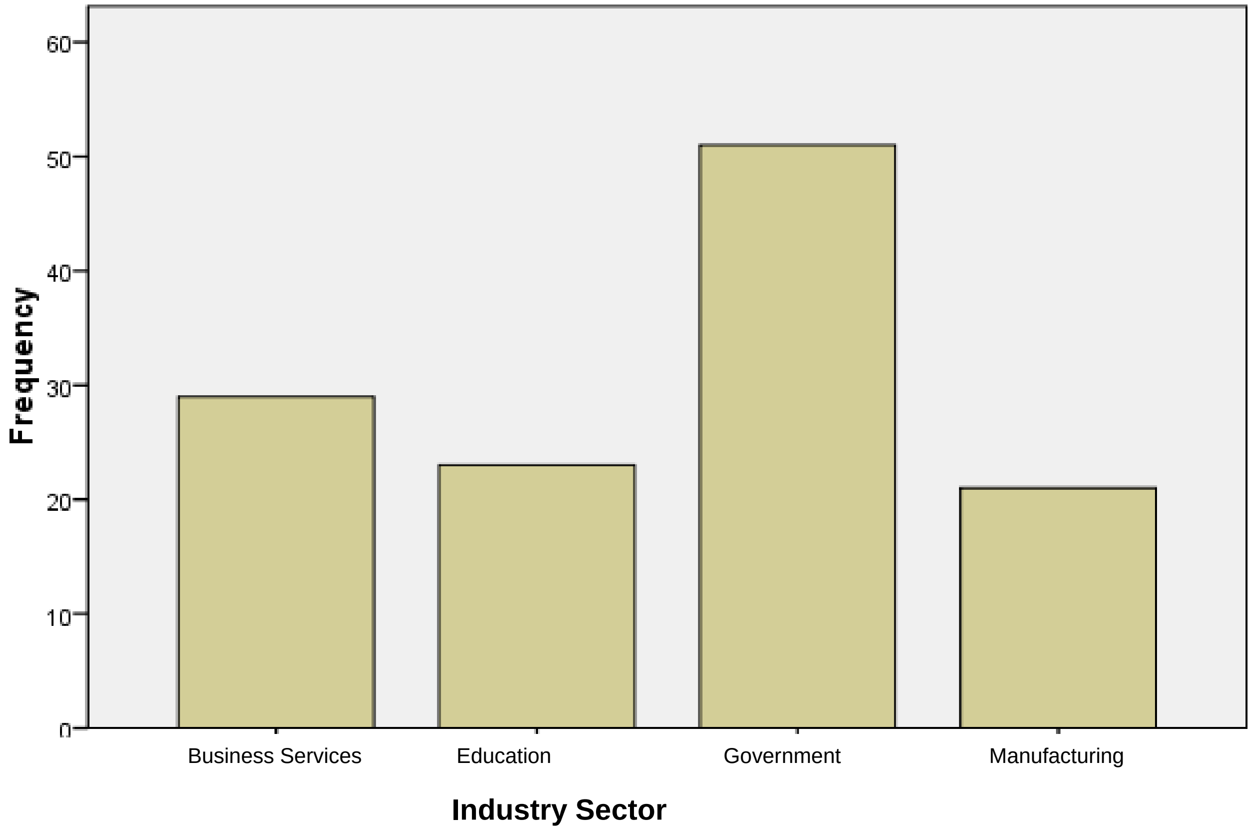

Figure 4: Frequency Distribution of Primary Industry Sector

Reliability of Scales

The mean of the items within each of the scales was used to determine the reliability of the scales. Cronbach's Alpha "is the most common measure of scale reliability" (Field, 2005, p. 667), and a value of .7-.8 is generally indicative of acceptability and, thus, reliability of a scale (Field, 2005). This statistical test was used to test reliability of each scale. Items with missing variables (13) were excluded from this analysis. "By default, SPSS excludes cases listwise, which means that if a person has a missing value for any variable, then they [sic] are excluded from the whole analysis" (Fields, 2005, p. 183). A total of 114 cases, or 89.8%, of the sample population were included in the calculation of Cronbach's Alpha. See Table 5 for the reliability analysis of the scales.

Table 5

Survey Instrument Reliability Analysis of Scales

Scale	Number of Items in Scale	Cronbach's Alpha
Management of Technological Change	4	.761
Management of Organizational Change	6	.833
Technology Project Management	8	.869
Assessment and Evaluation of Technology	8	.848
Quality Management of Technology	9	.903
Information/Knowledge Management	9	.888
Management of Innovation and Product Development	4	.803
Strategic Management of Technology	5	.893

The reliability value of the Strategic Management of Technology scale improved substantially over the pilot test survey reliability analysis (i.e., increasing from .564 on the pilot test instrument to .893 in the final survey instrument). This enhanced reliability may have resulted from moving the scale to the end of the survey. The Management of Innovation and Product Development scale reliability also improved from .762 during the pilot test to .803 for the final instrument.

Research Questions

In the following section, each of the four research questions will be addressed in detail. The question will be posed, and then data received from participants via the survey instrument will be presented and analyzed using appropriate statistical tests.

Research Question 1: *What is the relative perceived importance of each of the eight core competency areas (management of technological change, management of organizational change, project management, assessment and evaluation of technology, quality management of technology, information and knowledge management, innovation and product development, and strategic management of technology) in technology management?*

A weighted scale was developed by dividing the mean value of each scale by the number of items within the scale to arrive at a weighted mean. The weighted means were then compared to determine their relative importance to each other. A sample *t* test was performed on the means of the weighted scales to determine statistical significance at the <.01 level (see Table 6).

Table 6

T test of Weighted Scales

Weighted Scale	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Management of Technological Change	127	1.4429	.48814	33.312	126	.000
Management of Organizational Change	124	1.5121	.49119	34.280	123	.000
Technology Project Management	127	1.3532	.44737	34.088	126	.000
Assessment and Evaluation of Technology	125	1.5720	.46481	37.813	124	.000
Quality Management of Technology	124	1.6478	.55902	32.825	123	.000
Information/Knowledge Management	124	1.4875	.47474	34.890	123	.000
Management of Innovation and Product Development	125	1.7320	.58645	33.019	124	.000
Strategic Management of Technology	127	1.5213	.58236	29.438	126	.000

All of the scales were significant at the <.01 level. A visual representation of the means of the weighted scales is included in Figure 5.

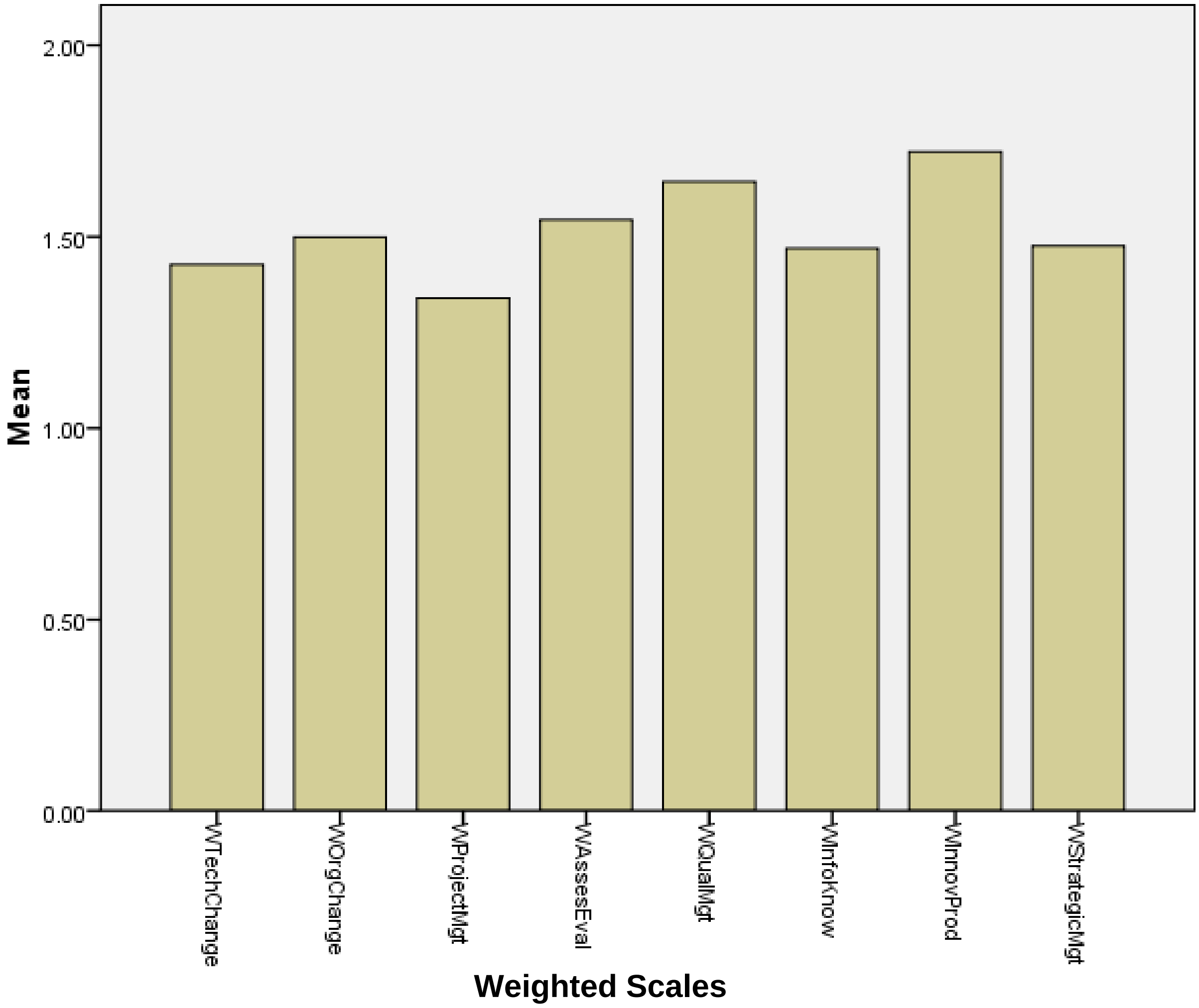

Figure 5: Weighted Means of Scales

The means of the weighted scale ranged between 1.35 for the Technology Project Management scale, which was perceived as having the highest level of relative importance by the respondents, to 1.73 for the Management of Innovation and Product Development scale. The differences in the weighted means of the scales are minor, and the majority of respondents, as evidenced by the weighted means, either strongly agreed or somewhat agreed that undergraduate technology management students should be proficient in all eight of the core competency areas. See Table 7.

Table 7

Weighted Means of Scales by Perceived Level of Importance

Perceived Level of Importance	Weighted Scale	Number of Respondents	Weighted Mean
1	Technology Project Management	127	1.3532
2	Management of Technological Change	127	1.4429
3	Information/Knowledge Management	124	1.4875
4	Management of Organizational Change	124	1.5121
5	Strategic Management of Technology	127	1.5213
6	Assessment and Evaluation of Technology	125	1.5720
7	Quality Management of Technology	124	1.6478
8	Management of Innovation and Product Development	125	1.7320

Research Question 2: *What is the relative perceived level of importance of each item within each of the eight core competency technology management scales?*

Management of Technological Change

A one sample *t* test was completed for the Management of Technological Change items. All items within the scale were found to be significant at the <.01 level. The scale had a Cronbach’s Alpha of .761 (see Table 8).

Table 8

T test for Items within the Management of Technological Change Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to assess the need for technological change	127	1.42	.695	22.978	126	.000
Ability to assess an organization's readiness for technological change	127	1.49	.665	25.217	126	.000
Ability to implement technological change	127	1.33	.535	28.013	126	.000
Ability to scan significant technological changes occurring within the external environment of the organization	127	1.54	.652	26.532	126	.000

The median score for all of the items within the scale was 1.0, or "strongly agree" (see Appendix N for responses [frequencies and percentages] for items associated with the Management of Technological Change scale). A visual representation of the means of the items within the Management of Technology Change scale is included in Figure 6.

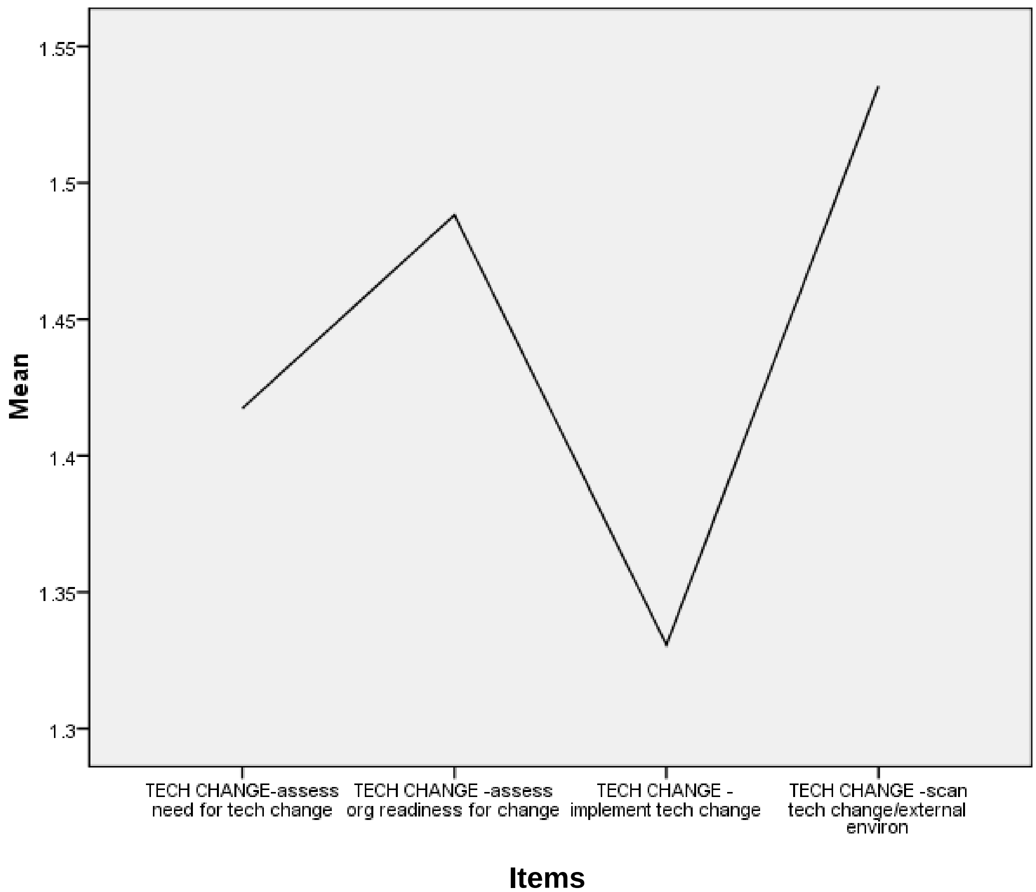

Figure 6: Management of Technological Change Item Means

The mean value of the scale items ranged from 1.33 for the ability to implement technological change to 1.54 for the ability to scan significant technological changes occurring within the organization's external environment. One item in this category, the ability to implement technological change, had 89 (70.1%) respondents who strongly agreed that this component was an essential ingredient in an undergraduate technology management program. See Table 9 for the perceived level of importance of items with the Management of Technological Change scale.

Table 9

Perceived Level of Importance of Items within Management of Technological Change Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Ability to implement technological change	127	1.33
2	Ability to assess the need for technological change	127	1.42
3	Ability to assess an organization's readiness for technological change	127	1.49
4	Ability to scan significant technological changes occurring within the external environment of the organization	127	1.54

Based on data presented and analyzed, respondents overwhelmingly maintained that the undergraduate technology management curriculum should include a significant component on the management of technological change. The specific competencies that need to be addressed, in order of their importance, are the ability to implement technological innovations, ability to assess the need for technological change, ability to determine the organization's readiness to implement technological change, and ability to identify technological changes occurring in the external environment.

Management of Organizational Change

A one sample *t* test was completed for the Management of Organizational Change items. All items within the scale were found to be significant at the $<.01$ level. The scale had an overall Cronbach's Alpha of .833 (see Table 10).

Table 10

T test for Items within Management of Organizational Change Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to assess the need for organizational change	127	1.43	.650	24.859	126	.000
Understanding of how to integrate new organizational processes	127	1.44	.686	23.669	126	.000
Ability to implement organizational change	127	1.57	.719	24.551	126	.000
Ability to plan for and implement various forms of cross-functional teams and processes	127	1.53	.653	26.381	126	.000
Ability to assess and implement requisite changes in human resource management	125	1.82	.766	26.504	124	.000
Understanding of leadership strategies and methods	126	1.37	.574	26.688	125	.000

The median score for all of the items within the scale was 1.0, or “strongly agree,” with the exception of the ability to assess and implement requisite changes in human resource management, which had a median score of 2.0, or “somewhat agree.” Only 37.6%, or 47 respondents, “strongly agreed” that this item should be included in an undergraduate technology management program. See Appendix O for information about participants’ responses (frequencies and percentages) to the items associated with the Management of Organizational Change scale. A visual representation of the means of the items within the Management of Organizational Change scale is included in Figure 7.

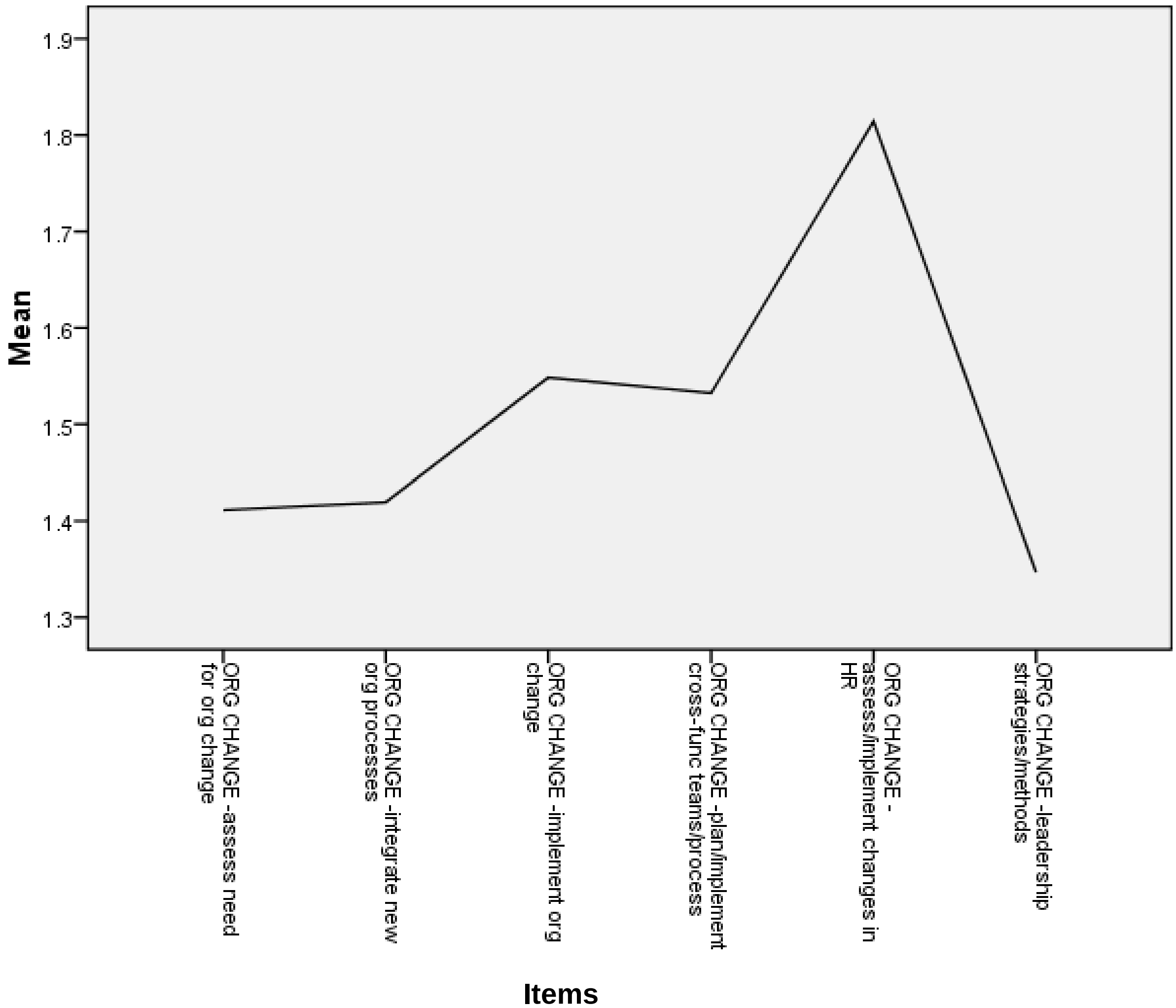

Figure 7: Management of Organizational Change Item Means

The means of the scale items ranged from 1.37 for understanding of leadership strategies and methods to 1.82 for ability to assess and implement requisite changes in human resource management. See Table 11 for the perceived level of importance of items within the Management of Organizational Change scale.

Table 11

Perceived Level of Importance of Items within Management of Organizational Change Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Understanding of leadership strategies and methods	126	1.37
2	Ability to assess the need for organizational change	127	1.43
3	Understanding of how to integrate new organizational processes	127	1.44
4	Ability to plan for and implement various forms of cross-functional teams and processes	127	1.53
5	Ability to implement organizational change	127	1.57
6	Ability to assess and implement requisite changes in human resource management	125	1.82

Once again, the respondents convincingly indicated that the undergraduate technology management curriculum should include a component on the management of organizational change. They maintained that graduates should be proficient in the following competencies, in the following priority order: strategies and methods of leading, assessing the need for organizational change, integrating new organizational change processes, using cross-functional teams/processes, implementing organizational change, and assessing and implementing innovative human resource management processes.

Technology Project Management

A one sample *t* test was completed for the Technology Project Management items. All items within the scale were found to be significant at the <.01 level. The scale had an overall Cronbach's Alpha of .869 (see Table 12).

Table 12

T test for Items within the Technology Project Management Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to plan and organize projects	127	1.25	.471	29.963	126	.000
Ability to implement projects effectively	127	1.31	.559	26.500	126	.000
Ability to work effectively with functional groups within the organization to plan and implement projects	127	1.31	.530	27.957	126	.000
Ability to schedule projects effectively and within the constraints of the organization	127	1.31	.559	26.500	126	.000
Ability to gather data on the task, schedule, budget, monitor and evaluate the total effort	127	1.30	.608	24.068	126	.000
Ability to reduce implementation costs of new projects	127	1.62	.745	24.549	126	.000
Ability to manage and lead the project team	127	1.35	.673	22.681	126	.000

The median score for the items within the scale were 1.0, or "strongly agree." See Appendix P for participants' responses (frequency and percentage) to items associated with the Technology Project Management scale. A visual representation of the means of the items within the Technology Project Management scale is included in Figure 8.

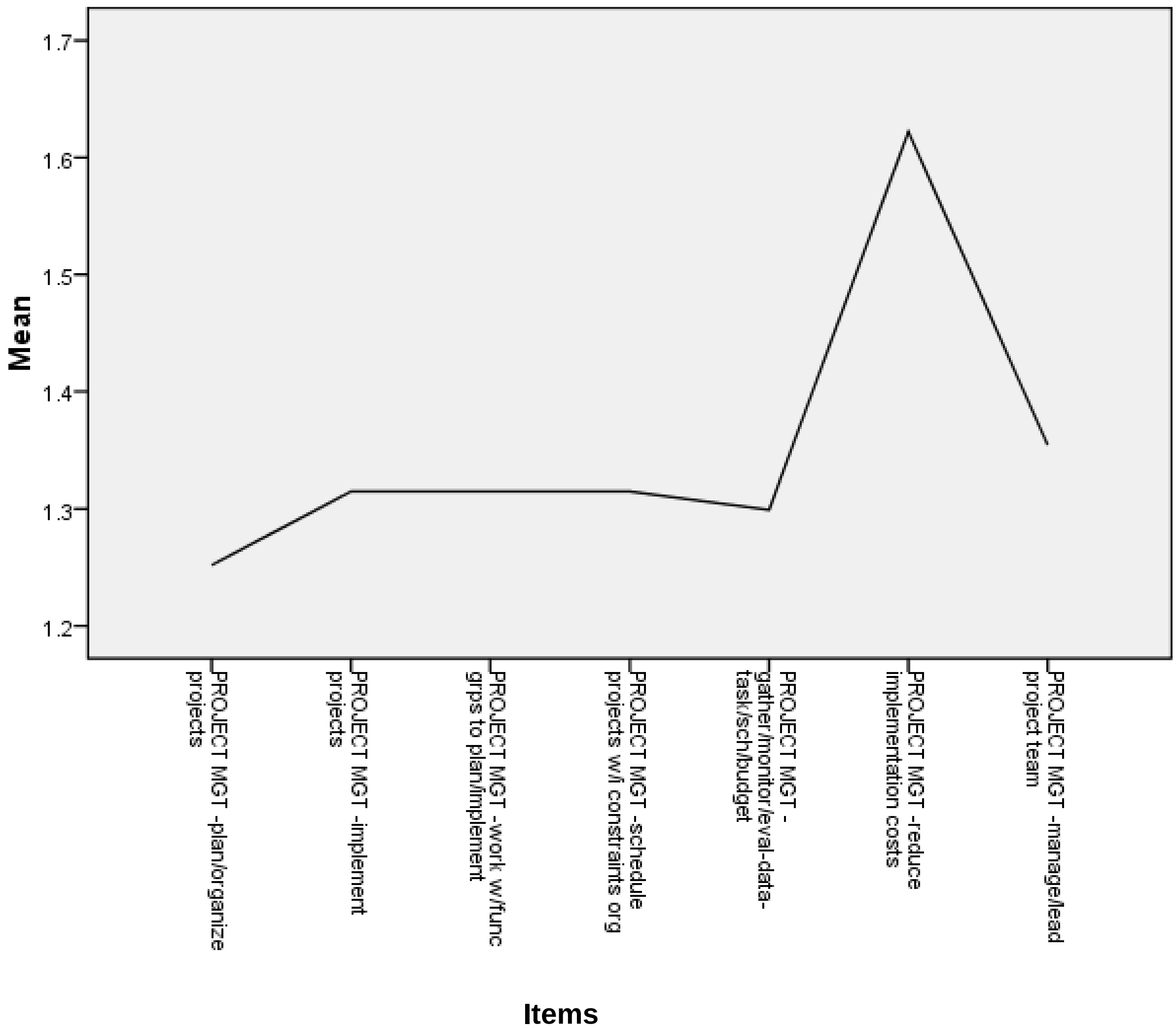

Figure 8: Management of Technology Project Management Item Means

The mean value of the scale items ranged from 1.25 for the ability to plan and organize projects to 1.62 for the ability to reduce implementation costs of new projects. Only one item in this scale, the ability to reduce implementation costs of new projects, had less than 71.7% of respondents who strongly agreed that the item should be included; this item had a 52.8% level of agreement. See Table 13 for the perceived level of importance of items within the Technology Project Management scale.

Table 13

Perceived Level of Importance of Items within Technology Project Management Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Ability to plan and organize projects	127	1.25
2	Ability to gather data on the task, schedule, budget, monitor, and evaluate the total effort	127	1.30
3	Ability to implement projects effectively	127	1.31
4	Ability to work effectively with functional groups within the organization to plan and implement projects	127	1.31
5	Ability to schedule projects effectively and within the constraints of the organization	127	1.31
6	Ability to manage and lead the project team	127	1.35
7	Ability to reduce implementation costs of new projects	127	1.62

Respondents considered technology project management to be the most important component of the undergraduate technology management curriculum. In this category, they maintained that these skills needed to be acquired by graduates (importance in the order listed): planning and organizing projects; data gathering; scheduling; budgeting, monitoring, and evaluating projects; project implementation; working effectively with functional groups; effective scheduling within organizational constraints; leading and managing the project team; and identifying cost savings when implementing new projects.

Assessment and Evaluation of Technology

A one sample *t* test was completed for the Assessment and Evaluation of Technology items. All eight items within the scale were found to be significant at the <.01 level, and the scale had an overall Cronbach's Alpha of .848 (see Table 14).

Table 14

T test for Items within the Assessment and Evaluation of Technology Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to assess training needs in association with the implementation of new technologies	126	1.54	.677	25.526	125	.000
Ability to assess cost and benefits of new technologies	127	1.49	.677	24.776	126	.000
Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies	127	1.50	.722	23.463	126	.000
Ability to assess the effects of technologies on society	127	1.83	.794	26.024	126	.000
Ability to identify technologies important to the business	127	1.32	.502	29.691	126	.000
Ability to anticipate how new technologies may effect the organization	126	1.39	.565	27.579	125	.000
Ability to assess the integrative effects of technology on the organization (customer, market, process, employee, vendor, and owner-related factors)	127	1.65	.717	25.993	126	.000
Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology	127	1.98	.913	24.407	126	.000

The median score for five of the eight items within the scale was 1.0, or “strongly agree,” and three of the items (ability to assess the integrative effects of technology on the organization, ability to assess the effects of technologies on society, and an understanding of Porter’s Five Forces Model) had a median value of 2.0, which equates to “somewhat agree.” See Appendix Q for information about the response frequencies and percentages associated with the Assessment and Evaluation of Technology scale. A visual representation of the means of the items within the Assessment and Evaluation of Technology scale is included in Figure 9.

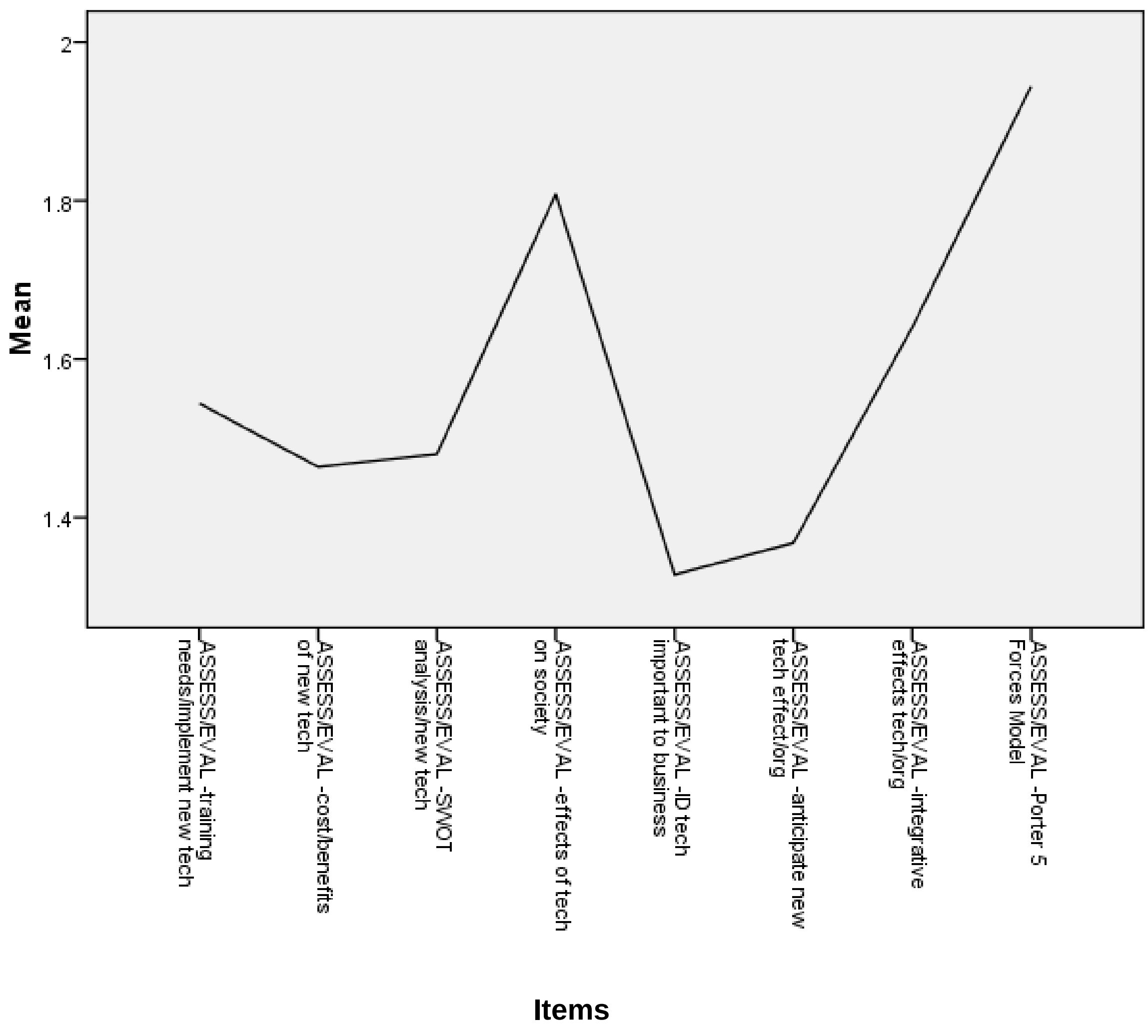

Figure 9: Assessment and Evaluation of Technology Item Means

The means of the scale items ranged from 1.32 for the ability to identify technologies important to the business to 1.98 for an understanding of Porter's Five Forces Model. See Table 15 for the perceived level of importance of items within the Assessment and Evaluation of Technology scale.

Table 15

Perceived Level of Importance of Items within the Assessment and Evaluation of Technology Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Ability to identify technologies important to the business	127	1.32
2	Ability to anticipate how new technologies may effect the organization	126	1.39
3	Ability to assess cost and benefits of new technologies	127	1.49
4	Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies	127	1.50
5	Ability to assess training needs in association with the implementation of new technologies	126	1.54
6	Ability to assess the integrative effects of technology on the organization (customer, market, process, employee, vendor, and owner-related factors)	127	1.65
7	Ability to assess the effects of technologies on society	127	1.83
8	Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology	127	1.98

Based on participants' responses, the undergraduate technology management curriculum should also include an emphasis on the assessment and evaluation of technology. Respondents agreed that the skills required of graduates should be as follows: identifying technologies that will have a significant impact on the organization, anticipating the effect of new technologies on business operations, using cost-benefit analysis when reviewing new technologies, conducting SWOT analysis, assessing technology training needs, assessing the integrative effects of technology on all aspects of the organization, determining the impact of new technologies on society, and understanding Porter's Five Forces Model in assessing technology.

Quality Management of Technology

A one sample *t* test was completed for the Quality Management of Technology items. All items within the scale were found to be significant at the <.01 level. The scale had an overall Cronbach's Alpha of .903 and the highest Cronbach's Alpha rating of all of the scales (see Table 16).

Table 16

T test for Items within the Quality Management of Technology Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to manage for quality outcomes	127	1.53	.722	23.848	126	.000
Ability to manage for performance excellence	127	1.50	.711	23.828	126	.000
Understanding of the tools used in process improvement	127	1.38	.590	26.321	126	.000
Understanding of the principles of Six Sigma	126	1.82	.804	25.374	125	.000
Understanding of the Baldridge criteria for quality	126	2.02	.858	26.381	125	.000
Understanding of the Deming philosophy of quality improvement	125	1.83	.801	25.585	124	.000
Understanding of ISO 9000 standards	127	1.94	.889	24.565	126	.000
Understanding of principles of total quality management (with a focus on customers and stakeholders, participation and teamwork by organization members, and continuous improvement and learning)	125	1.46	.629	25.894	124	.000
Ability to implement process improvement schemes	127	1.45	.651	25.076	126	.000

The median score for more than half (five) of the items within the scale was 1.0, or "strongly agree." The other four items were focused on specific quality management philosophies or methods (Six Sigma, Baldridge, Deming, and ISO 9000) and had a median value of 2.0, or "somewhat agree." Two of these four items (understanding of ISO 9000 standards and understanding of the Baldridge criteria for quality) had fewer than 39%, or 49, respondents who strongly agreed that these items should be included in an undergraduate technology management program. See Appendix R for participants' responses (frequency and percentage) to items associated with the Quality Management of Technology scale. A visual representation of the means of the items within the Quality Management of Technology scale is included in Figure 10.

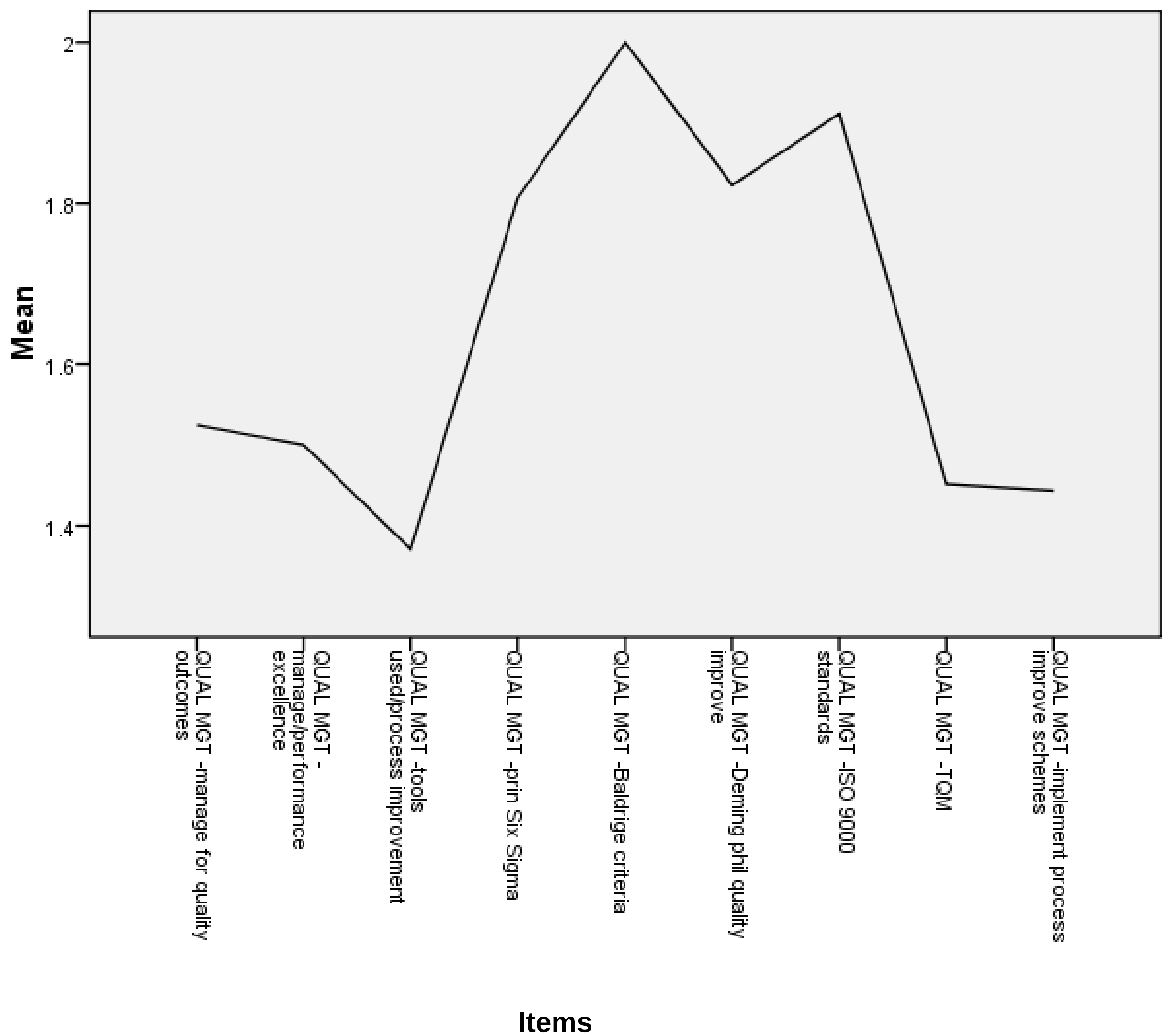

Figure 10: Quality Management of Technology Item Means

The mean values of the scale items ranged from 1.38 for an understanding of the tools used in process improvement to 2.02 for an understanding of the Baldridge criteria for quality. See Table 17 for the perceived level of importance of items within the Quality Management of Technology scale.

Table 17

Perceived Level of Importance of Items within Quality Management of Technology Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Understanding of the tools used in process improvement	127	1.38
2	Ability to implement process improvement schemes	127	1.45
3	Understanding of principles of total quality management (which has a focus on customers and stakeholders, participation and teamwork by organization members, and continuous improvement and learning)	125	1.46
4	Ability to manage for performance excellence	127	1.50
5	Ability to manage for quality outcomes	127	1.53
6	Understanding of the principles of Six Sigma	126	1.82
7	Understanding of the Deming philosophy of quality improvement	125	1.83
8	Understanding of ISO 9000 standards	127	1.94
9	Understanding of the Baldridge criteria for quality	126	2.02

Quality management of technology was yet another component of the undergraduate technology management curriculum respondents deemed essential for success in the profession. Participants went on to say that graduates should be able to demonstrate competence in the following skills (in the order listed): understanding of process-improvement tools; implementation of process-improvement strategies;

knowledge of total quality management, management for performance excellence, and quality outcomes; and familiarity with the principles of Six Sigma, Deming's quality management philosophy, ISO 9000 standards, and Baldridge criteria for quality.

Information and Knowledge Management

A one sample *t* test was completed for the Information and Knowledge Management items. All items within the scale were found to be significant at the <.01 level, and the scale had an overall Cronbach's Alpha of .888 (see Table 18).

Table 18

T test for Items within the Information and Knowledge Management Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	127	1.54	.676	25.743	126	.000
Ability to use online collaboration systems	127	1.49	.665	25.217	126	.000
Understanding of ethical, security, and privacy issues surrounding the use of electronic information	127	1.32	.533	27.981	126	.000
Ability to use and manage databases	127	1.46	.588	28.061	126	.000
Ability to use spreadsheets for quantitative analysis of information	127	1.35	.525	28.891	126	.000
Understanding of electronic commerce applications and principles	126	1.69	.774	24.509	125	.000
Understanding of information technology and system development	126	1.44	.663	24.311	125	.000
Ability to integrate and use information technology to increase the competitive stance of an organization	126	1.41	.623	25.447	125	.000
Understanding of business to business e-commerce	127	1.72	.786	24.619	126	.000

The median score for most (seven of nine) of the items within the scale was 1.0, or “strongly agree.” The two items with a median value of 2.0, or “somewhat agree,” were both related to e-commerce, specifically an understanding of electronic commerce applications and principles and an understanding of business-to-business e-commerce. See Appendix S for participant responses (frequencies and percentages) to the items associated with the Information and Knowledge Management scale. A visual representation of the means of the items within the Information and Knowledge Management scale is included in Figure 11.

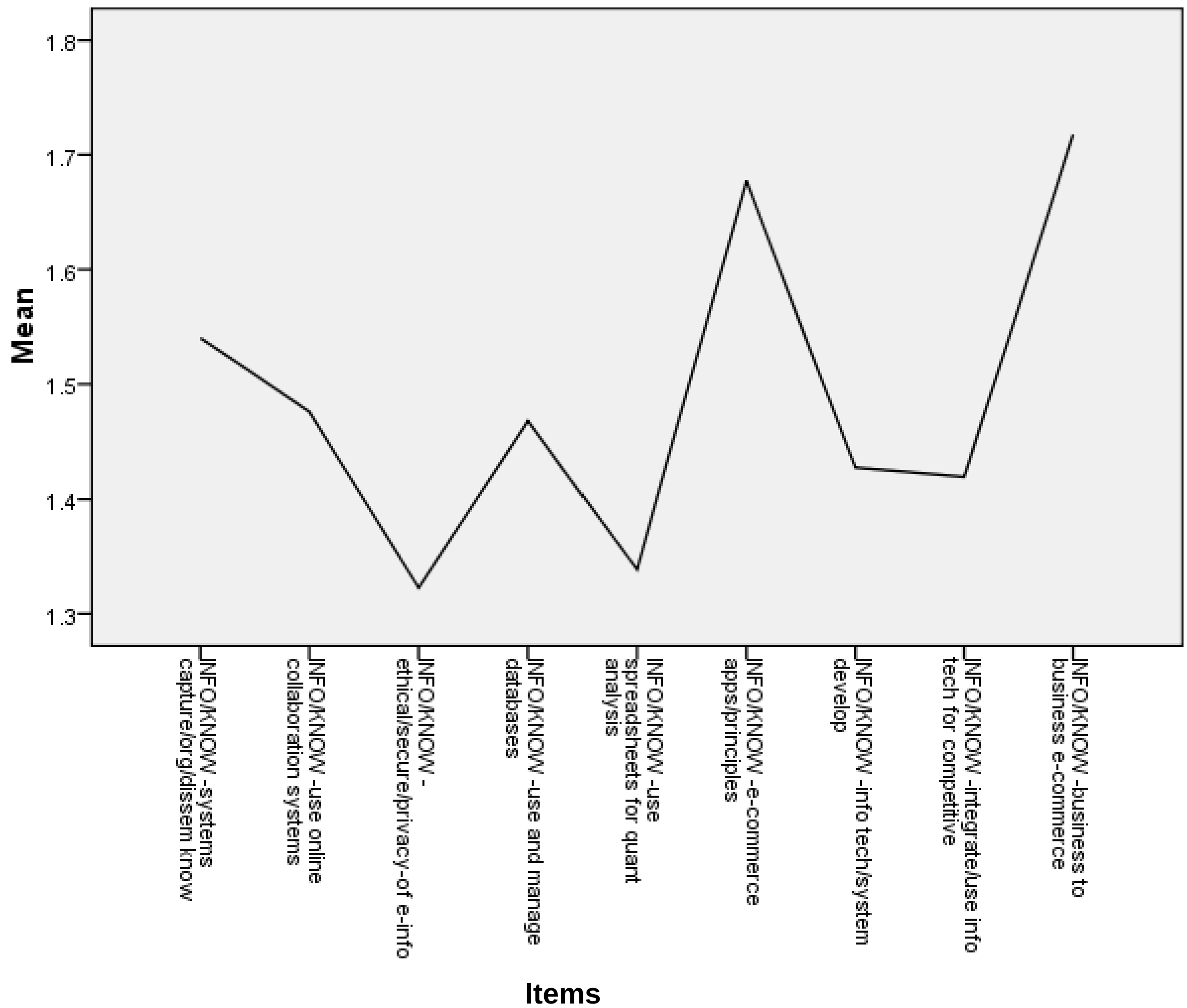

Figure 11: Information and Knowledge Management Item Means

The mean values of the scale items ranged from 1.32 for understanding of ethical, security, and privacy issues surrounding the use of electronic information to 1.72 for understanding of business-to-business e-commerce. Only one item, understanding of ethical, security, and privacy issues surrounding the use of electronic information, had greater than 70% (or 90) of respondents strongly agreeing that this item should be included in an undergraduate technology management program. See Table 19 for the perceived level of importance of items within the Information and Knowledge Management scale.

Table 19

Perceived Level of Importance of Items within the Information and Knowledge Management Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Understanding of ethical, security, and privacy issues surrounding the use of electronic information	127	1.32
2	Ability to use spreadsheets for quantitative analysis of information	127	1.35
3	Ability to integrate and use information technology to increase the competitive stance of an organization	126	1.41
4	Understanding of information technology and system development	126	1.44
5	Ability to use and manage databases	127	1.46
6	Ability to use online collaboration systems	127	1.49
7	Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	127	1.54
8	Understanding of electronic commerce applications and principles	126	1.69
9	Understanding of business-to-business e-commerce	127	1.72

Results indicate that the undergraduate technology management curriculum should also include a significant emphasis on information and knowledge management. As such, graduates should possess skills in these areas (in priority order as listed): understanding ethical, security, and privacy issues involved with electronic information; use of spreadsheets in quantitative analysis; use of information technology to enhance organizational competitiveness; understanding of information technology and system development; use and management of databases; use of online collaborative systems; use of knowledge management systems; and knowledge of electronic commerce applications/principles as well as business-to-business e-commerce.

Management of Innovation and Product Development

A one sample *t* test was completed for the four Management of Innovation and Product Development items. All items within the scale were found to be significant at the <.01 level. The scale had an overall Cronbach's Alpha of .803. See Table 20.

Table 20

T test for Items within the Management of Innovation and Product Development Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Understanding of the platform approach to product development	127	1.84	.771	26.940	126	.000
Ability to predict new product success	127	1.85	.788	26.477	126	.000
Understanding of processes used to launch new products	125	1.65	.687	26.823	124	.000
Ability to plan for and implement team-based management systems used in the development and launching of new products	127	1.59	.705	25.408	126	.000

The median value for three of the four items within the scale were 2.0, or "somewhat agree," and only one item had a median value of 1.0, or "strongly agree," for the ability to plan for and implement team-based management systems used in the development and launching of new products. See Appendix T for participant responses (frequencies and percentages) to items associated with the Management of Innovation and Product Development scale. A visual representation of the means of the items within the Management of Innovation and Product Development scale is included in Figure 12.

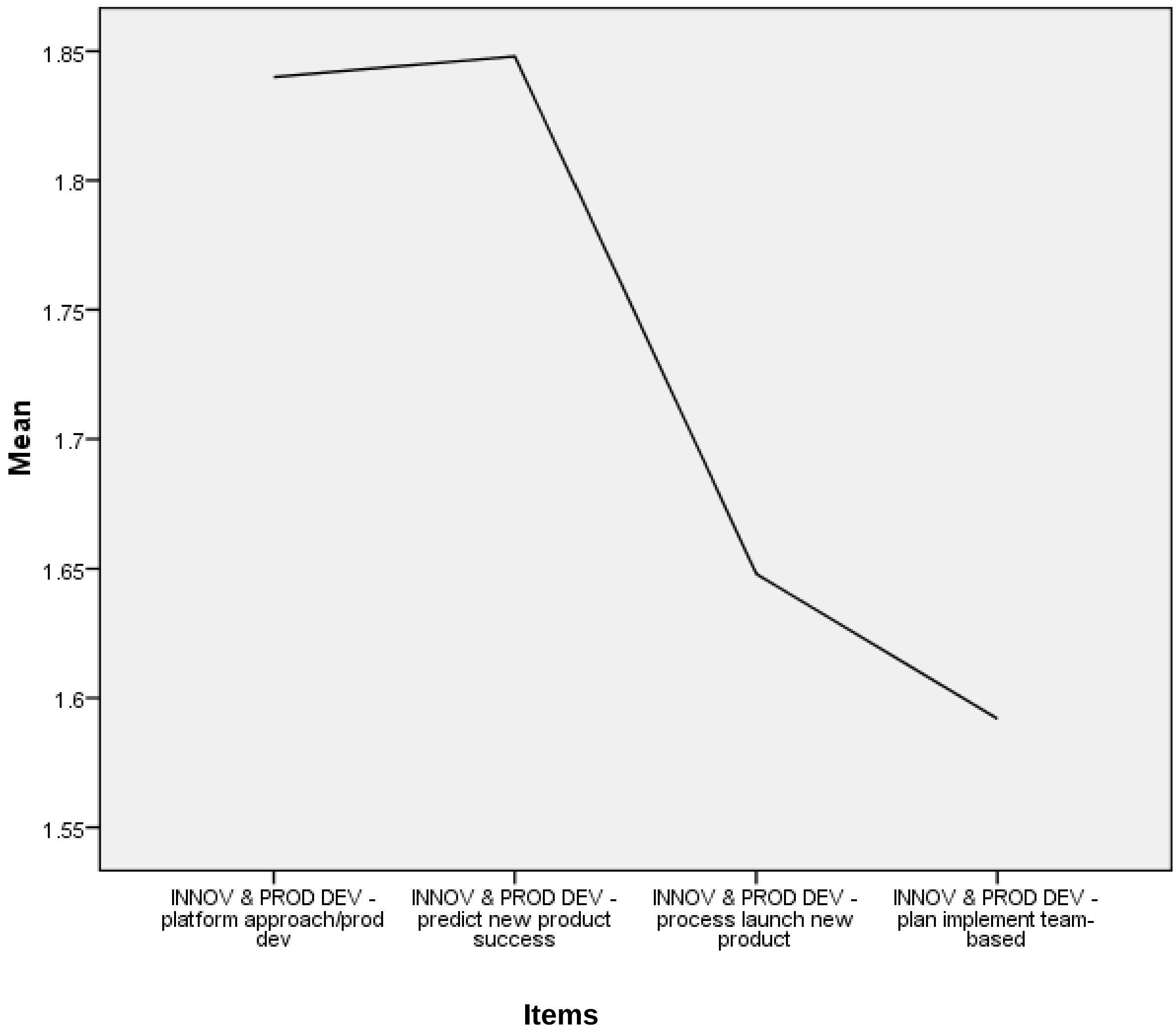

Figure 12: Management of Innovation and Product Development Item Means

The mean values of the scale items ranged from 1.59 for the ability to plan for and implement team-based management systems used in the development and launching of new products to 1.85 for an ability to predict new product success. Two items (an understanding of the platform approach to product development and the ability to predict new product success) had 37% or fewer respondents who strongly agreed that these items should be included as core competencies in an undergraduate technology management program. See Table 21 for the perceived level of importance of items within the Management of Innovation and Product Development scale.

Table 21

Perceived Level of Importance of Items within Management of Innovation and Product Development Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Ability to plan for and implement team-based management systems used in the development and launching of new products	127	1.59
2	Understanding of processes used to launch new products	125	1.65
3	Understanding of the platform approach to product development	127	1.84
4	Ability to predict new product success	127	1.85

According to respondents, information about the management of innovation and product development should also be included as a component of an effective undergraduate technology management curriculum. Participants reported that the elements of this component that should be translated into competencies for graduates were as follows (listed in order of priority): use of team-based management systems in developing and launching new products, knowledge of processes for launching new products, familiarity with platform approach to product development, and ability to predict new product success rates.

Strategic Management of Technology

A one sample *t* test was completed for the Strategic Management of Technology items. All items within the scale were significant at the <.01 level. The scale had an overall Cronbach's Alpha of .893 (see Table 22).

Table 22

T test for Items within the Strategic Management of Technology Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	*df*	Sig <.01 Level
Ability to develop an effective technology strategy for achieving competitive advantage	127	1.56	.742	23.690	126	.000
Ability to develop effective planning procedures for selecting new technology	127	1.46	.652	25.308	126	.000
Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	127	1.61	.735	24.745	126	.000
Ability to align the organization's structure and processes with its core technologies	127	1.56	.720	24.404	126	.000
Ability to create value through the use of technology	127	1.41	.622	25.547	126	.000

The median score for all of the items within the scale was 1, or "strongly agree." See Appendix U for responses (frequencies and percentages) for items associated with the Strategic Management of Technology scale. A visual representation of the means of the items within the Strategic Management of Technology scale is included in Figure 13.

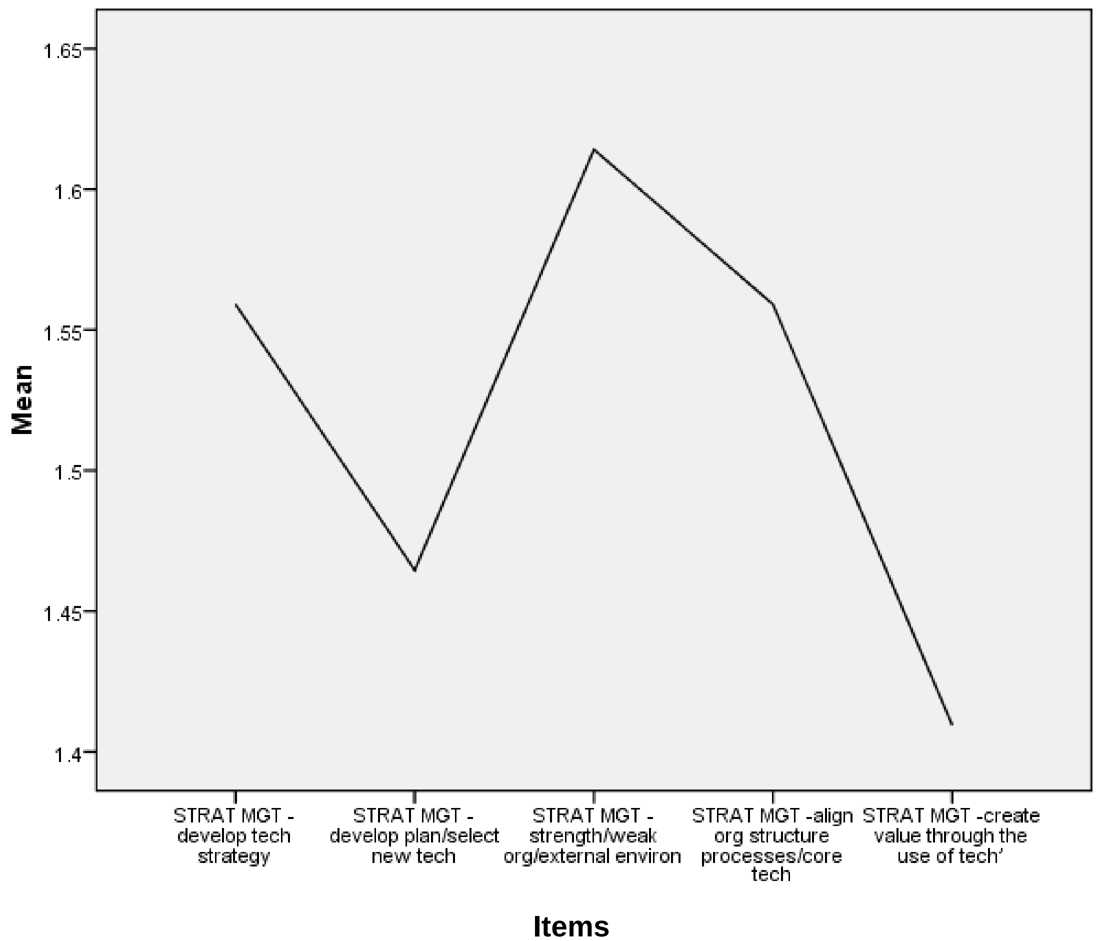

Figure 13: Strategic Management of Technology Item Means

The mean value of the scale items ranged from 1.41 for the ability to create value through the use of technology to 1.61 for an ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization. See Table 23 for the perceived level of importance of items within the Strategic Management of Technology scale.

Table 23

Perceived Level of Importance of Items within Strategic Management of Technology Scale

Perceived Level of Importance	Item	Number of Respondents	Mean
1	Ability to create value through the use of technology	127	1.41
2	Ability to develop effective planning procedures for selecting new technology	127	1.46
3	Ability to develop an effective technology strategy for achieving competitive advantage	127	1.56
4	Ability to align the organization's structure and processes with its core technologies	127	1.56
5	Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	127	1.61

Research Question 3: *Do any differences exist between industry sectors (business services, education, government, and manufacturing) and their representatives' perceptions of the relative importance of the eight core competency areas?*

A one-way analysis of variance procedure was performed on the weighted values of the eight scales to determine if any differences existed in the perceived level of agreement between industry sectors. Weighted values were used to ensure a common frame of reference in the data analysis. The results of the one-way analysis of variance for all scales are included in Appendix V.

Responses to only one scale (Information and Knowledge Management) were significantly different at the <.015 level between industry sectors. Specifically, a difference was noted between respondents from the business services sector, which had a weighted mean value of 1.3086, and the manufacturing sector with a weighted mean value of 1.7222. Respondents from the business services sector considered information and knowledge management to be an important component of an undergraduate technology management curriculum, whereas respondents from the manufacturing sector indicated a lower level of importance for the area. See Table 24 for the analysis of variance results for the weighted Information and Knowledge Management scale.

Table 24

Analysis of Variance Results for the Weighted Information and Knowledge Management Scale

		Sum of Squares	*df*	Mean Square	*F*	p*
Information and Knowledge Management	Between Groups	2.224	3	.741	3.656	0.015*
	Within Groups	23.726	117	.203		
	Total	25.951	120			

**Significant at the <.05 level*

Hochberg's GT2 post-hoc procedure and the Games-Howell procedure were also performed on the data. Hochberg's GT2 is a "pairwise test procedure...designed to cope with situations in which sample sizes are different" (Field, 2005, p. 341). Because the sample size of the government sector (51 respondents) was more than twice as large as the sample sizes from the education sector (23 respondents) and the manufacturing sector (21 respondents), the Hochberg GT2 procedure was chosen for this analysis. The Games-Howell procedure was run in conjunction with the Hochberg's GT2 test because of the uncertainty of equal population variances. Both of these procedures were recommended by Field (2005) for use in circumstances where an unequal sample size exists.

Hochberg's GT2 procedure indicated a significant difference at the <.014 level between the manufacturing sector and the business services sector on the Information and Knowledge Management scale. The Games-Howell procedure also supported this statistical difference at the .025 level. A visual representation of the differences in weighted means between the four industry sectors is included in Figure 14. See Appendix V for the detailed statistical analysis results.

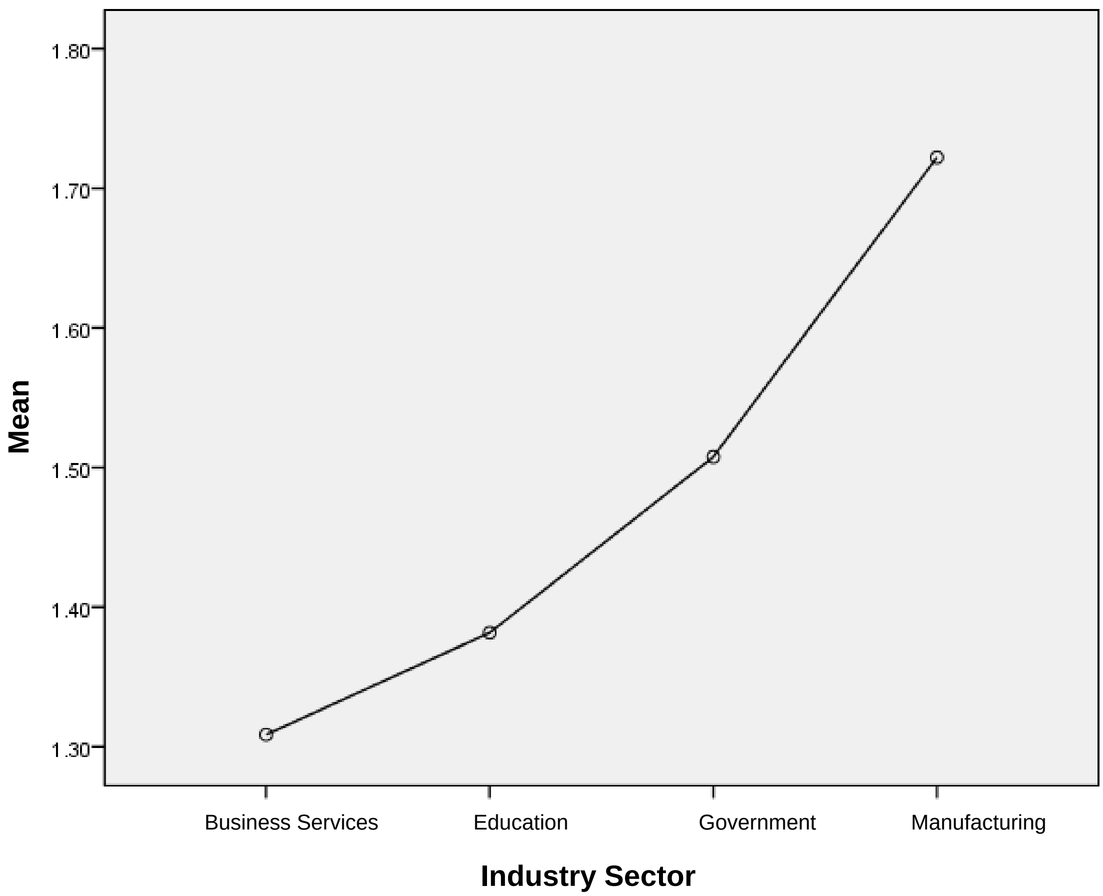

Figure 14: Weighted Means of the Information and Knowledge Management Scale by Industry Sector

Research Question 4: *Do any differences exist between industry sectors and their representatives' perceptions of the items within each of the core-competency areas?*

A one-way analysis of variance procedure was performed on the mean values of each item within the eight scales to determine if differences existed in the perceived level of agreement between representatives from the four industry sectors. In addition, two post-hoc procedures were performed on the items within each of the scales: Hochberg's GT2 and Games-Howell. A significance level of $p=<.05$ for all three (i.e., analysis of variance, Hochberg's GT2, and Games-Howell) of these procedures was deemed necessary to indicate significant statistical differences between industry sectors by this researcher. Based on these criteria, significant differences were found between representatives of industry sectors within the following four scales: (a) management of technological change, (b) assessment and evaluation of technology, (c) quality management of technology, and (d) information and knowledge management. Appendix V contains a display of the one-way analysis of variance results for all items within each of these four scales; in addition, the results of the post-hoc procedural tests, which document multiple comparisons of data, are presented. Each of these areas will be addressed in detail in the following sections.

Management of Technological Change

A one-way analysis of variance procedure revealed that responses to one item (the ability to assess the need for technological change) in the Management of Technological Change scale were significantly different between participants by industry sector at the $p=.044$ level (see Table 25).

Table 25

Results of the Analysis of Variance for the Ability to Assess the Need for Technological Change

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to assess the need for technological change	Between Groups	2.934	3	.978	2.778	0.044*
	Within Groups	42.251	120	.352		
Total		45.185	123			

**Significant at the <.05 level.*

Differences in perceived level of importance were noted between respondents from the business services sector, who reported a mean value of 1.21, and representatives of the manufacturing sector, who registered a mean value of 1.62. However, the post-hoc tests failed to support the statistical significance of the finding. Specifically, the results of the Hochberg's GT2 procedure showed a lack of statistical significance at the p=.096 level, and the Games-Howell procedure indicated a lack of statistical significance at the p=.120 level for the item. Figure 15 includes a visual plot of the means for this item.

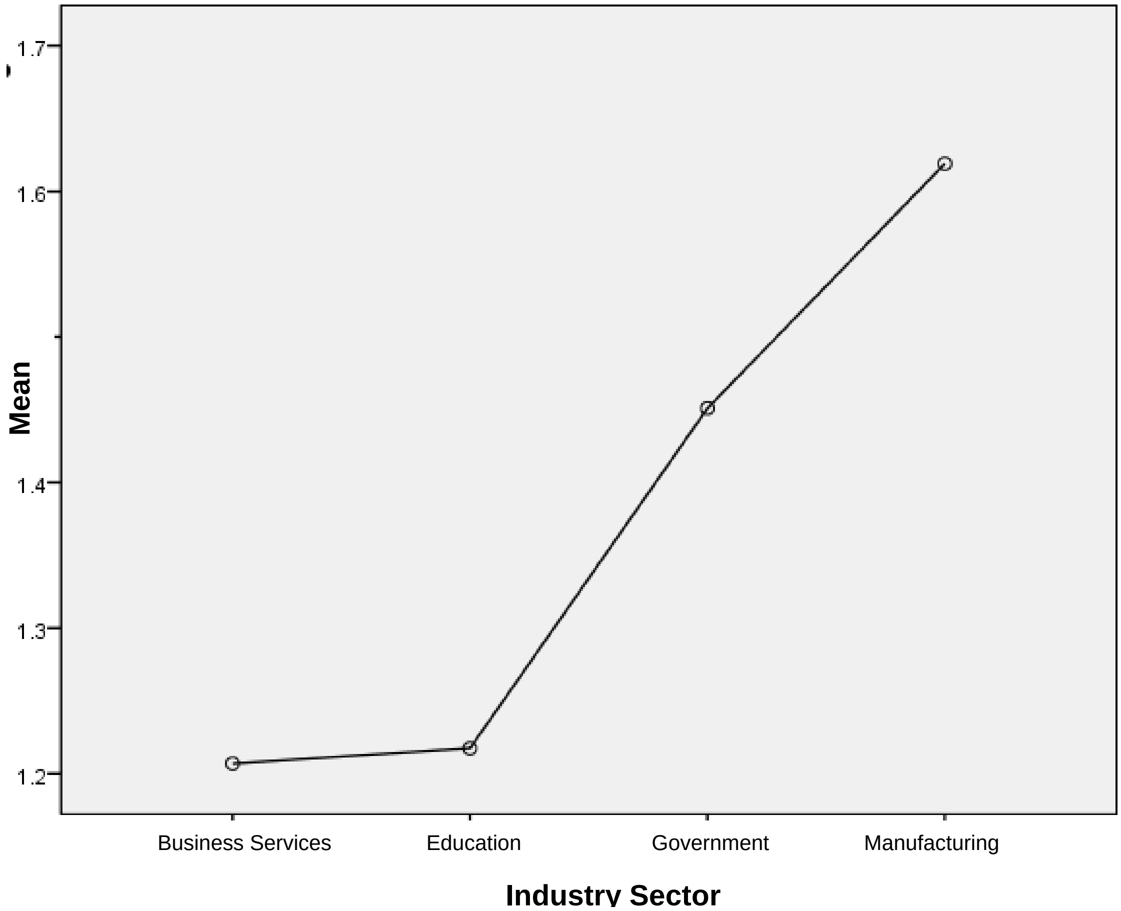

Figure 15: Means of Ability to Assess the Need for Technological Change by Industry Sector

Assessment and Evaluation of Technology

The one-way analysis of variance results indicated that responses to only one item (the ability to assess the effects of technologies on society) produced a significant difference between representatives of industry sectors at the p=.028 level in the Assessment and Evaluation of Technology scale. A specific difference was found between the business services sector participants, whose mean value for the item was 1.52, and respondents from the education sector, whose mean value was 2.17 (see Table 26 for specific data). Application of Hochberg's GT2 and Games-Howell post-hoc tests produced support for the significant difference at p=.018 and p=.041, respectively.

Table 26

Analysis of Variance Results for the Ability to Assess the Effects of Technologies on Society

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to assess the effects of technologies on society	Between Groups	5.702	3	1.901	3.151	.028*
	Within Groups	72.394	120	.603		
Total		78.097	123			

**Significant at the <.05 level.*

Consequently, these results indicate that respondents from the business services sector placed greater importance on the inclusion of information about the ability to assess the effects of technology on society than did education sector respondents. See Figure 16 for a visual representation of the mean values for this item.

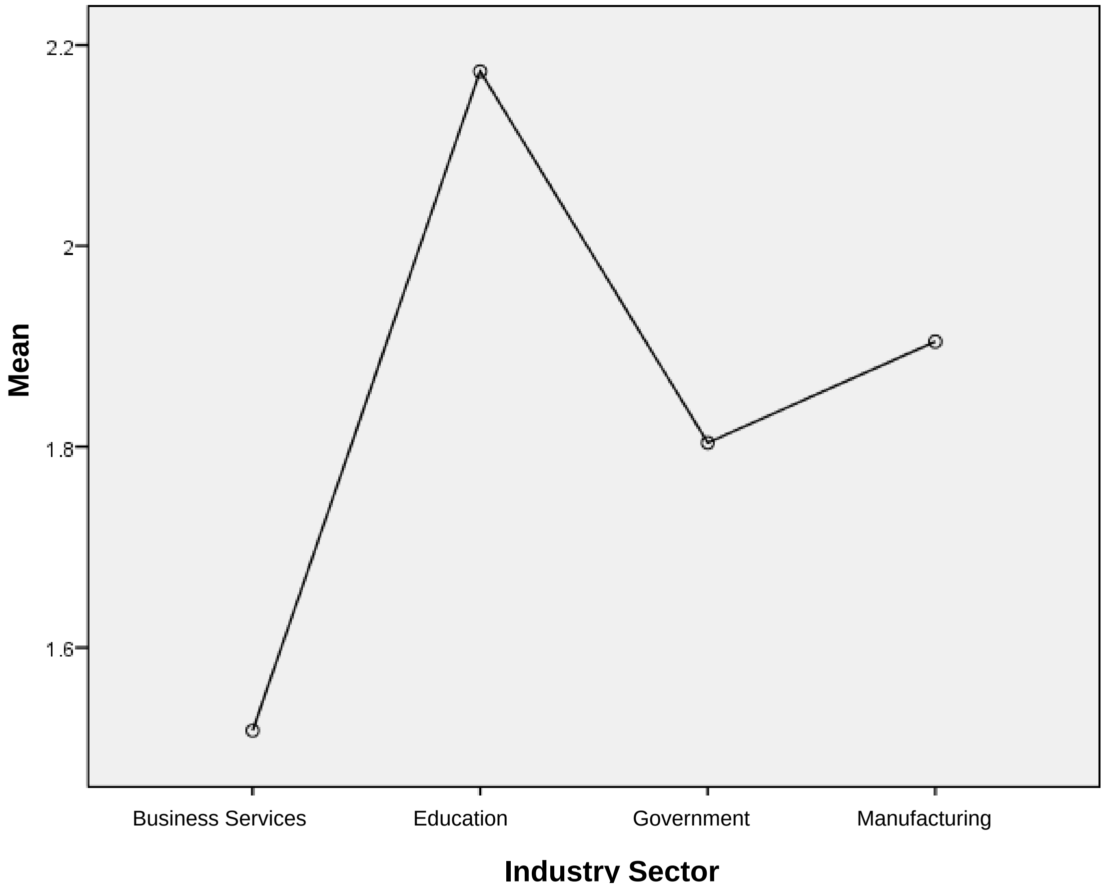

Figure 16: Means of Ability to Assess the Effects of Technologies on Society by Industry Sector

Quality Management of Technology

Once again, one-way analysis of variance procedure revealed that responses to two items within the Quality Management of Technology scale (an understanding of the tools used in process improvement and an understanding of ISO 9000 standards) produced significant differences between respondents from different industry sectors. Both of the differences occurred between representatives of the business services sector and the government sector. Specifically, participants from the business services sector scored a mean value of 1.17, and respondents from the government sector reported a mean value of 1.51 for understanding of the tools used in process improvement. For understanding of ISO 9000 standards, business services sector participants registered a mean value of 1.52 and government sector representatives scored a mean value of 2.08. See Table 27 for the analysis of variance results for both items.

Table 27

Analysis of Variance Results for Understanding of the Tools Used in Process Improvement and Understanding of ISO 9000 Standards

		Sum of Squares	*df*	Mean Square	*F*	*p**
Understanding of the Tools Used in Process Improvement	Between Groups	3.151	3	1.050	3.149	0.028*
	Within Groups	40.034	120	.334		
Total		43.185	123			
Understanding of ISO 9000 Standards	Between Groups	7.028	3	2.343	3.041	0.032*
	Within Groups	92.456	120	.770		
Total		99.484	123			

**Significant at the <.05 level.*

Hochberg's GT2 procedure did not support the existence of a significant difference between participants from the business services and government sectors on understanding of the tools used in process improvement in that only a $p=.077$ was produced. Yet the results of the Games-Howell procedure documented a significant difference at $p=.05$ for this item between the identified industry sectors. See Figure 17 for a visual representation of the means between industry sectors for this item. Consequently, the analysis does not support the finding of significant statistical differences between industry sectors for this item.

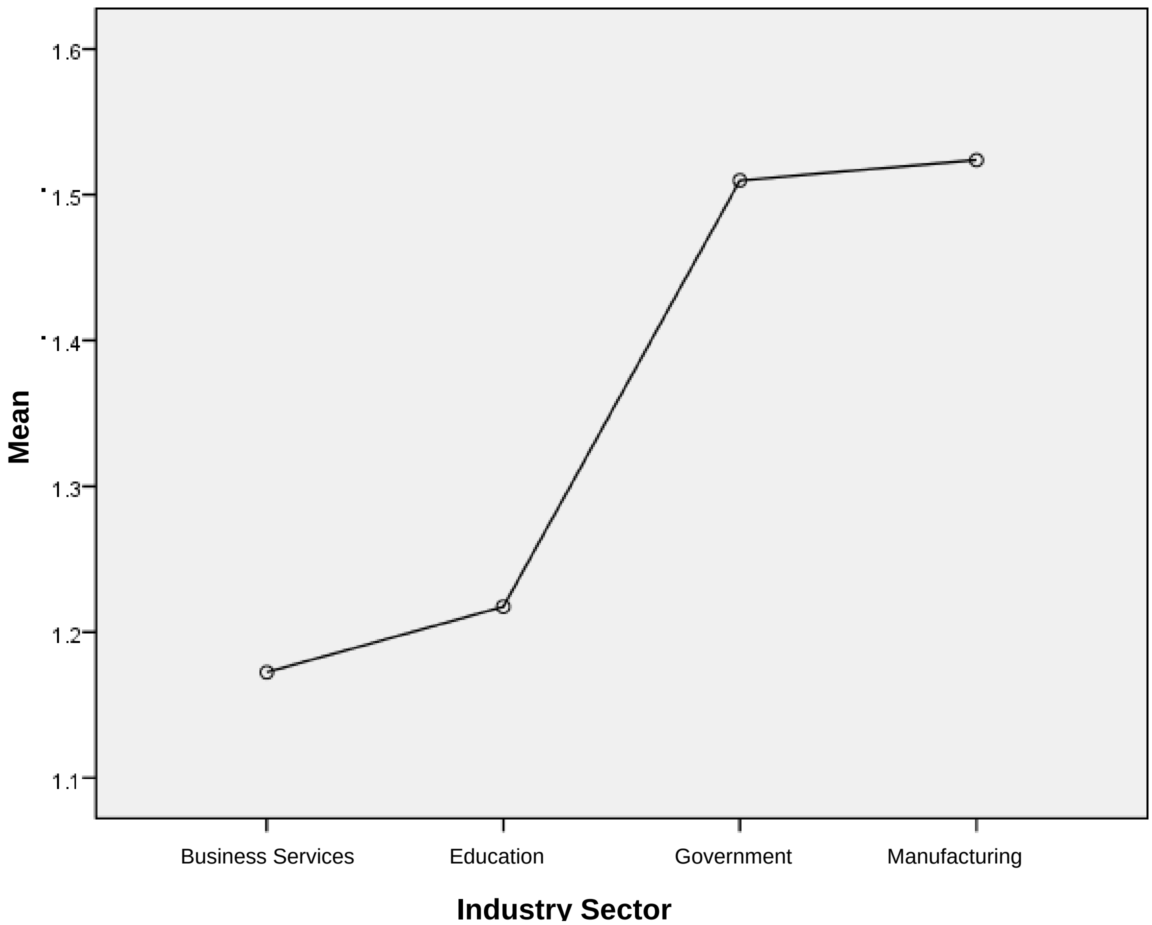

Figure 17: Mean Values of Understanding of the Tools Used in Process Improvement by Industry Sector

The results of applying Hochberg's GT2 and Games-Howell procedures did, however, support the finding of a significant difference between the responses of business service and government sector participants on understanding of ISO 9000 standards, with p=.041 and p=.018, respectively. Therefore, respondents from the business services sector agreed more strongly that ISO 9000 standards should be included in an undergraduate technology management curriculum than did respondents from the government sector. See Figure 18 for the means plot between industry sectors for this item.

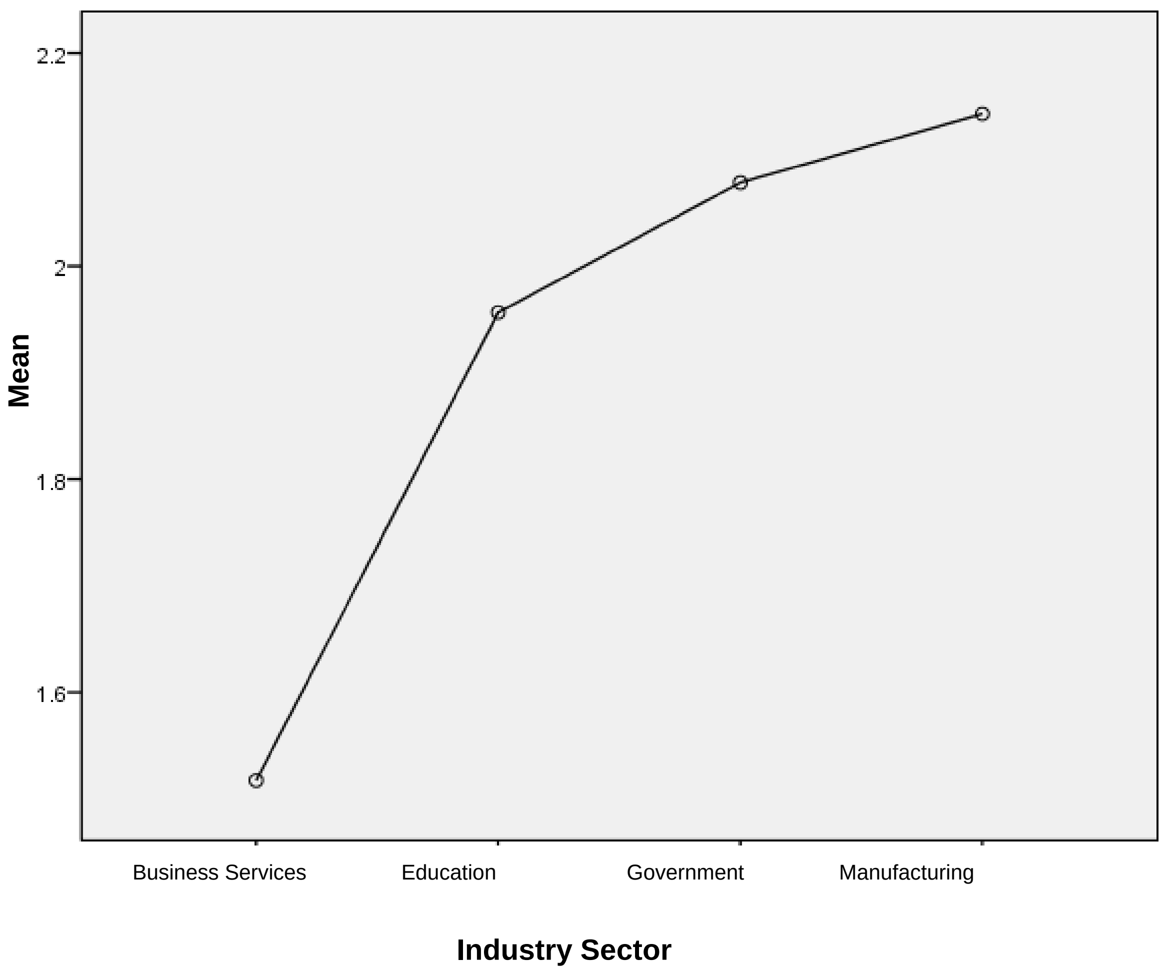

Figure 18: Means of the Understanding of ISO 9000 Standards by Industry Sector

Information and Knowledge Management

Responses to the Information and Knowledge Management scale items produced the most differences between industry sector representatives. In fact, significant differences were found between respondents from different industry sectors on the following three items: (a) ability to use online collaboration systems, with p=.024; (b) ability to use and manage databases, with p=.024; and (c) understanding of electronic commerce applications and principles, with p=.043. In addition, differences between industry sector participants were found at the p=.052 for ability to use spreadsheets for quantitative analysis of information. See Table 28 for the analysis of variance results for these five items.

Table 28

Analysis of Variance Results for Selected Items within the Information and Knowledge Management Scale

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to use online collaboration systems	Between Groups	3.844	3	1.281	3.275	0.024*
	Within Groups	46.954	120	.391		
Total		50.798	123			
Ability to use and manage databases	Between Groups	3.239	3	1.080	3.270	0.024*
	Within Groups	39.632	120	.330		
Total		42.871	123			
Ability to use spreadsheets for quantitative analysis of information	Between Groups	1.975	3	.658	2.652	0.052*
	Within Groups	29.799	120	.248		
Total		31.774	123			
Understanding of electronic commerce applications and principles	Between Groups	4.788	3	1.596	2.799	0.043*
	Within Groups	67.846	119	.570		
Total		72.634	122			

**Significant at the <.05 level.*

Differences between research participants from the business services sector and the manufacturing sector were noted on ability to use online collaboration systems.

Specifically, the business services sector respondents reported a higher level of importance for this item, with a mean value of 1.28, than the representatives of the manufacturing sector, who recorded a mean value of 1.81. Application of Hochberg's GT2 post-hoc test produced support for a significant difference with p=.021. However, the level of significance dropped to p=.059 when the Games-Howell procedure was performed and statistical significance between the industry sectors was not verified (see Figure 19).

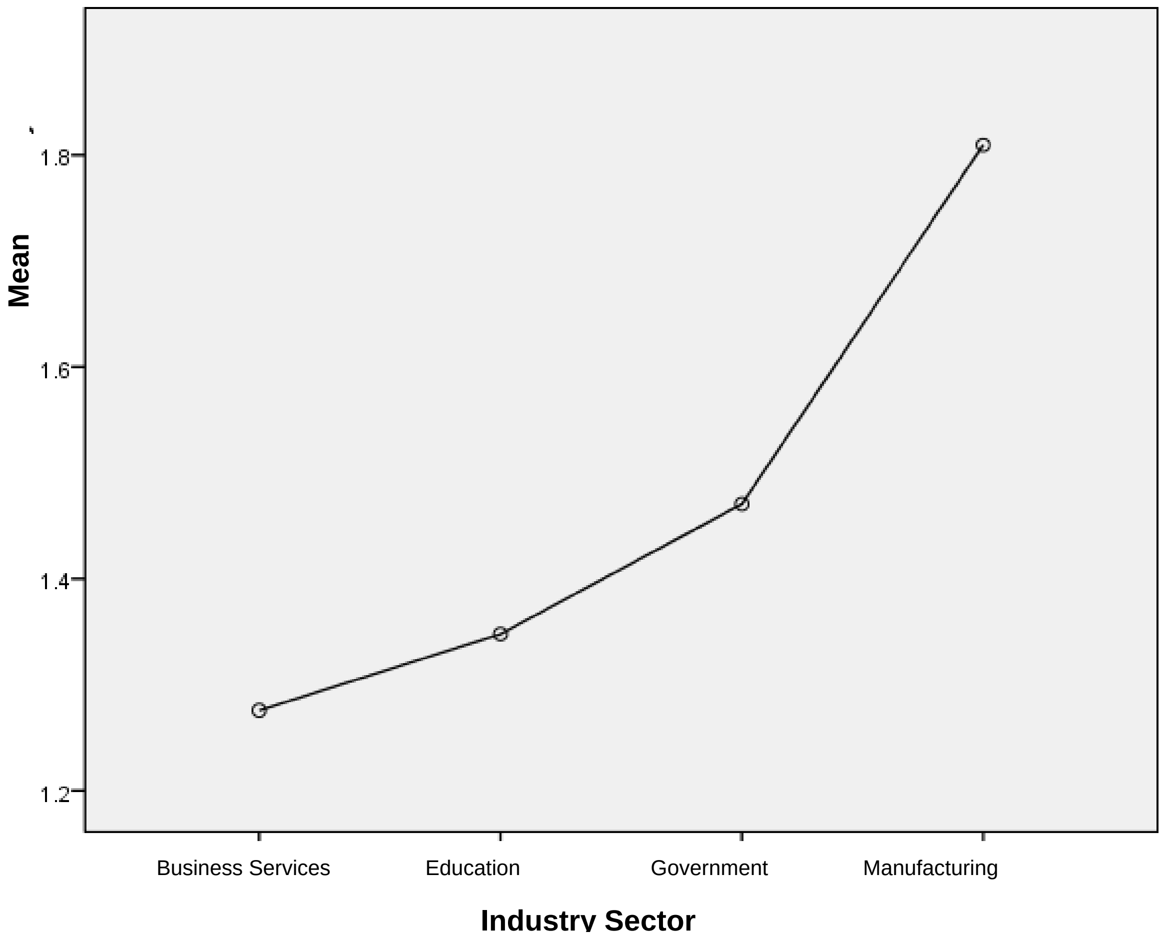

Figure 19: Mean Values of the Ability to Use Online Collaboration Systems by Industry Sector

Although the results of the one-way analysis of variance indicated that significant differences existed between industry sector representatives for ability to use and manage databases, these differences were not supported when the post-hoc procedures were performed. A mean value of 1.31 was reported by respondents from the business services sector, and a mean value of 1.71 was indicated by participants from the manufacturing sector. The results of Hochberg's GT2 procedure showed significance with p=.089 for this item, and the Games-Howell level was even lower, with p=.151. Figure 20 depicts the mean value between industry sectors for this item.

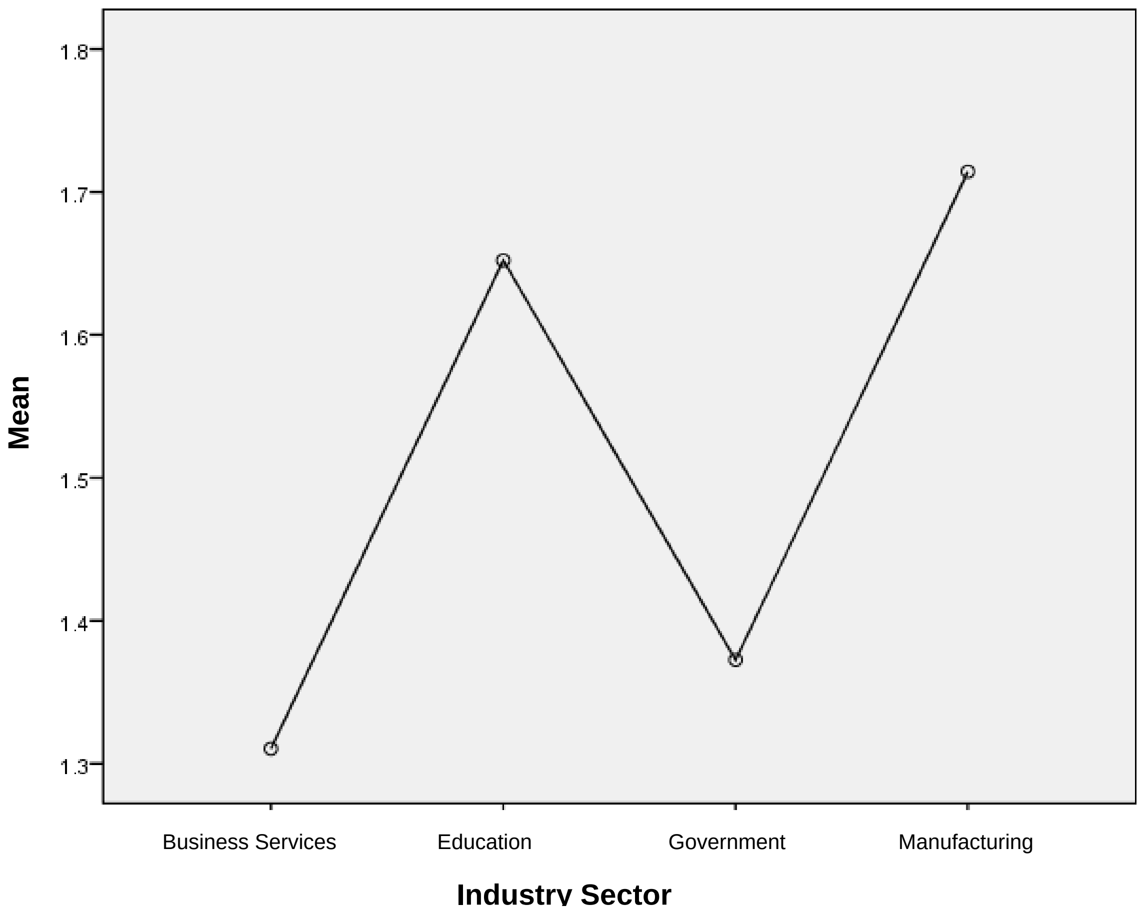

Figure 20: Mean Values of the Ability to Use and Manage Databases by Industry Sector

The results of the one-way analysis of variance on the ability to use spreadsheets for quantitative analysis of information indicated a level of significance of .052. Neither post-hoc test produced support for findings of significance between groups. See Figure 21 for details.

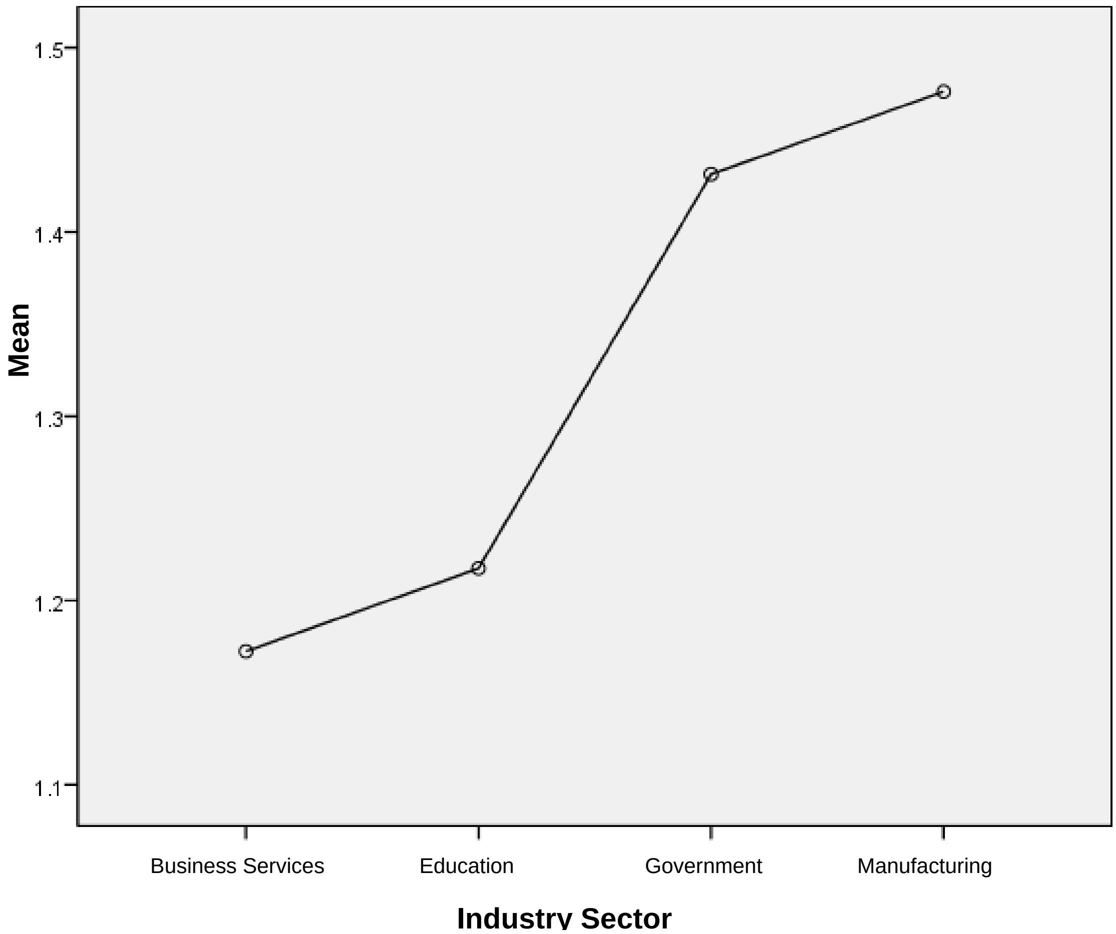

Figure 21: Means of the Ability to Use Spreadsheets for Quantitative Analysis of Information by Industry Sector

For understanding of e-commerce applications and principles, significant differences were found using the one-way analysis of variance procedure. However, only the Games-Howell post-hoc test supported this finding, with p=.039 between participants from the manufacturing and business services sectors. The Hochberg’s GT2 post-hoc test results indicated lack of significant difference between these two industry sectors, with p=.067. The mean values for this item were 1.54 for respondents from the business services sector and 2.10 for contributors from the manufacturing sector. See Figure 22 for additional information.

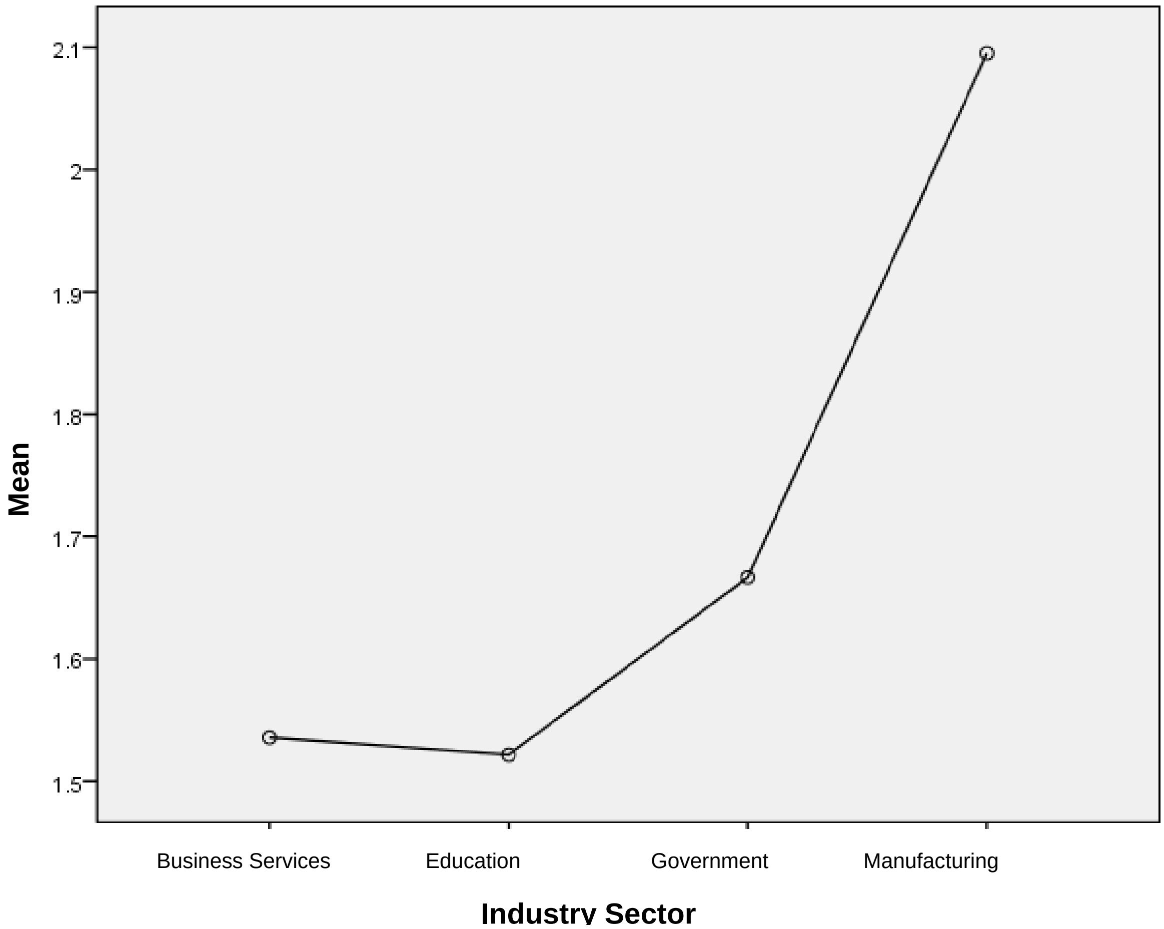

Figure 22: Means of the Understanding of Electronic Commerce Applications and Principles by Industry Sector

CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH AND ACTION

The ability to manage technology is critical for economic success in today's rapidly changing, technologically based business environment (Thamhain, 2005); this requirement has resulted in a fundamental need for technology management education programs (Badawy, 1998; Khalil & Yanez, 2006; van Wyk, 2004). Even though the establishment of academic programs in undergraduate technology management continues (Fortino, 2006), minimal research has been focused on this area. Therefore, this exploratory descriptive research study was conducted to determine the core curricular elements of an effective undergraduate technology management program. In this chapter, summary information about the topic will be provided, and conclusions reached from data collected will be presented. The researcher will then make recommendations for further research and action.

Summary

Technological changes have been a driving force in economic development (Burke, 2003; U.S. National Science and Technology Council, Office of Technology Policy, 1996), and the need for competent employees who have technical, scientific, and professional skills is expected to increase by 28.4% by 2014 (U.S. Department of Labor, Bureau of Labor Statistics, 2005). Obtaining higher education degrees is a critical factor in preparing employees for productive positions in a changing technologically based environment (Council for Adult and Experiential Learning, 2008), and the hiring of graduates with baccalaureate degrees is projected to increase (Casner-Lotto & Barrington, 2006). Career-focused programs, such as technology management, make up approximately 60% of all undergraduate degrees awarded (Hudson & Carey, 2005), and enrollments in higher education institutions are projected to increase in the next 10 years (U.S. Department of Education, 2007). Extensive agreement exists about the need for technology management education programs (Badawy, 1998; Herink et al., 1987; Khalil & Yanez, 2006; Nambisan & Wilemon, 2003; van Wyk, 2004).

The evolving discipline of technology management has experienced significant growth in terms of the number of academic programs offered in the past 20 years (Kocaoglu et al., 2003). Some problems, however, still exist in defining the field of study (Thamhain, 2005; van Wyk, 2004). A Classification of Instructional Programs (CIP) code for technology management programs in the taxonomic structure used by the U.S. Department of Education's National Center for Education Statistics (2002) does not exist, although a CIP code for engineering management is available. According to most researchers, engineering management and technology management are two distinct disciplines (Badawy, 1998; Herink, et al., 1987; Nambisan & Wilemon, 2004; Thamhain, 2005); however, some researchers consider them to be the same area of interest (Alvear, Guillermo, Hernandez, & Kocaoglu, 2006; Daim et al., 2007). The lack of a dedicated CIP code and the questionable combining of these two fields are impediments to the discipline of technology management.

The issues and responsibilities related to the field of technology management were delineated by Herink et al. in 1987, and recent efforts by researchers to define a common body of knowledge in technology management have occurred (van Wyk, 2004; Yanez, 2006). An assortment of curriculum development models has been used by faculty members in designing technology management programs, including Badawy's

(1998) alternative model for graduate technology management education, van Wyk's (2004) template for graduate programs in the management of technology, and Klingenberg and Rothberg's (2006) vision-driven approach. Nambisan and Wilemon (2004) recommended that leaders from industry should be involved in defining the curriculum for technology management programs. These four areas emerged in the research and suggest a way courses can be grouped: (a) technology management-related courses, (b) corporate functionality-related courses, (c) technology-specific courses, and (d) foundational courses. This study focused exclusively on core competencies in technology management; competencies related to corporate functionality and foundational knowledge were not addressed, nor were technology-specific competencies.

Many professional organizations associated with the technology management discipline exist, including the Academy of Management (AOM) Division of Technology and Innovation Management (TIM), the Engineering and Technology Management Education and Research Council (ETMERC), the International Association for Management of Technology (IAMOT), the Portland International Center for the Management of Engineering and Technology (PICMET), and the Technology Management Education Association (TMEDA). Two accrediting agencies are active in the discipline, the Association to Advance Collegiate Schools of Business and the National Association of Industrial Technology, and IAMOT is in the process of becoming an accrediting body for technology management graduate programs (IAMOT, 2007). In addition to the professional organizations associated with technology management, numerous publications and journals are devoted to the field of study.

Although little research exists on academic offerings at the undergraduate level in technology management, programs are being established at an increasing rate, and the number is expected to continue to grow (Fortino, 2006). The scarcity of research on undergraduate technology management education has contributed to the fragmented nature of the coursework required in these programs and the lack of a cohesive, recognizable curriculum at this level. Only 28% of (or 5) undergraduate programs even require a course in their curriculum with the words *technology management* in their title (Becker, 2007), and only these five courses in undergraduate technology management programs met a 50% commonality criterion: (a) accounting, (b) marketing, (c) organizational behavior, (d) quality, and (e) statistics (Becker, 2007).

At the undergraduate level, two types of degrees are awarded in technology management education programs: a bachelor of science degree and a bachelor of applied science degree. Some of the bachelor of applied science degrees are conferred by community colleges, and debate continues about the appropriateness of community colleges offering baccalaureate degrees. Most of the undergraduate technology management programs (72%, or 13 programs) did, however, accept transfer credit in the form of technical coursework and general education requirements from community colleges.

Many new academic programs are being established in higher education to meet needs presented by frequently changing economic conditions, global and instantaneous communications, and technological updates. For instance, approximately 750 programs were added to the CIP taxonomic structure compiled by the National Center for Education Statistics (U.S. Department of Education, National Center for Education

Statistics, 2002). Of those new programs, 37 contained the term *management* in their titles. Much of the growth in program establishment is likely attributed to new technologies. The use of distance education (Internet-based delivery of courses) is also becoming increasingly popular in higher education settings and in technology management programs (Alvear, Rueda, Hernandez, & Kocaoglu, 2006; U.S. Department of Education, National Center for Education Statistics, 2005).

Career-focused professional and occupational undergraduate programs make up the majority (59.9%) of degrees conferred at the undergraduate level (Hudson & Carey, 2005). Societal influences, such as the expansion of technological capabilities, directly affect these career-focused programs (Stark & Lattuca, 1997). Technology management educational programs that developed as a direct result of changing societal needs (Badawy, 1998; Herink et al., 1987) are considered career-focused programs. Naturally, technology management programs must be responsive to changing economic and societal needs in order to be considered effective (Dickeson, 1999).

In addition to being responsive to societal and economic shifts, undergraduate and graduate technology management programs must be intimately tied to the institutional mission of the college or university in which they reside (Wendt. Jr., 1995). This connection is also required by accrediting agency standards (e.g., AACSB International, NAIT). Specialized accreditation of technology management programs has become an increasingly important consideration (Whittlesey, 2005) as accountability for educational program outcomes has gained importance (Burke, 2005).

This researcher selected a survey method to solicit the opinions of the sample population regarding effective core curricular competencies in an undergraduate technology management program. The following five procedures were used in implementing this research: (a) identification of the sample population, (b) selection of the survey software, (c) survey instrument design and pilot testing, (d) data gathering, and (e) data analysis.

A purposive expert sample of employees with expertise in technology management from four industry sectors (business services, education, government, and manufacturing) participated in this study. In addition, economic developers from the Michigan Economic Development Corporation (MEDC) and members of the Southern Wayne County Regional Chamber of Commerce (SWCCC) were involved in the endeavor. Data were obtained through use of a Web- and paper-based survey instrument. Email invitations were sent to participants from the business services, education, and manufacturing sectors, and to executive members of MEDC; two follow-up requests were sent to participants who had not responded to the initial survey. A paper-based survey was distributed to employees from the government sector and to members of SWCCC. A total of 228 surveys were distributed, and 127 were returned for an overall response rate of 55.7%.

Three survey software packages were reviewed by this researcher (Snap, Survey Methods, and Survey Monkey). Survey Monkey was chosen because of its ability to generate a PDF file of the survey instrument that enabled the use of a mixed-mode research instrument.

The survey instrument was developed after an extensive review of the literature and textbooks associated with the field of technology management. The following eight areas in which competencies should be achieved by graduates of technology management programs resulted from this research: (a) strategic management of technology, (b) management of innovation and product development, (c) management of technological change, (d) management of organizational change, (e) project management, (f) assessment and evaluation of technology, (g) quality management of technology, and (h) information/knowledge management (Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Angus, Gundersen, & Cullinan, 2000; Evans & Lindsay, 2008; Haag, Cummings, & McCubbrey, 2005; Herink et al., 1987; Porter, Roper, Mason, Rossini, & Banks, 1991; Thamhain, 2005; Yanez, 2006; Yanez & Khalil, 2007). A pilot survey test was electronically distributed to 30 upper-division undergraduate technology management majors and to 15 master of science in technology studies students at Eastern Michigan University. Pilot study results were analyzed, and alpha reliability for each of the eight scales and the items within the scales were tested. One sample *t* tests were performed to determine statistical significance. Only minor revisions were made to the final survey instrument in an effort to improve reliability of the strategic management of technology scale and the management of innovation and product development scale. These two scales were moved to the end of the survey. In addition, one item was removed from the technology project management scale to eliminate redundancy.

The survey instrument used in this study was divided into the following 10 categories: (a) informed consent, (b) demographic information, (c) management of technological change, (d) management of organizational change, (e) project management, (f) assessment and evaluation of technology, (g) quality management of technology, (h) information/knowledge management, (i) management of innovation and product development, and (j) strategic management of technology. A five-point (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, and strongly disagree) Likert scale was used to measure the perceived level of agreement of the respondents regarding the inclusion of items associated with the eight core competency areas in undergraduate technology management programs.

The survey instrument achieved a very high level of reliability, which was tested using Cronbach's alpha (α=.902). Descriptive statistics, including the range, averages, and measures of central tendencies, were used to analyze data in this exploratory descriptive research study. The mean for each item within each of the eight categories was calculated to determine the relative importance of each item. Weighted means were calculated for each scale by dividing the mean value of each scale by the number of items within the scale. The weighted means in each of the eight areas were then compared to determine their relative importance to each other. One sample *t* tests were computed to test for statistical significance of each scale and of each item within each scale. An analysis of variance procedure was performed to determine if any perceived levels of differences existed between industry sectors on the eight scales and on each item within the eight scales. Two post-hoc procedures (Hochberg's GT2 and Games-Howell) were also performed on data to determine statistical significance of the findings.

Conclusions

Because this research is exploratory by design, no literature is available to use in making direct comparisons with information gleaned from this study. However, in order to be comprehensive, this researcher will compare the related literature and research on graduate programs in technology management education and the information from the engineering and technology management (ETM) study by Kocaoglu et al. (2003) to the initial conclusions about the undergraduate core curriculum included in this section.

In essence, the very minimal research on technology management programs, while instructive, is inadequate as far as empirical research goes for the following reasons:

- None of the studies identified (Alvear, Rueda, Hernandez, and Kocaoglu [2006]; Kocaoglu, Sarihan, Sudrajat, and Hernandez [2003]; or Yanez [2006]) had an overall response rate of more than 12.3%. Therefore, drawing any valid conclusions is risky.
- Aje's (2005) research was based on a review of syllabi and course catalog content from the 148 institutions involved in ETM research study (which represented only 12.3% of the 1,200 institutions surveyed by Kocaoglu et al. [2003]).
- Nambisan and Wilemon's (2002) research, *Graduate Management of Technology Education: Global Survey, Critical Issues and Emerging Trends,* involved an examination of 123 institutions and may be the only study with a response rate substantial enough to support solid research conclusions (67 responses, or a 54.5% response rate). However, some confusion exists as to the actual return rate. Specifically, the authors indicated in a 2003 article, *A Global Study of Graduate Management of Technology Programs,* that 170 surveys were distributed and that 53 "usable" responses were returned for a response rate of about 33%. However, in the initial article about the study in 2002, *Graduate*

Management of Technology Education: Global Survey, Critical Issues and Emerging Trends, 67 responses were returned from the distribution of 123 surveys for a 54.5% response rate. Both of these research articles appear to focus on the same study of global graduate management of technology programs/education, but the authors report different respondent numbers.

- In all of these research studies, except Yanez (2006), academics studied academics. Only Yanez (2006) included industry representatives as potential respondents; for Yanez's study, only 35 representatives from industry were among the 129 participants who returned the second survey he distributed.

When considering the conclusions drawn from this study, the reader should be aware of the study's delimitations. For instance, this exploratory research was delimited by the purposive selection of the survey population. This researcher was interested in obtaining the opinions of people with expertise in technology management from four different industry sectors (business services, education, government, and manufacturing) and from economic developers. The reader, therefore, should be aware of how the participants were selected when making generalizations based on the results of the study.

Moreover, the researcher did not address the need for foundational courses or supporting areas of knowledge for technology management education degree programs. Topical areas such as the ability to communicate effectively, reason quantitatively, use computer applications effectively, and develop an understanding of economic principles were outside the scope of this study. The inclusion of these foundational courses as part of an undergraduate technology management education degree program should, however, be a consideration for faculty members as they develop a comprehensive baccalaureate degree framework.

Technology-specific courses, such as technology theory and emerging technologies, also were not addressed in this study. Additionally, questions related to the technical-specialty area commonly included in undergraduate technology management education programs (Becker, 2007) were not incorporated into this study.

Corporate functions typically taught in a school or college of business as part of a traditional management major were also not handled in this particular research project. Participants were not asked to express their opinions about the inclusion of the following topics in an undergraduate technology management education program: accounting, finance, law, marketing, or organizational behavior. Although courses in these topical areas may be important components of an undergraduate technology management education program, this researcher focused only on areas directly related to the discipline of technology management.

An ideal undergraduate technology management program would likely contain courses from the following four areas: core technology management, traditional corporate functions, general education, and a technical concentration. See Table 29 for an example of a model undergraduate technology management curriculum.

Table 29

Model Undergraduate Technology Management Curriculum

Technology Management Related Courses	Assessment and Evaluation of Technology Information Technology Management Management of Innovation and Product Development Management of Organizational Change Management of Technological Change Quality Management of Technology Strategic Management of Technology Technology Project Management
Corporate Functionality Related Courses	Accounting Finance Law Marketing Organizational Behavior
Technical Concentrations	Automotive Service Technology Biomedical Engineering Technology Computer Service Technology Environmental Technology Fluid Power Technology Graphic Design Technology Health Information Technology Information Technology Network Technology Public Safety Technology Telecommunication Technology
Foundational Courses	Advanced Composition Computer Applications Economics Quantitative Reasoning

The technology management education survey instrument had a high level of reliability (Crobach's alpha ranged from .761 for the management of technological change scale to α=.903 for the quality management of technology scale, with the other scales ranging between α=.803 to α=.893) and provided support for the conclusions drawn from participant data. Participants were asked their opinions about the inclusion of 52 items organized into eight areas using a five-point Likert scale. The conclusions reached for each of the four research questions will now be presented.

Research Question 1: *What is the relative perceived importance of each of the eight core competency areas (management of technological change, management of organizational change, project management, assessment and evaluation of technology, quality management of technology, information and knowledge management, innovation and product development, and strategic management of technology) in technology management?*

According to survey respondents, the following eight core competency areas should definitely be included in an undergraduate technology management education program in the following priority order:

1. technology project management
2. management of technological change
3. information and knowledge management
4. management of organizational change
5. strategic management of technology
6. assessment and evaluation of technology
7. quality management of technology and
8. innovation and product development.

Technology project management was viewed as the most important area, while the management of innovation and product development was perceived as the least important area to include in the core curriculum.

In comparing the findings from this research study on the undergraduate core curriculum to previously published research by Aje (2005), none of the core competency areas identified were offered at 50% of the institutions involved in Aje's (2005) study.

Alvear et al.'s (2006) research included courses that were offered in 35% or more of the programs, but only indicated rankings of the courses and not the actual numbers or percentages of the courses taught in the engineering and technology management programs.

The results of this study concurred with Nambisan and Wilemon's (2002) findings at the graduate level. Specifically, they found that the institutions involved in their survey included these courses in their curriculum: technology strategy (91%), strategic management (88%), innovation management (75%), new product development (78%), information technology (43%), and quality management (42%). Their 2003 study indicated that innovation management, strategy, and technology management were the three most important themes addressed in technology management programs. Yanez's (2006) study denoted the following eight courses in order of perceived importance as core elements in graduate technology management programs: strategic management, innovation management, fundamentals of technology management, product development management, knowledge management, entrepreneurship, project management, and technology foresight and forecasting. Quality management and change management were considered electives. In summary, similarities exist between graduate and undergraduate technology management course offerings, the identified MOT body of knowledge, and industry participants' perception of required core competencies in undergraduate technology management programs.

Research Question 2: *What is the relative perceived level of importance of each item within the eight core competency technology management scales?*

Technology project management was identified as the most important area to include in an undergraduate technology management education core curriculum. The competencies that all graduates must develop are listed below in order of importance:

1. ability to plan and organize projects,
2. ability to gather data on the task, schedule, budget, monitor, and evaluate the total effort,
3. ability to implement projects effectively,
4. ability to work effectively with functional groups within the organization to plan and implement projects,
5. ability to schedule projects effectively and within the constraints of the organization,
6. ability to manage and lead the project team, and
7. ability to reduce implementation costs of new projects

Most researchers (Alvear et al., 2006; Badawy, 1998; Herink et al., 1987; Klingenberg & Rothberg, 2006; Yanez 2006) agreed that a course in project management was important, although Hauck (1999) did not include a course in technology project management, nor did Nambisan and Wilemon (2002) reference one as an MOT course. A course in project management was not identified as meeting the 50% commonality criterion in Becker's 2007 study of undergraduate technology management programs. None of the researchers broke down the components or competencies required in a course in technology project management. However, Yanez (2006) included information about project management put forth by the Project Management Institute (PMI) in his analysis. A course including the entire seven competency areas related to the technology project management noted above should be included in an undergraduate technology management program.

When dealing with the management of technological change, the ability to *implement* technological change appeared to be the most important skill for graduates to develop in an undergraduate technology management education program. An ability to scan significant technological changes occurring within the external environment of the organization seemed to be less important but still critical enough to include in the curriculum. In addition, graduates must be able to demonstrate competence in an ability to assess the need for technological change and an ability to assess an organization's readiness for technological change. The analysis by Alvear et al. (2006) and the issues and responsibilities specific to the management of technology identified by Herink et al. (1987) supported the inclusion of a course in management of technological change in technology management programs. Yanez (2006), however, viewed change management as an elective area at the graduate level. Industry respondents indicated that competencies in the management of technological change were crucial for undergraduates of technology management programs.

Within the information and knowledge management area, there are nine competencies that technology management education undergraduates must acquire; the following competencies are listed by the level of importance indicated by survey respondents:

1. understanding of ethical, security, and privacy issues surrounding the use of electronic information;
2. ability to use spreadsheets for quantitative analysis of information;

3. ability to integrate and use information technology to increase the competitive stance of an organization;
4. understanding of information technology and system development;
5. ability to use and manage databases;
6. ability to use online collaboration systems;
7. understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization;
8. understanding of electronic commerce applications and principles; and
9. understanding of business-to-business e-commerce

Again, information and knowledge management was considered an important component in technology management programs by researchers who focused on graduate-level programming (i.e., Badawy, 1998; Herink et al., 1987; Klingenberg & Rothberg, 2006; Nambisan & Wilemon, 2002; Yanez, 2006) and in ETM programs offered by business schools (Alvear et al., 2006). Responses from industry sector participants in this study deemed competencies in information and knowledge management to be vital in undergraduate technology management programs.

When addressing the core competency area known as the management of organizational change, an understanding of leadership strategies and methods surfaced as the most important area to be taught in this segment of the curriculum. The ability to assess and implement requisite changes in human resource management was perceived as being the least important. The other four skills that graduates must acquire, by level of importance, were ability to assess the need for organizational change, understanding of how to integrate new organizational processes, ability to plan for and implement various forms of cross-functional teams and processes, and ability to implement organizational change.

The only researchers of graduate technology management programs who included a course in the management of organizational change were Klingenberg and Rothberg (2006). Hauck (1999) identified a core course in team problem solving and leadership. However, industry respondents in this study indicated that all six areas identified in the management of organizational change should be included in undergraduate technology management programs as core competencies.

Strategic management of technology was considered an essential component of an undergraduate technology management education degree program. The most important skill for graduates to acquire was an ability to create value through the use of technology, while the ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization was viewed as the least important skill (but still one that needed to be included in the curriculum). The other three competencies considered necessary for graduates are listed as follows by perceived level of importance:

1. ability to develop effective planning procedures for selecting new technology;
2. ability to develop an effective technology strategy for achieving competitive advantage; and
3. ability to align the organization's structure and processes with its core technologies.

All of the researchers focusing on graduate programs in technology management identified competencies in the strategic management of technology as important attributes for graduates of these programs. In fact, Yanez (2006) found the strategic management of technology to be the most important competency area in his study. Interestingly, Aje's (2005) analysis showed that strategic management courses were being taught at only 41 (27.7%) institutions, but the examination by Alvear et al. (2006) pointed out that a course in strategic planning was taught at 35% or more of the ETM programs. Although Becker's 2007 study did not indicate that at least 50% of undergraduate technology management programs required a course in strategic management of technology, this principal area should be included in undergraduate educational programs in technology management.

In the core competency area of assessment and evaluation of technology, the skills, knowledge, behaviors, and abilities considered most important for undergraduates to acquire was the ability to identify technologies important to the business; the knowledge area considered least important, but still important enough to include in the curriculum, was an understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology. The other six competencies that graduates need to demonstrate, by perceived level of importance according to survey respondents, were:

1. ability to anticipate how new technologies may affect the organization;
2. ability to assess cost and benefits of new technologies;

3. ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies;
4. ability to assess training needs in association with the implementation of new technologies;
5. ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors); and
6. ability to assess the effects of technologies on society.

None of the research in graduate technology management educational programs specifically addressed the assessment and evaluation of technology, although Herink et al. (1987) mentioned technological forecasting and assessment, Badawy (1998) recommended a foundational course in technology analysis, and van Wyk (2004) as well as Yanez (2006) recommended a core course in technology forecasting. Again, respondents from industry indicated that this important competency area was essential to success by undergraduates and that material related to the area should be included in undergraduate technology management programs.

Quality management of technology was also regarded as a central competency area for graduates of undergraduate technology management education programs by respondents. The competencies that must be included in the core curriculum are listed by perceived level of importance as follows:

1. understanding of the tools used in process improvement;
2. ability to implement process improvement schemes;

3. understanding of principles of total quality management;
4. ability to manage for performance excellence;
5. ability to manage for quality outcomes;
6. understanding of the principles of Six Sigma;
7. understanding of the Deming philosophy of quality improvement;
8. understanding of ISO 9000 standards; and
9. an understanding of the Baldrige criteria for quality

While quality management of technology was viewed as an elective course in the graduate body of knowledge framework set forth by Yanez (2006), quality management of technology was identified by Herink et al. (1987) as an issue and responsibility specific to the management of technology. A course in quality was required in half (9) of the undergraduate technology management programs identified by Becker (2007), and the inclusion of a course focusing on quality management of technology should be required in undergraduate technology management programs, according to respondents from industry who participated in this study.

Although innovation and product development had the lowest level of perceived importance of the eight core competency areas, respondents still felt that graduates of baccalaureate technology management education programs should have the following competencies (based on level of rated importance):

1. ability to plan for and implement team-based management systems used in the development and launching of new products;
2. understanding of processes used to launch new products;
3. understanding of the platform approach to product development; and

4. an ability to predict new product success

At the graduate level, management of innovation and product development was deemed vital by the following researchers: Badawy, 1998; Herink et al., 1987; Nambisan and Wilemon, 2002; van Wyk, 2004; and Yanez, 2006. A course in innovation management also met the 35% criterion for inclusion in engineering schools in an analysis by Alvear et al. (2006). Competencies in innovation and product development should be included in undergraduate technology management programs, as indicated by industry respondents.

Research Question 3: *Do any differences exist between industry sectors (business services, education, government, and manufacturing) and their representatives' perceptions of the relative importance of the eight core competency areas?*

Differences between industry sectors (business services, education, government, and manufacturing) and their representatives' perception of the relative importance of the eight core competency areas were evident in only one core competency area: information and knowledge management. The respondents from the business services sector perceived information and knowledge management as being more important than did participants from the manufacturing sector. This difference may be attributed to the greater emphasis placed on information and knowledge management by individuals from the business service sectors versus the emphasis on production by employees in the manufacturing sector. Researchers in graduate technology management did not address this difference found between industry sectors.

Research Question 4: *Do any differences exist between industry sectors and their representatives' perceptions of the items within each of the core competency areas?*

In the core competency area of assessment and evaluation of technology, the respondents from the business services sector placed greater importance on the ability to assess the effects of technologies on society than did respondents from the education sector. This researcher did not locate any information in the literature that would indicate why this difference may have occurred.

Differences between respondents from the business services sector as compared to the government sector were also noted on understanding of ISO 9000 standards, which was a component of the quality management of technology core competency area. Business services sector respondents indicated more support for inclusion of this competency in the curriculum than did government respondents. Possibly because members of the government sector are not required to meet quality standards set forth in the ISO 9000 standards, they may not perceive the standards to be as important as members of the business services sector who have direct experience with ISO 9000 standard compliance.

In summary, results from this study indicated the importance of including the following eight core competency areas in an undergraduate technology management academic curriculum in the priority order indicated:

1. technology project management
2. management of technological change
3. information and knowledge management

4. management of organizational change
5. strategic management of technology
6. assessment and evaluation of technology
7. quality management of technology and
8. innovation and product development.

Recommendations for Further Research and Action

Although this study addressed an important area where research was lacking, far more research is needed in the discipline of technology management. Suggestions for further research endeavors are as follows:

1. More research is essential regarding the specific technology management needs of employers in various industry sectors, including business services, education, government, and manufacturing. The content of technology management education programs can then be modified, if necessary, to meet the needs of employers in the particular industry sectors and in the surrounding communities where the educational institution is located.

2. A national study of business and industry technology management stakeholders (i.e., academics and representatives from the four industry sectors) should occur using the reliable and valid Technology Management Curriculum Inventory to determine the appropriate curricular content of both undergraduate and graduate programs in technology management. The results of such a study will help define the relevant technology management body of knowledge.

3. Research focused specifically on undergraduate programs must continue. A definite need for undergraduate technology management programs has been recognized, and the process of program establishment is expected to continue. Very few researchers have dealt with this topical area, and it is important for the discipline of technology management to develop a relevant, cohesive curriculum for academic programs taught at the undergraduate level.

4. In determining and identifying the body of knowledge for technology management, researchers should focus on topics related to *technology management* and should not include content from other disciplinary areas. Divergent views surrounding the body of knowledge in the technology management discipline exist among practitioners and academics. Although technology management may be considered an interdisciplinary field by some researchers, and, in fact, does draw content from several disciplinary areas, the body of knowledge should be focused on technology management practices. Acknowledgment of other disciplinary connections should be made but not included in the body of knowledge.

5. Research on the use of distance education (i.e., Internet-based) delivery formats in technology management educational programs should occur at both the undergraduate and graduate levels. Online delivery of technology management courses and programs will most likely continue to increase, and pedagogical considerations related to this method of delivering instruction must be addressed.

6. Research on varying levels of knowledge associated with baccalaureate, master's, and doctoral programs should occur. Although this dissertation research project did not specifically address the varying levels of knowledge for technology management

programs at the bachelor, master's, and doctoral levels, research should be undertaken that addresses this issue, as academic programs in technology management are offered at all three levels. This researcher believes that bachelor's degree programs in technology management should have an applied focus and prepare students for entry-level positions in the field. Technology management master's degree programs should maintain a greater emphasis on research and foster a greater degree of specialization. Courses in strategic planning, innovation, and product development as well as the theory of technology will need greater emphasis at the master's level than at the undergraduate level. Doctoral programs in technology management should have a theoretical focus with an even greater emphasis on research and scholarship in the discipline.

This study has also illustrated the necessity for action to occur in several areas associated with the discipline of technology management. These actions are denoted in the following section.

1. Practitioners and academics alike must come to a working agreement on the definition of technology management in order for the discipline to move forward and be formally recognized. Some debate still exists about the definition of the term *technology management* (Badawy, 1998; Bellamy, Becker, & Kuwik, 2003; Thamhain, 2005). This researcher believes that much of the ambiguity surrounding the definition of technology management will be alleviated if a specific CIP code were approved by the U.S. Department of Education: National Center for Educational Statistics for technology management.

2. A concerted effort must be made to have this discipline recognized by the U.S. Department of Education, National Center for Education Statistics. Faculty members

associated with the technology management discipline and members of technology management professional associations must make obtaining a dedicated CIP code for technology management a top priority.

3. Faculty members within the technology management discipline in higher education institutions need to recognize and support the critical importance of undergraduate technology management education degree programs. Members of professional associations also need to recognize and serve as advocates for undergraduate technology management education programs and research.

Undergraduate technology management education programs appear to be held in lower esteem by members of the academic community than graduate programs in technology management. This fact is evidenced by the lack of research devoted to this particular area. The hierarchical nature of higher education supports the fallacy that undergraduate education is less valued or important than graduate education. In addition, some faculty employed within graduate technology management education programs have indicated that undergraduate technology management education programs are inappropriate and that baccalaureate students do not have the requisite knowledge to succeed as technology managers.

Several undergraduate technology management degree programs cater to the adult learner, and many adult learners are returning to college to complete baccalaureate degree programs in technology management. These adult students require a baccalaureate degree to increase their upward mobility in the job market and/or find well-paying employment opportunities. They bring valid educational experience from technical associate degrees and relevant work experience to the programs. Graduates of undergraduate technology management degree programs fulfill a critical need in society and are qualified for gainful and productive employment.

4. In developing accreditation guidelines for technology management education programs, guidelines for undergraduate programs must also be included. IAMOT is in the process of becoming an accrediting body for graduate technology management education programs. At this point, no efforts are being made to accredit undergraduate technology management education programs. Growth in program establishment of undergraduate technology management education programs will continue, and the importance of accrediting these programs also cannot be overemphasized.

Summary

This research study has identified the core curricular elements necessary for inclusion in an effective undergraduate technology management education program. These eight core competency areas include (a) technology project management, (b) management of technological change, (c) information and knowledge management, (d) management of organizational change, (e) strategic management of technology, (f) assessment and evaluation of technology, (g) quality management of technology, and (h) innovation and product development. Content related to these eight areas should be included in all undergraduate technology management education programs.

The discipline of technology management is essential for economic growth in the nation and the world. Therefore, academic programs in technology management must be relevant, and the content taught in these programs must be germane and meet the needs of employers and students. Graduates of baccalaureate technology management programs in which appropriate material is taught will be favorably perceived and sought after by employers. Clearly, giving undergraduate students access to a program of study focused on the development of technology management competencies identified by industry representatives as soon as they are needed in the workforce will represent the ideal partnership between higher education and business where everyone wins.

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Yanez, Jr., M. (2006). A management of technology (MOT) body-of-knowledge (BOK) framework for the formulation and evaluation of MOT graduate educational curricula. *Dissertation Abstracts International, 67*(08A), 2912. (UMI No. 3228184).

Yanez, Jr., M., & Khalil, T. M. (2007). An accreditation program for MOT graduate education: Recognition of need and a body-of-knowledge framework. In *International Association for Management of Technology IAMOT 2007 Proceedings* (pp. 786-796). Coral Gables, FL.

Appendix A
Titles of Selected Technology Management Publications

- Creativity and Innovation Management
- Entrepreneurship: Theory and Practice
- IEEE Transactions on Engineering Management
- Inderscience Enterprises Limited
- Information Systems Journal
- Innovation: Management, Policy & Practice
- International Journal for Entrepreneurship and Innovation
- International Journal of Innovation and Technology Management
- International Journal of Technology and Innovation Management Education
- International Journal of Technology Management
- International Journal of Technology Marketing
- International Transactions in Operational Research
- Journal of Engineering and Technology Management
- Journal of Management Studies
- Journal of Product Innovation Management
- Journal of Technology Transfer
- R&D Management
- Research in Technology Management
- Technological Forecasting and Social Change
- Technology Management News
- Technovation
- The Journal of Manufacturing Technology Management

Appendix B

Program Titles of Undergraduate Engineering Technology and Management Programs

1. Bachelor of Applied Science in Engineering Management
2. Bachelor of Applied Science in Technology Management
3. Bachelor of Business in Operations Management
4. Bachelor of Technology
5. Bachelor of Technology in Technology Management
6. Business and Technology
7. E-Business
8. Engineering and Management
9. Engineering Management
10. Engineering Management Technology
11. Engineering Science
12. Engineering Technology Management
13. Industrial Engineering and Engineering Management
14. Industrial Engineering and Management
15. Industrial Engineering with an Engineering Management Concentration
16. Industrial Management
17. Industrial Technology
18. Information Management and Information Systems
19. Interdisciplinary Engineering and Management
20. Management Engineering
21. Management Science
22. Manufacturing Engineering Management
23. Manufacturing Management
24. Manufacturing Technology and Management
25. Mechanical Engineering Technology
26. Technology and Society

Source: Kocaoglu, Sarihan, Sudrajat, & Hernandez, 2003

Appendix C

Technology Management Curriculum Inventory (TMCI)

Strategic Management of Technology

- Ability to develop an effective technology strategy for achieving competitive advantage
- Ability to develop effective planning procedures for selecting new technology
- Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization
- Ability to align the organization's structure and processes with its core technologies
- Ability to create value through the use of technology

Management of Innovation and Product Development

- Understanding of the platform approach to product development
- Ability to predict new product success
- Understanding of processes used to launch new products
- Ability to plan for and implement team-based management systems used in the development and launching of new products

Management of Technological Change

- Ability to assess the need for technological change
- Ability to assess an organization's readiness for technological change
- Ability to implement technological change
- Ability to scan significant technological changes occurring within the external environment of the organization

Management of Organizational Change

- Ability to assess the need for organizational change
- Understanding of how to integrate new organizational processes
- Ability to implement organizational change
- Ability to plan for and implement various forms of cross-functional teams and processes
- Ability to assess and implement requisite changes in human resource management
- Understanding of leadership strategies and methods

Technology Project Management

- Ability to plan and organize projects
- Ability to implement projects effectively
- Ability to work effectively with functional groups within the organization to plan and implement projects

- Ability to schedule projects effectively and within the constraints of the organization
- Ability to gather data on the task, schedule, budget, monitor, and evaluate the total effort
- Ability to reduce implementation costs of new projects
- Ability to manage and lead the project team
- Ability to manage large and complex projects

Assessment and Evaluation of Technology
- Ability to assess training needs in association with the implementation of new technologies
- Ability to assess cost and benefits of new technologies
- Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies
- Ability to assess the effects of technologies on society
- Ability to identify technologies important to the business
- Ability to anticipate how new technologies may effect the organization
- Ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors)
- Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology

Quality Management of Technology
- Ability to manage for quality outcomes
- Ability to manage for performance excellence
- Understanding of the tools used in process improvement
- Understanding of the principles of Six Sigma
- Understanding of the Baldrige criteria for quality
- Understanding of the Deming philosophy of quality improvement
- Understanding of ISO 9000 standards
- Understanding of principles of total quality management (which has a focus on customers and stakeholders, participation and teamwork by organization members, and continuous improvement and learning)
- Ability to implement process improvement schemes

Information/Knowledge Management
- Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization
- Ability to use online collaboration systems
- Understanding of ethical, security, and privacy issues surrounding the use of electronic information

- Ability to use and manage databases
- Ability to use spreadsheets for quantitative analysis of information
- Understanding of electronic commerce applications and principles
- Understanding of information technology and system development
- Ability to integrate and use information technology to increase the competitive stance of an organization
- Understanding of business-to-business e-commerce

Sources: Afuah, 2003; Alvear, Rueda, Hernandez, & Kocaoglu, 2006; Angus, Gundersen, & Cullinan, 2000; Arnold, & Holler, 1995; Badawy, 1995; Badiru, 1996; Bennett, 1996; Dorf, 1999; Durham, & Kennedy, 1997; Ettlie, 2006; Evans & Lindsay, 2008; Gehani, 1998; Gerwin, & Kolodny, 1992; Haag, Cummings, & McCubbrey, 2005; Haddad, 2002; Hammer, & Champy, 2003; Herink et al., 1987; Hitt, Costa, & Nixon, 1998; Jain, & Triandis, 1997; Katz, 2004; Khalil, 2000; Laudon, & Laudon, 2001; McGrath, 1995; Mintzberg, Lampel, Quinn, & Ghoshal, 2003; Morel-Guimaraes, Khalil, & Hosni, 2005; Narayanan, 2001; Porter, Roper, Mason, Rossini, & Banks, 1991; Rosenau, Jr., 1992; Sherif, & Khalil, 2007; Thamhain, 2005; Tushman, & Anderson, 2004; Van Wyk, 2004; Warren, 2002; Yanez, 2006; Yanez & Khalil, 2007.

Appendix D

Eastern Michigan University Institutional Review Board Approval Form

EASTERN MICHIGAN UNIVERSITY
Education First

April 14, 2008

Pamela Becker
3151 Gotfredson Road
Ypsilanti, MI 48198

Dear Pamela Becker:

The Human Subjects Institutional Review Board (IRB) of Eastern Michigan University has reviewed and approved as exempt research your proposal titled, "Core Curriculum Elements of Undergraduate Technology-Management Academic Programs." The IRB determined that the rights and welfare of the individual subjects involved in this research are carefully guarded. Additionally, the methods used to obtain informed consent are appropriate, and the individuals participating in your study are not at risk.

Exempt research does not require reporting of continuation one year after approval if the project continues. However, should the sample or procedures change as to have an impact on human subjects, then UHSRC should be notified by using the *Minor Modification to Research Protocol* or the *Request for Human Subjects Approval* form depending upon the scope of the changes (see the forms online).

On behalf of the Human Subjects Committee, I wish you success in conducting your research.

Sincerely,

Deb de Laski-Smith

Deb de Laski-Smith, Ph.D.
Interim Dean
Graduate School
Administrative Co-Chair
University Human Subjects Review Committee

Reference #: 080411

University Human Subjects Review Committee · Eastern Michigan University · 200 Boone Hall
Ypsilanti, Michigan 48197
Phone: 734.487.0042 Fax: 734.487.0050
E-mail: human.subjects@emich.edu
www.ord.emich.edu

Appendix E

Textbooks Reviewed in the Development of the Technology Management Curriculum Inventory

Author	**Year**	**Title**
Afuah, A.	2003	*Innovation management: Strategies, implementation, and profits*
Angus, R. B., Gundersen, N. A., & Cullinan, T. P.	2000	*Planning, performing, and controlling projects: Principles and applications (2nd Ed.)*
Arnold, K. L., & Holler, M.	1995	*Quality assurance: Methods and technologies*
Badawy, M. K.	1995	*Developing managerial skills in engineers and scientists: Succeeding as a technical manager. (2nd Ed.)*
Badiru, A. B.	1996	*Project management in manufacturing and high technology operations (2nd Ed.)*
Bennett, F. L.	1996	*The management of engineering: Human, quality, organizational, legal, and ethical aspects of professional practice*
Dorf, R. (Ed.)	1999	*The technology management handbook*
Durham, K., & Kennedy, B.	1997	*The new high-tech manager: Six rules for success in changing times*
Ettlie, J. E.	2006	*Managing innovation: New technology, new products, and new services in a global economy*
Evans, J. R., & Lindsay, W. M.	2008	*Managing for quality and performance excellence (7th Ed.)*
Gehani, R.	1998	*Management of technology and operations*
Gerwin, D., & Kolodny, H.	1992	*Management of advanced manufacturing technology: Strategy, organization, and innovation*
Haag, S., Cummings, M., & McCubbrey, D. J.	2005	*Management information systems for the information age. (5th Ed.)*
Haddad, C.	2002	*Managing technological change: A strategic partnership*
Hammer, M., & Champy, J.	2003	*Reengineering the corporation: A manifesto for business revolution*
Hitt, M., Costa, J., & Nixon, R. (Eds.)	1998	*New managerial mindsets: Organizational transformation and strategy implementation*
Jain, R. K., & Triandis, H. C.	1997	*Management of research and development organizations: Managing the unmanageable*
Katz, R. (Ed.)	2004	*The human side of managing technological innovation: A collection of readings*
Khalil, T.	2000	*Management of technology: The key to competitiveness and wealth creation*

McGrath, M.	1995	*Product strategy for high-technology companies: How to achieve growth, competitive advantage, and increased profits*
Mintzberg, H., Lampel, J., Quinn, J., & Ghoshal, S.	2003	*The strategy process: Concepts, contexts, cases. (4th Ed.)*
Morel-Guimaraes, L., Khalil, T., & Hosni, Y.	2005	*Management of technology: Key success factors for innovation and sustainable development (2nd Ed.)*
Narayanan, V. K.	2001	*Managing technology and innovation for competitive advantage*
Porter, A. L., Roper, A. T., Mason, T. W., Rossini, F. A., & Banks, J.	1991	*Forecasting and management of technology*
Rosenau, Jr., M.	1992	*Successful project management: A step-by-step approach with practical example (2nd Ed.)*
Sherif, M. H., & Khalil, T. (Eds.)	2007	*Management of technology: New directions in technology management*
Thamhain, H. J.	2005	*Management of technology: Managing effectively in technology-intensive organizations*
Tushman, M. L., & Anderson, P. (Eds.)	2004	*Managing strategic innovation and change (2nd Ed.)*
van Wyk, R.	2004	*Technology a unifying code: A simple and coherent view of technology*
Warren, K.	2002	*Competitive strategy dynamics*

Appendix F

Pilot Test Survey Instrument

Technology Management Education Survey 1.0

1.

Technology-Management Education Survey

April 12, 2008

Dear Survey Participant,

You are invited to participate in this survey because your opinions are extremely important to the development of a core curriculum in undergraduate technology management programs. Rapid technological change is occurring in all areas of business and industry, as Thamhain (2005) observed, "the magnitude and speed of technological advances over the past decades are stunning, reshaping our world and influencing virtually every aspect of life...as technology crosses virtually all levels and all disciplines of an enterprise" (p. xi). Technological progress is credited with generating approximately half of the economic growth seen in the US in the last 50 years (US National Science and Technology Council, Office of Technology Policy [NSTC], 1996, p. 1). This rapid technological change has resulted in a pressing need for qualified employees who have technical, scientific, and professional skills, with employment growth projections of 28.4% and 1.9 million new jobs in these areas expected by 2014 (US Bureau of Labor Statistics, 2006-07). The United States Department of Labor (2005) has also projected growth of 60.5% in management, scientific, and technical consulting services which is being driven "by the increased use of new technology and computer software and the growing complexity of business" (p. 6).

The development of relevant core competencies in technology managers is critical to the economic success of Michigan as we move from a manufacturing based economy to a technologically based service economy. Technology managers are found in many areas of business and industry including but not limited to the following: alternative energy, environmental technologies, automotive technologies, health, information technology, graphic design, manufacturing, production, public safety, and security. This survey will attempt to answer the following research question about undergraduate technology-management education:

What core competencies are necessary for undergraduate technology management majors to be successful when they enter the workplace? "Core competencies refer to the knowledge, skills, abilities and behaviors that contribute to an employee's job success and that are often included in corporate human resource development plans" (Casner-Lotto & Barrington, 2006, p. 15). The following eight categories have been identified in the technology management literature, and you will be asked your opinion on whether or not you agree that graduates of technology management programs should have core competencies in these categories:

1. Strategic management of technology
2. Management of innovation and product development
3. Management of technological change
4. Management of organizational change
5. Technology project management
6. Assessment and evaluation of technology
7. Quality management of technology
8. Information/knowledge management

Upon submission of the completed survey, your name will be entered into a drawing for a $100.00 Visa gift certificate.

This dissertation research study is being conducted by Pamela R. Becker, Assistant Professor and Technology Management Program Coordinator at Eastern Michigan University. If you have any technical difficulties, questions, or would like to request a paper-based copy of the survey, please contact her at 734.487.1161 or by email at pam.becker@emich.edu.

This survey should take approximately 10 minutes to complete. Please click on the "Next Button" below to begin the survey. If you would like to request a paper-based version of the survey, please provide your contact information in the box below.

1. Name and mailing address:

Technology Management Education Survey 1.0

2. Informed Consent

Informed Consent

April 11, 2008

You are being asked to participate in a dissertation research study that focuses on undergraduate technology-management education programs. Your participation in this study is voluntary and you may withdraw from the study at any time.

No harm or discomfort should occur since your identity will be kept confidential at all times. To ensure confidentiality email survey responses will be stored on a secure server, and paper-based responses will be kept by the researcher in a locked file cabinet at her residence. Upon completion of the study, the consent forms, the responses, and any identifying information will be destroyed. In addition, when the study is complete, you may request a copy of the findings. Data collected will be published in the dissertation and may be used in presentations and other publications, but neither your name nor your organization will be associated with any responses and the material will be presented only in aggregate form at presentations or in publications.

The survey should take approximately ten minutes to complete. No direct benefits are anticipated to incur as the result of completing the survey.

For questions about this research, please contact Pamela Becker, Assistant Professor, Eastern Michigan University at 734.487.1161, or her dissertation chair, Dr. Martha W. Tack, Professor, Eastern Michigan University, at 734.487.0255.

This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from April 14, 2008 to April 13, 2009 (date). If you have questions about the approval process, please contact Dr. Deb deLaski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSRC, human.subjects@emich.edu).

I confirm that I know the purpose and parameters of the research study outlined above. I understand that the duration of my participation in this research study will be limited to the completion of the survey. I am aware that participation is completely voluntary and that I may withdraw from the study at any time without penalty. I hereby provide consent for the use of my responses and wish to participate in this research endeavor.

*** 1. Please check the desired box below.**

- ◯ I agree to participate in this study.
- ◯ I do not agree to participate in this study.

Technology Management Education Survey 1.0

3. Demographic Information

Please tell us about yourself.

1. Please complete the following.

Note: Completion of the contact information is optional and is only required if you would like your name submitted to the drawing for the $100.00 Visa Gift Certificate.

Full Name:
Organization:
Address:
Address 2 (optional):
City/Town:
State:
ZIP/Postal Code:
Country:
Email Address:
Phone Number :

2. What is your position title?

3. What is your gender?

- Male
- Female

4. What is your age?

5. What is the primary industry in which you are involved?

- Business Services
- Education
- Health Care
- Information Technology
- Law Enforcement
- Manufacturing
- R&D/Engineering
- Web Design

Other (please specify)

Technology Management Education Survey 1.0

4. Strategic Management of Technology

When answering the following questions, keep in mind that the purpose of this research study is to determine the knowledge, skills, abilities, and behaviors that contribute to job success and should be the outcome of completing an undergraduate degree in technology management.

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to develop an effective technology strategy for achieving competitive advantage.	○	○	○	○	○
2. Ability to develop effective planning procedures for selecting new technology.	○	○	○	○	○
3. Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization.	○	○	○	○	○
4. Ability to align the organization's structure and processes with its core technologies.	○	○	○	○	○
5. Ability to create value through the use of technology.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.0

5. Management of Innovation and Product Development

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Understanding of the platform approach to product development.	○	○	○	○	○
2. Ability to predict new product success.	○	○	○	○	○
3. Understanding of processes used to launch new products.	○	○	○	○	○
4. Ability to plan for and implement team-based management systems used in the development and launching of new products.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.0

6. Management of Technological Change

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess the need for technological change.	○	○	○	○	○
2. Ability to assess an organizations readiness for technological change.	○	○	○	○	○
3. Ability to implement technological change.	○	○	○	○	○
4. Ability to scan significant technological changes occurring within the external environment of the organization.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.0

7. Management of Organizational Change

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess the need for organizational change.	○	○	○	○	○
2. Understanding of how to integrate new organizational processes.	○	○	○	○	○
3. Ability to implement organizational change.	○	○	○	○	○
4. Ability to plan for and implement various forms of cross-functional teams and processes.	○	○	○	○	○
5. Ability to assess and implement requisite changes in human resource management.	○	○	○	○	○
6. Understanding of leadership strategies and methods.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.0

8. Technology Project Management

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to plan and organize projects.	○	○	○	○	○
2. Ability to effectively implement projects.	○	○	○	○	○
3. Ability to work effectively with functional groups within the organization to plan and implement projects.	○	○	○	○	○
4. Ability to schedule projects effectively and within the constraints of the organization.	○	○	○	○	○
5. Ability to gather data on the task, schedule, budget, monitor, and evaluate the total effort.	○	○	○	○	○
6. Ability to reduce implementation costs of new projects	○	○	○	○	○
7. Ability to manage and lead the project team.	○	○	○	○	○
8. Ability to manage large and complex projects.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.0

9. Assessment and Evaluation of Technology

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess training needs in association with the implementation of new technologies.	○	○	○	○	○
2. Ability to assess cost and benefits of new technologies.	○	○	○	○	○
3. Ability to do a SWOT (strengths, weaknesses, opportunities, and threats) analysis associated with new technologies.	○	○	○	○	○
4. Ability to assess the effect of technologies on society.	○	○	○	○	○
5. Ability to identify technologies important to the business.	○	○	○	○	○
6. Ability to anticipate how new technologies may effect the organization.	○	○	○	○	○
7. Ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors).	○	○	○	○	○
8. Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology.	○	○	○	○	○

Additional Comments (optional)

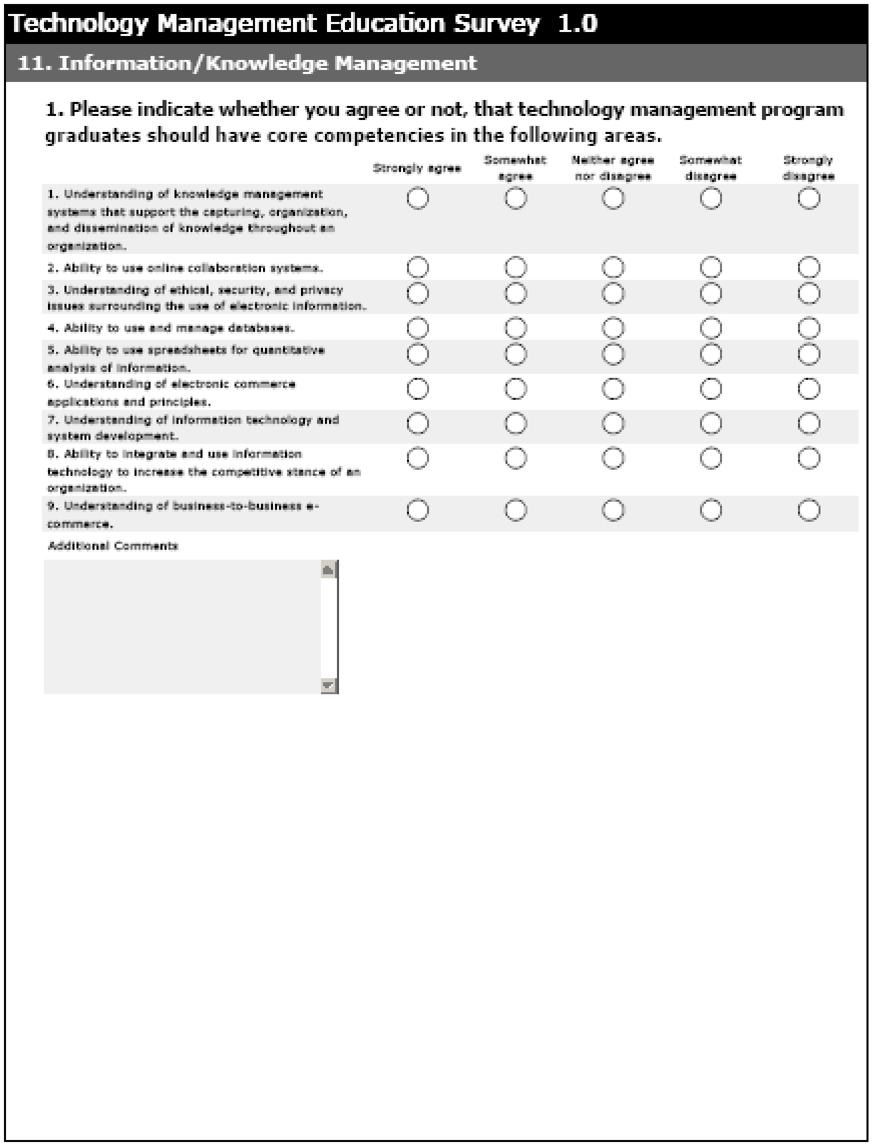
Technology Management Education Survey 1.0

10. Quality Management of Technology

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to manage for quality outcomes.	○	○	○	○	○
2. Ability to manage for performance excellence.	○	○	○	○	○
3. Understanding of the tools used in process improvement.	○	○	○	○	○
4. Understanding of the principles of Six Sigma.	○	○	○	○	○
5. Understanding of the Baldrige criteria for quality.	○	○	○	○	○
6. Understanding of the Deming philosophy of quality improvement.	○	○	○	○	○
7. Understanding of ISO 9000 standards.	○	○	○	○	○
8. Understanding of principles of total quality management (which has a focus on customers and stakeholders; participation and teamwork by organization members; and continuous improvement and learning).	○	○	○	○	○
9. Ability to implement process improvement schemes.	○	○	○	○	○

Additional Comments



Technology Management Education Survey 1.0

11. Information/Knowledge Management

1. Please indicate whether you agree or not, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization.	○	○	○	○	○
2. Ability to use online collaboration systems.	○	○	○	○	○
3. Understanding of ethical, security, and privacy issues surrounding the use of electronic information.	○	○	○	○	○
4. Ability to use and manage databases.	○	○	○	○	○
5. Ability to use spreadsheets for quantitative analysis of information.	○	○	○	○	○
6. Understanding of electronic commerce applications and principles.	○	○	○	○	○
7. Understanding of information technology and system development.	○	○	○	○	○
8. Ability to integrate and use information technology to increase the competitive stance of an organization.	○	○	○	○	○
9. Understanding of business-to-business e-commerce.	○	○	○	○	○

Additional Comments

Technology Management Education Survey 1.0

12. Thank You!

Thank you very much for taking the time to complete this important survey. Your name is now entered into a drawing to receive a $100.00 Visa gift certificate.

If you would like to receive summary results of the research study, please email Pamela R. Becker at pam.becker@emich.edu .

The following sources used in the development of this survey:

Alvear, A., Rueda, G. R., Hernandez, I. P., & Kocaoglu, D.F. (2006). Analysis of the engineering and technology management (ETM) educational program. In PICMET 2006 (pp. 1325-1331). Istanbul, Turkey.

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Yanez, Jr. M., & Khalil, T. M. (2007). An accreditation program for MOT graduate education: Recognition of need and a body-of-knowledge framework. In International Association for Management of Technology IAMOT 2007 Proceedings. (pp. 786-796). Coral Gables, FL.

Appendix G

Pilot Test Reliability Analysis of Each Item within Each Scale

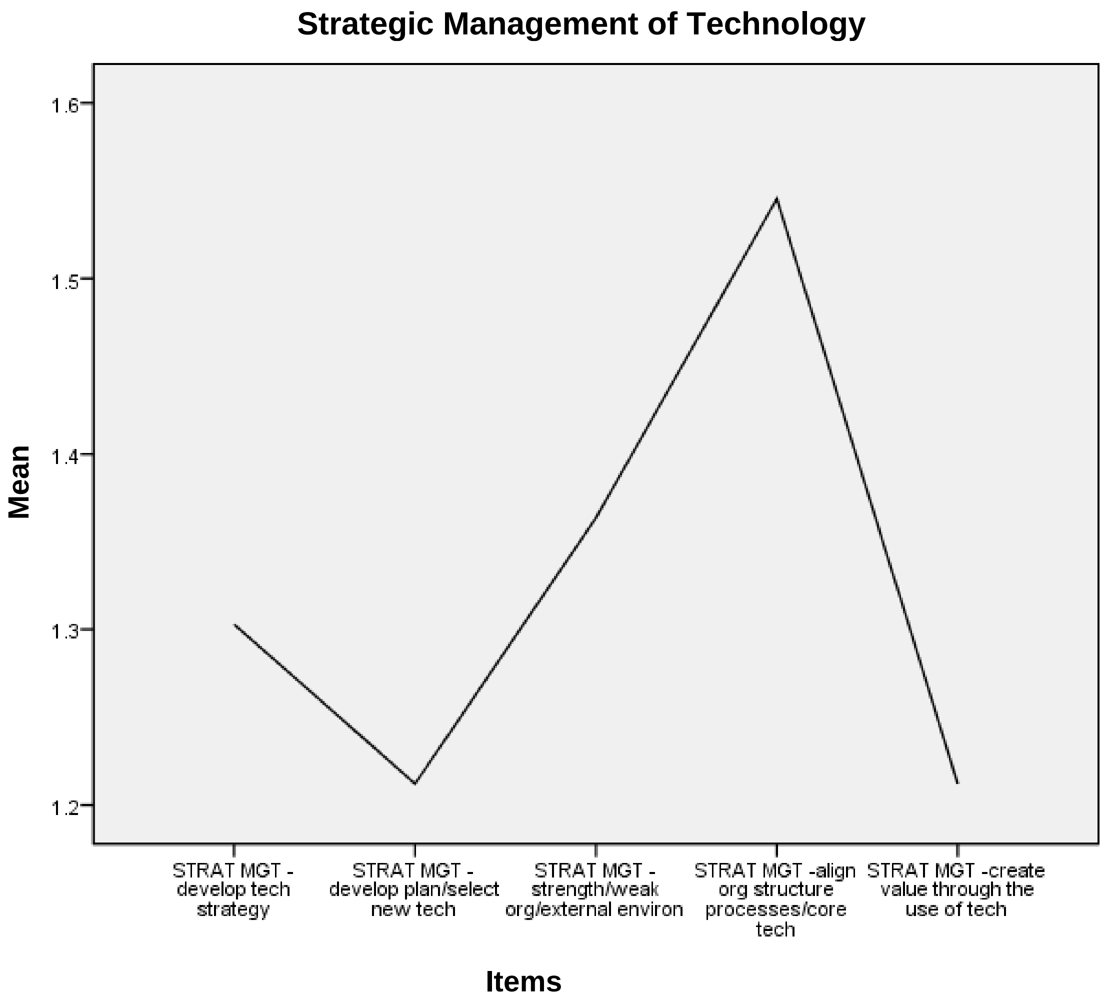
Strategic Management of Technology

Pilot Test Reliability Analysis of Items within the *Strategic Management of Technology* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to develop an effective technology strategy for achieving competitive advantage	33	1.30	.529	14.138	32	.000
Ability to develop effective planning procedures for selecting new technology	33	1.21	.415	16.773	32	.000
Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	33	1.36	.742	10.552	32	.000
Ability to align the organization's structure and processes with its core technologies	33	1.55	.711	12.485	32	.000
Ability to create value through the use of technology	33	1.21	.485	14.368	32	

Note: Cronbach's Alpha for the five items within scale=.564

Pilot Test Mean Values of Items within the *Strategic Management of Technology* Scale



Pilot Test Perceived Level of Importance of Items within the *Strategic Management of Technology* Scale

Item	Number of Respondents	Mean
Ability to develop effective planning procedures for selecting new technology	33	1.21
Ability to create value through the use of technology	33	1.21
Ability to develop an effective technology strategy for achieving competitive advantage	33	1.30
Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	33	1.36
Ability to align the organization's structure and processes with its core technologies	33	1.55

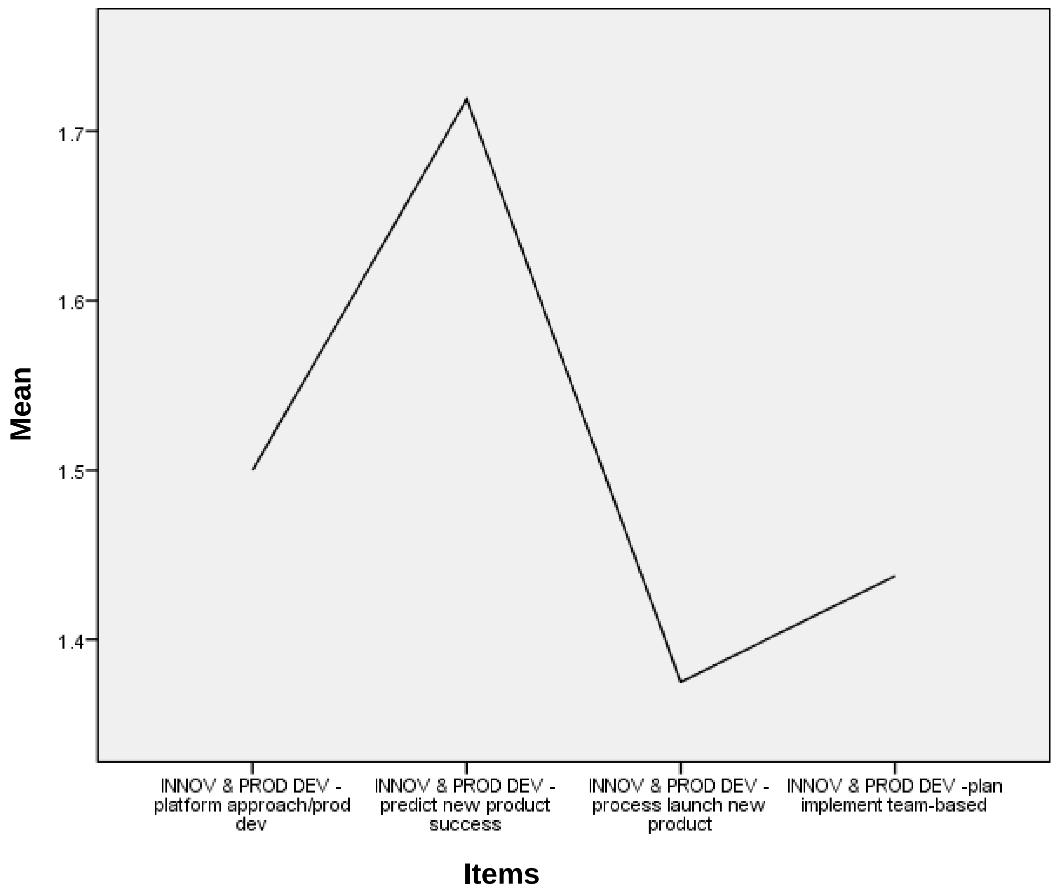
Management of Innovation and Product Development

Pilot Test Reliability Analysis of Items within the *Management of Innovation and Product Development* Scale

Item	Number of Respondents	Mean	Standard Deviation	t-test	df	Sig <.01 Level
Understanding of the platform approach to product development	33	1.52	.667	13.047	32	.000
Ability to predict new product success	33	1.79	.893	11.502	32	.000
Understanding of processes used to launch new products	32	1.38	.707	11.000	31	.000
Ability to plan for and implement team-based management systems used in the development and launching of new products	33	1.45	.666	12.551	32	.000

Note: Cronbach's Alpha for the four items within scale=.762

Pilot Test Mean Values of Items within the *Management of Innovation and Product Development* Scale



Pilot Test Perceived Level of Importance of Items within the *Management of Innovation and Product Development* Scale

Item	Number of Respondents	Mean
Understanding of processes used to launch new products	32	1.38
Ability to plan for and implement team-based management systems used in the development and launching of new products	33	1.45
Understanding of the platform approach to product development	33	1.52
Ability to predict new product success	33	1.79

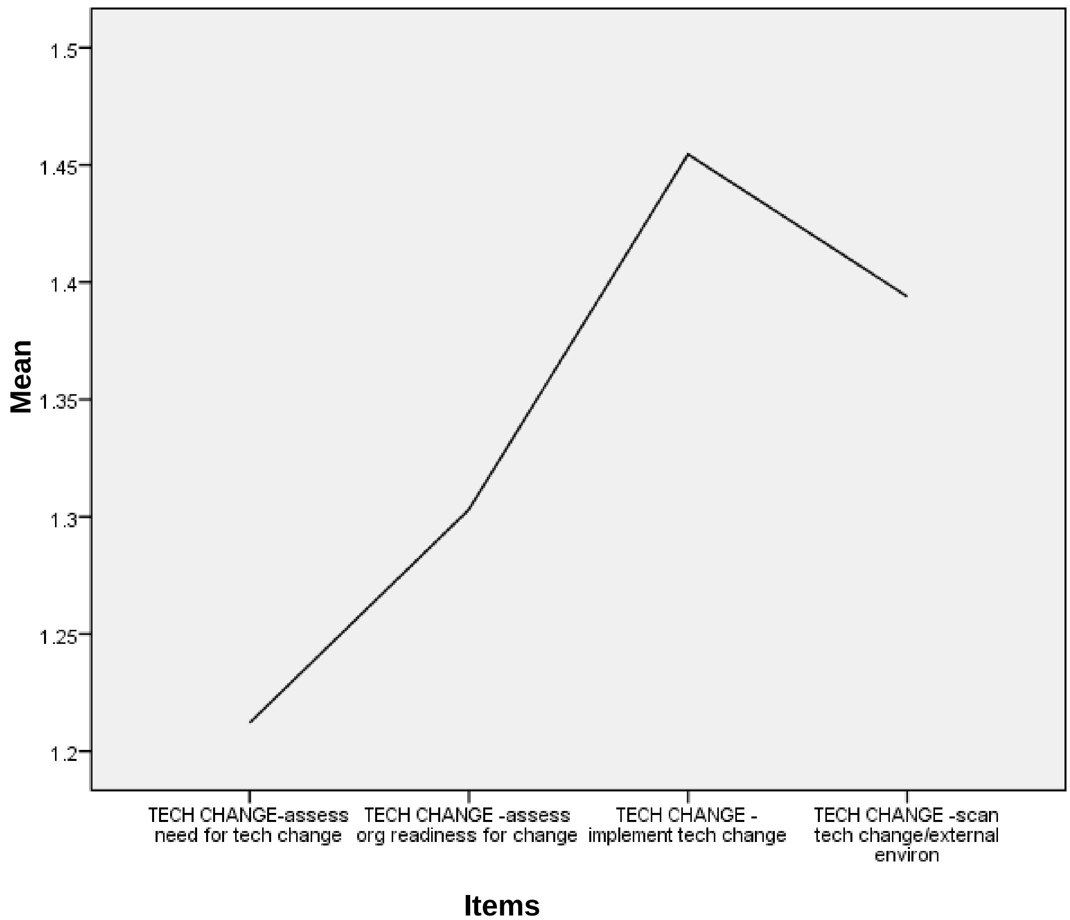
Management of Technological Change

Pilot Test Reliability Analysis of Items within the *Management of Technological Change* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to assess the need for technological change	33	1.21	.415	16.773	32	.000
Ability to assess an organization's readiness for technological change	33	1.30	.684	10.944	32	.000
Ability to implement technological change	33	1.45	.564	14.813	32	.000
Ability to scan significant technological changes occurring within the external environment of the organization	33	1.39	.659	12.159	32	.000

Note: Cronbach's Alpha for the four items within scale=.782

Pilot Test Mean Values of Items within the *Management of Technological Change* Scale



Pilot Test Perceived Level of Importance of Items within the *Management of Technological Change* Scale

Item	Number of Respondents	Mean
Ability to assess the need for technological change	33	1.21
Ability to assess an organization’s readiness for technological change	33	1.30
Ability to scan significant technological changes occurring within the external environment of the organization	33	1.39
Ability to implement technological change	33	1.45

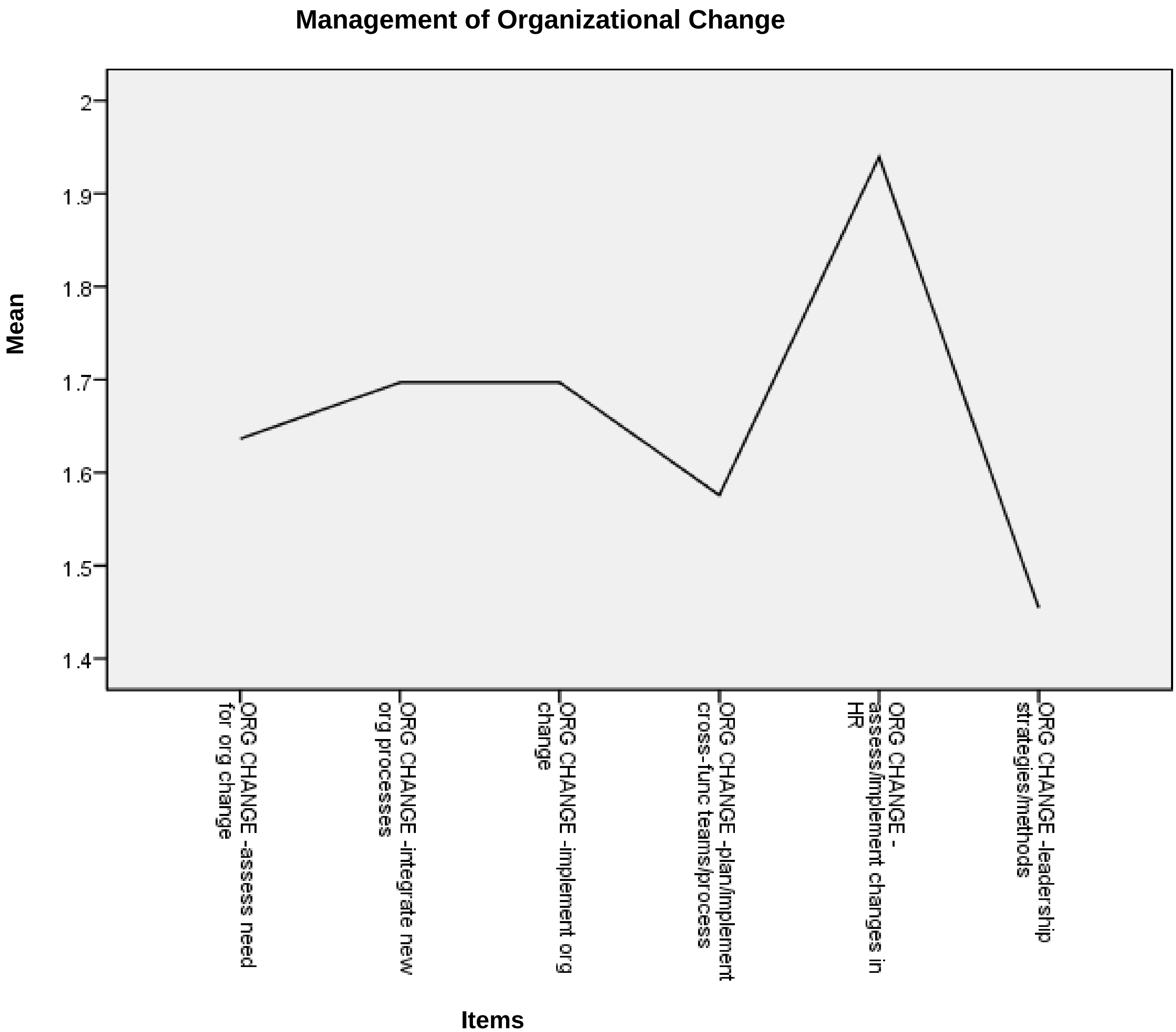
Management of Organizational Change

Pilot Test Reliability Analysis of Items within the *Management of Organizational Change* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to assess the need for organizational change	33	1.64	.895	10.502	32	.000
Understanding of how to integrate new organizational processes	33	1.70	.847	11.506	32	.000
Ability to implement organizational change	33	1.70	.810	12.042	32	.000
Ability to plan for and implement various forms of cross-functional teams and processes	33	1.58	.708	12.777	32	.000
Ability to assess and implement requisite changes in human resource management	33	1.94	.966	11.530	32	.000
Understanding of leadership strategies and methods	33	1.45	.666	12.551	32	.000

Note: Cronbach's Alpha for the six items within scale=.887

Pilot Test Mean Values of Items within the *Management of Organizational Change* Scale



Pilot Test Perceived Level of Importance of Items within the *Management of Organizational Change* Scale

Item	Number of Respondents	Mean
Understanding of leadership strategies and methods	33	1.45
Ability to plan for and implement various forms of cross-functional teams and processes	33	1.58
Ability to assess the need for organizational change	33	1.64
Understanding of how to integrate new organizational processes	33	1.70
Ability to implement organizational change	33	1.70
Ability to assess and implement requisite changes in human resource management	33	1.94

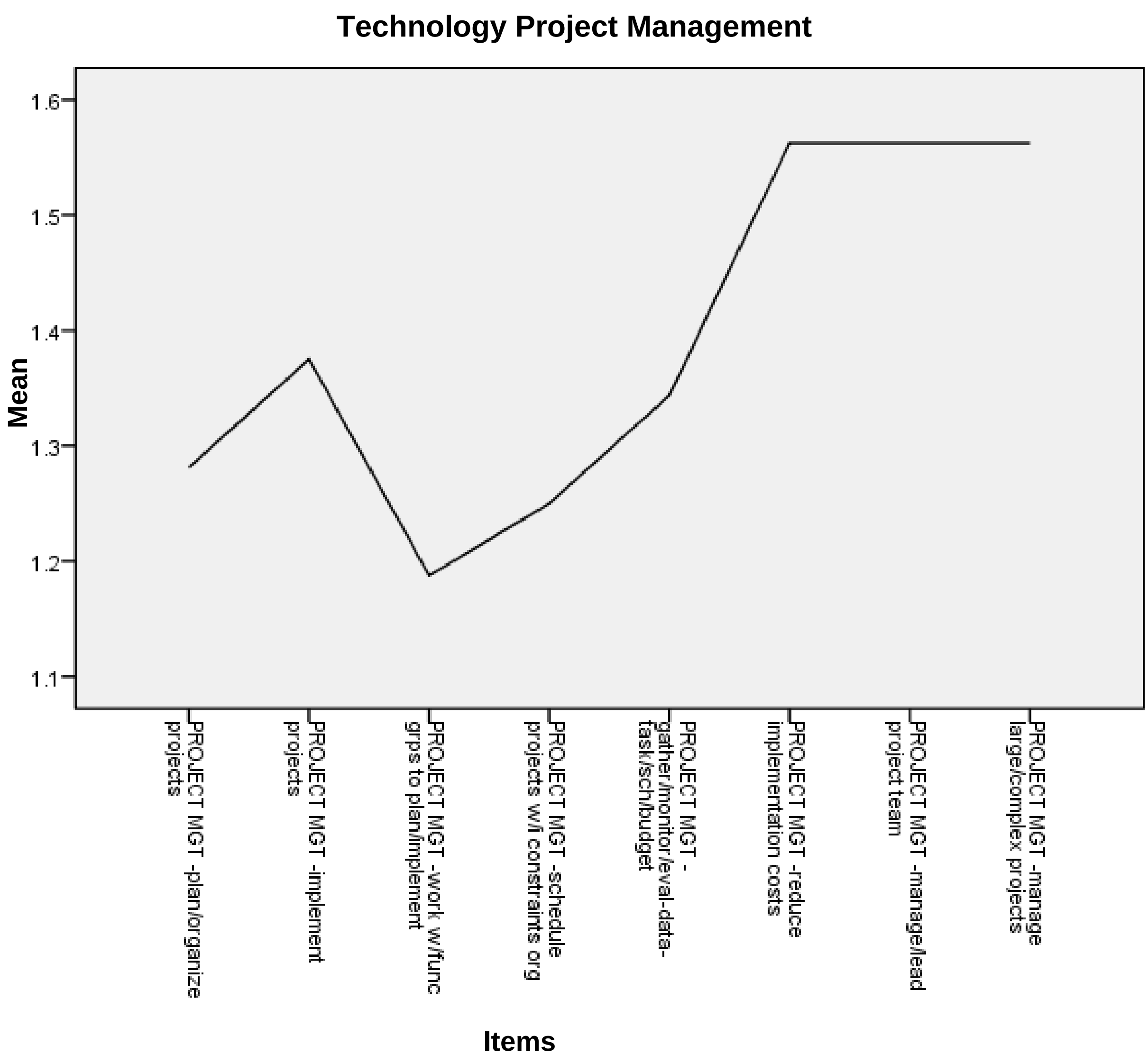
Technology Project Management

Pilot Test Reliability Analysis of Items within the *Technology Project Management* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to plan and organize projects	33	1.27	.517	14.148	32	.000
Ability to implement projects effectively	33	1.36	.489	16.036	32	.000
Ability to work effectively with functional groups within the organization to plan and implement projects	33	1.18	.392	17.333	32	.000
Ability to schedule projects effectively and within the constraints of the organization	33	1.24	.435	16.400	32	.000
Ability to gather data on the task, schedule, budget, monitor and evaluate the total effort	32	1.34	.545	13.939	31	.000
Ability to reduce implementation costs of new projects	33	1.55	.754	11.778	32	.000
Ability to manage and lead the project team	33	1.55	.754	11.778	32	.000
Ability to manage large and complex projects	33	1.55	.711	12.485	32	.000

Note: Cronbach's Alpha for the eight items within scale=.870

Pilot Test Mean Values of Items within the *Technology Project Management* Scale



Pilot Test Perceived Level of Importance of Items within the *Technology Project Management* Scale

Item	Number of Respondents	Mean
Ability to work effectively with functional groups within the organization to plan and implement projects	33	1.18
Ability to schedule projects effectively and within the constraints of the organization	33	1.24
Ability to plan and organize projects	33	1.27
Ability to gather data on the task, schedule, budget, monitor and evaluate the total effort	32	1.34
Ability to implement projects effectively	33	1.36
Ability to reduce implementation costs of new projects	33	1.55
Ability to manage and lead the project team	33	1.55
Ability to manage large and complex projects	33	1.55

Assessment and Evaluation of Technology

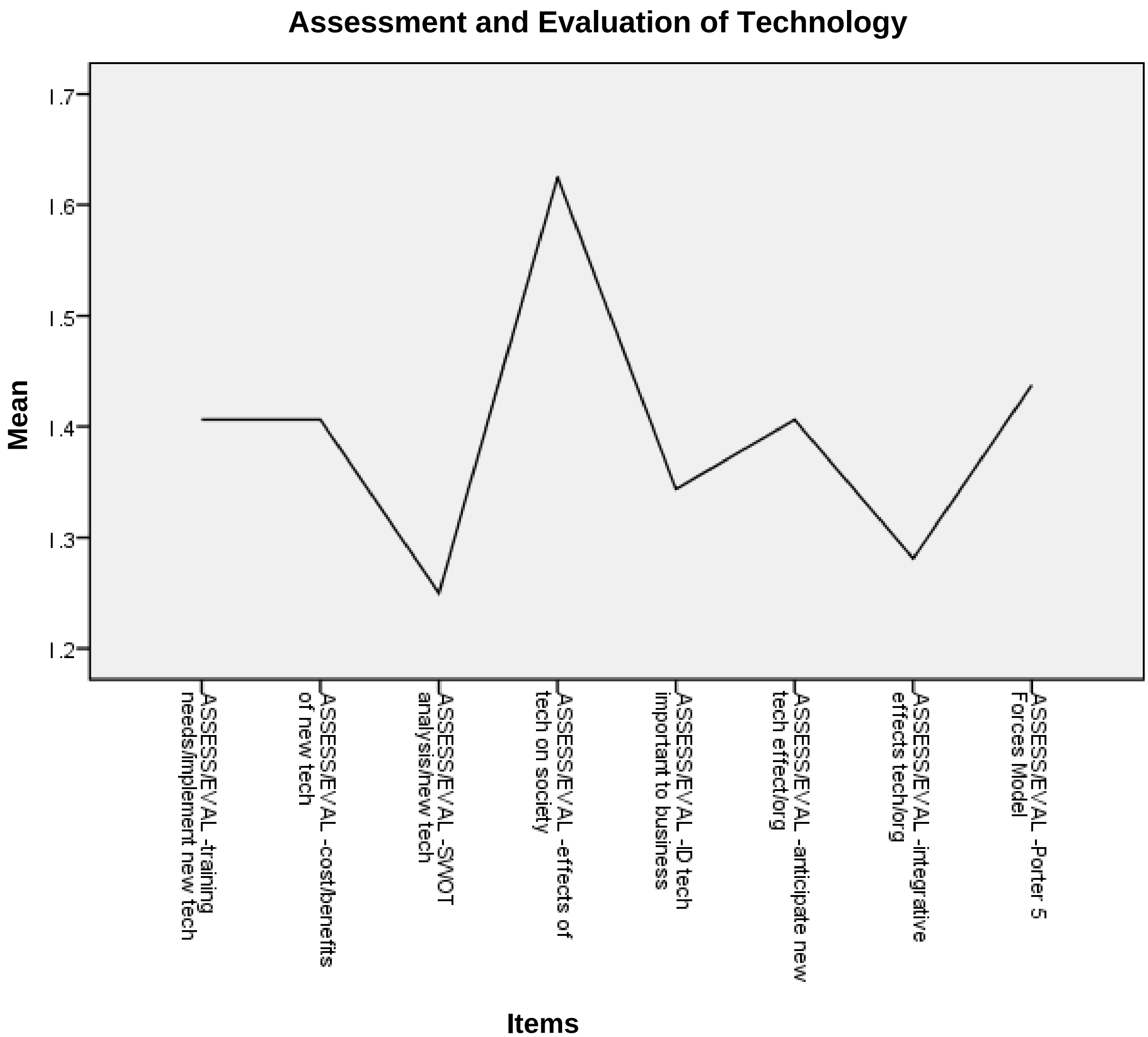
Pilot Test Reliability Analysis of Items within the *Assessment and Evaluation of Technology* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to assess training needs in association with the implementation of new technologies	33	1.42	.663	12.343	32	.000
Ability to assess cost and benefits of new technologies	33	1.42	.614	13.327	32	.000
Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies	33	1.24	.435	16.400	32	.000
Ability to assess the effects of technologies on society	33	1.61	.864	10.680	32	.000
Ability to identify technologies important to the business	32	1.34	.602	12.636	31	.000
Ability to anticipate how new technologies may effect the organization	33	1.39	.659	12.159	32	.000
Ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors)	33	1.27	.517	14.148	32	.000

Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology	33	1.42	.561	14.592	32	.000

Note: Cronbach's Alpha for the eight items within scale=.790

Pilot Test Mean Values of Items within the *Assessment and Evaluation of Technology* Scale



Pilot Test Perceived Level of Importance of Items within the *Assessment and Evaluation of Technology* Scale

Item	Number of Respondents	Mean
Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) analysis associated with new technologies	33	1.24
Ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors)	33	1.27
Ability to identify technologies important to the business	32	1.34
Ability to anticipate how new technologies may effect the organization	33	1.39
Ability to assess training needs in association with the implementation of new technologies	33	1.42
Ability to assess cost and benefits of new technologies	33	1.42
Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology	33	1.42
Ability to assess the effects of technologies on society	33	1.61

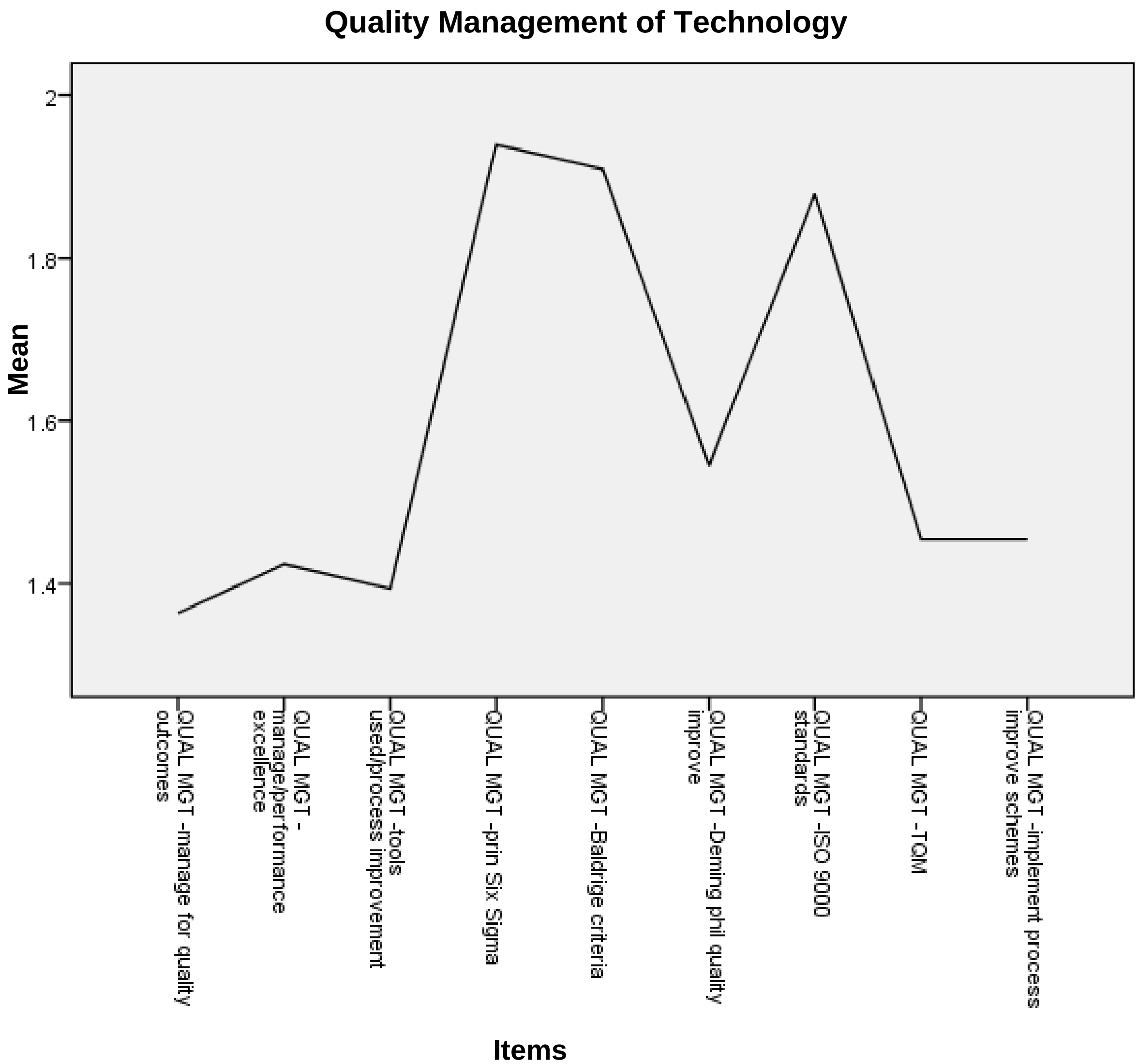
Quality Management of Technology

Pilot Test Reliability Analysis of Items within the *Quality Management of Technology* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Ability to manage for quality outcomes	33	1.36	.489	16.036	32	.000
Ability to manage for performance excellence	33	1.42	.614	13.327	32	.000
Understanding of the tools used in process improvement	33	1.39	.747	10.713	32	.000
Understanding of the principles of Six Sigma	33	1.94	1.088	10.240	32	.000
Understanding of the Baldrige criteria for quality	33	1.91	1.011	10.844	32	.000
Understanding of the Deming philosophy of quality improvement	33	1.55	.869	10.213	32	.000
Understanding of ISO 9000 standards	33	1.88	1.139	9.476	32	.000
Understanding of principles of total quality management (which has a focus on customers and stakeholders; participation and teamwork by organization members; and continuous improvement and learning)	33	1.45	.617	13.543	32	.000
Ability to implement process improvement schemes	33	1.45	.506	16.525	32	.000

Note: Cronbach's Alpha for the nine items within scale=.905

Pilot Test Mean Values of Items within the *Quality Management of Technology* Scale



Pilot Test Perceived Level of Importance of Items within the *Quality Management of Technology* Scale

Item	Number of Respondents	Mean
Ability to manage for quality outcomes	33	1.36
Understanding of the tools used in process improvement	33	1.39
Ability to manage for performance excellence	33	1.42
Understanding of principles of total quality management (which has a focus on customers and stakeholders, participation and teamwork by organization members, and continuous improvement and learning)	33	1.45
Ability to implement process improvement schemes	33	1.45
Understanding of the Deming philosophy of quality improvement	33	1.55
Understanding of ISO 9000 standards	33	1.88
Understanding of the Baldridge criteria for quality	33	1.91
Understanding of the principles of Six Sigma	33	1.94

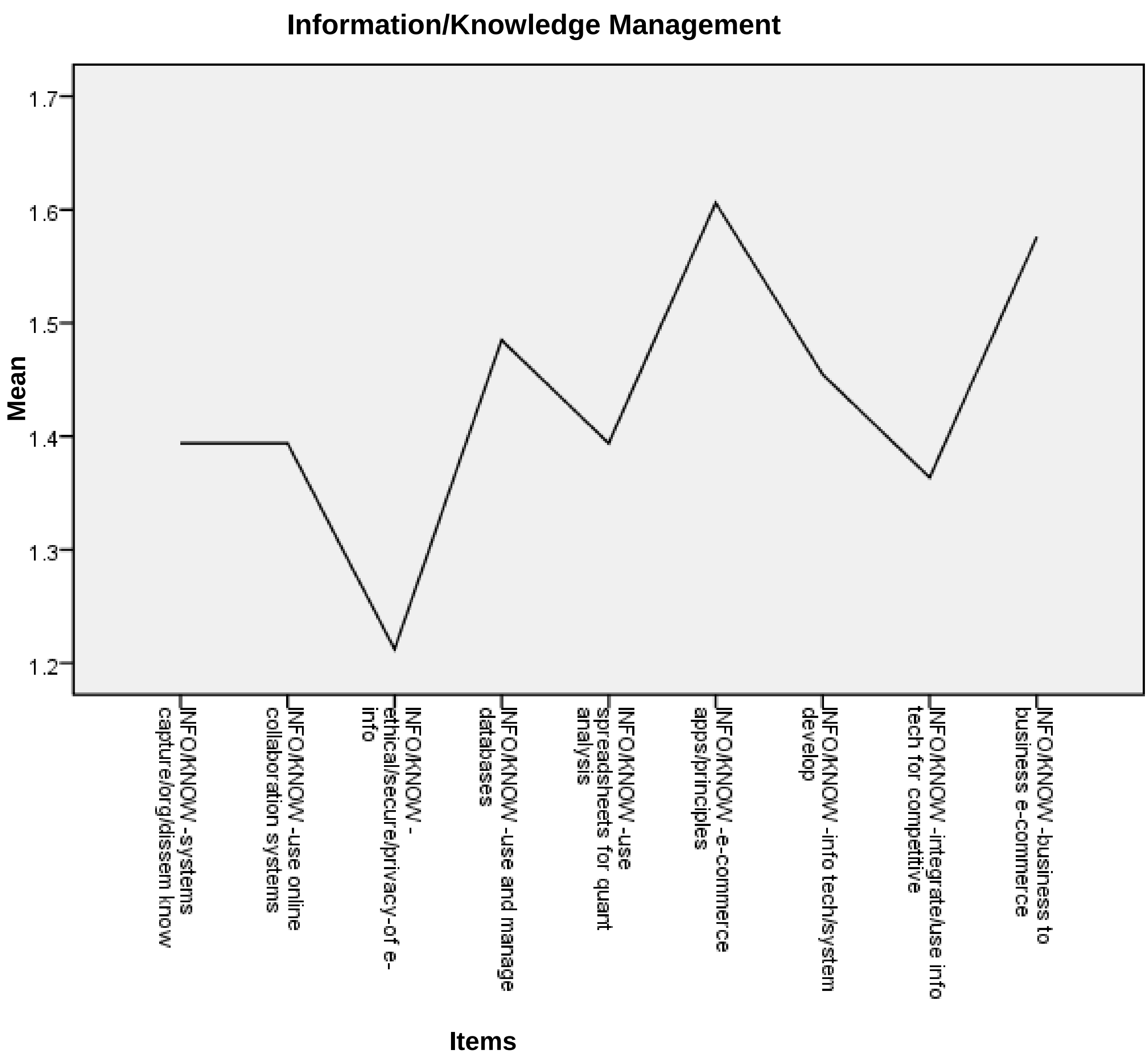
Information/Knowledge Management

Pilot Test Reliability Analysis of Items within the *Information/Knowledge Management* Scale

Item	Number of Respondents	Mean	Standard Deviation	*t* test	df	Sig <.01 Level
Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	33	1.39	.556	14.412	32	.000
Ability to use online collaboration systems	33	1.39	.659	12.159	32	.000
Understanding of ethical, security, and privacy issues surrounding the use of electronic information	33	1.21	.415	16.773	32	.000
Ability to use and manage databases	33	1.48	.667	12.786	32	.000
Ability to use spreadsheets for quantitative analysis of information	33	1.39	.609	13.143	32	.000
Understanding of electronic commerce applications and principles	33	1.61	.747	12.343	32	.000
Understanding of information technology and system development	33	1.45	.754	11.085	32	.000
Ability to integrate and use information technology to increase the competitive stance of an organization	33	1.36	.489	16.036	32	.000
Understanding of business to business e-commerce	33	1.58	.867	10.439	32	.000

Note: Cronbach's Alpha for the nine items within scale=.877

Pilot Test Mean Values of Items within the *Information/Knowledge Management* Scale



Pilot Test Perceived Level of Importance of Items within the *Information/Knowledge Management* Scale

Item	Number of Respondents	Mean
Understanding of ethical, security, and privacy issues surrounding the use of electronic information	33	1.21
Ability to integrate and use information technology to increase the competitive stance of an organization	33	1.36
Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	33	1.39
Ability to use online collaboration systems	33	1.39
Ability to use spreadsheets for quantitative analysis of information	33	1.39
Understanding of information technology and system development	33	1.45
Ability to use and manage databases	33	1.48
Understanding of business–to-business e-commerce	33	1.58
Understanding of electronic commerce applications and principles	33	1.61

Appendix H

Final Version of Survey Instrument

Technology Management Education Survey 1.1

1.

May 12, 2008

Dear Survey Participant,

You are invited to participate in this survey because your opinions are extremely important to the development of a core curriculum in undergraduate technology management programs. Rapid technological change is occurring in all areas of business and industry, as Thamhain (2005) observed, "the magnitude and speed of technological advances over the past decades are stunning, reshaping our world and influencing virtually every aspect of life...as technology crosses virtually all levels and all disciplines of an enterprise" (p. xi). Technological progress is credited with generating approximately half of the economic growth seen in the US in the last 50 years (US National Science and Technology Council, Office of Technology Policy [NSTC], 1996, p. 1). This rapid technological change has resulted in a pressing need for qualified employees who have technical, scientific, and professional skills, with employment growth projections of 28.4% and 1.9 million new jobs in these areas expected by 2014 (US Bureau of Labor Statistics, 2006-07). The United States Department of Labor (2005) has also projected growth of 60.5% in management, scientific, and technical consulting services which is being driven "by the increased use of new technology and computer software and the growing complexity of business" (p. 6).

The development of relevant core competencies in technology managers is critical to the economic success of Michigan as we move from a manufacturing based economy to a technologically based service economy. Technology managers are found in many areas of business and industry including but not limited to the following: alternative energy, education, environmental technologies, automotive technologies, health, information technology, graphic design, manufacturing, production, public safety, and security. This survey will attempt to answer the following research question about undergraduate technology-management education:

What core competencies are necessary for undergraduate technology management majors to be successful when they enter the workplace? "Core competencies refer to the knowledge, skills, abilities and behaviors that contribute to an employee's job success and that are often included in corporate human resource development plans" (Casner-Lotto & Barrington, 2006, p. 15). The following eight categories have been identified in the technology management literature, and you will be asked your opinion on whether or not you agree that graduates of technology management programs should have core competencies in these categories:

1. Management of technological change
2. Management of organizational change
3. Technology project management
4. Assessment and evaluation of technology
5. Quality management of technology
6. Information/knowledge management
7. Management of innovation and product development
8. Strategic management of technology

Upon submission of the completed survey, your name will be entered into a drawing for a $100.00 Visa gift certificate.

This dissertation research study is being conducted by Pamela R. Becker, Assistant Professor and Technology Management Program Coordinator at Eastern Michigan University. If you have any technical difficulties, questions, or would like to request a paper-based copy of the survey, please contact her at 734.487.1161 or by email at pam.becker@emich.edu.

This survey should take approximately 10 minutes to complete. Please click on the "Next Button" below to begin the survey. If you would like to request a paper-based version of the survey, please provide your contact information in the box below.

1. Name and mailing address:

Technology Management Education Survey 1.1

2. Informed Consent

May 12, 2008

You are being asked to participate in a dissertation research study that focuses on undergraduate technology-management education programs. Your participation in this study is voluntary and you may withdraw from the study at any time.

No harm or discomfort should occur since your identity will be kept confidential at all times. To ensure confidentiality email survey responses will be stored on a secure server, and paper-based responses will be kept by the researcher in a locked file cabinet at her residence. Upon completion of the study, the consent forms, the responses, and any identifying information will be destroyed. In addition, when the study is complete, you may request a copy of the findings. Data collected will be published in the dissertation and may be used in presentations and other publications, but neither your name nor your organization will be associated with any responses and the material will be presented only in aggregate form at presentations or in publications.

The survey should take approximately ten minutes to complete. No direct benefits are anticipated to incur as the result of completing the survey.

For questions about this research, please contact Pamela Becker, Assistant Professor, Eastern Michigan University at 734.487.1161, or her dissertation chair, Dr. Martha W. Tack, Professor, Eastern Michigan University, at 734.487.0255.

This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from April 14, 2008 to April 13, 2009. If you have questions about the approval process, please contact Dr. Deb deLaski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSRC, human.subjects@emich.edu).

I confirm that I know the purpose and parameters of the research study outlined above. I understand that the duration of my participation in this research study will be limited to the completion of the survey. I am aware that participation is completely voluntary and that I may withdraw from the study at any time without penalty. I hereby provide consent for the use of my responses and wish to participate in this research endeavor.

*** 1. Please check the desired box below.**

- ◯ I agree to participate in this study.
- ◯ I do not agree to participate in this study.

Technology Management Education Survey 1.1

3. Demographic Information

Please tell us about yourself.

1. Please complete the following.

Note: Completion of the contact information is optional and is only required if you would like your name submitted to the drawing for the $100.00 Visa Gift Certificate.

Full Name:
Organization:
Address:
Address 2 (optional):
City/Town:
State:
ZIP/Postal Code:
Country:
Email Address:
Phone Number :

2. What is your position title?

3. What is your gender?

- Male
- Female

4. What is your age?

5. What is the primary industry in which you are involved?

- Business Services
- Education
- Government
- Manufacturing

Other (please specify)

6. Are you a member of the Michigan Economic Development Corporation?

- Yes
- No

Technology Management Education Survey 1.1

4. Management of Technological Change

When answering the following questions, keep in mind that the purpose of this research study is to determine the knowledge, skills, abilities, and behaviors that contribute to job success and should be the outcome of completing an undergraduate degree in technology management.

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess the need for technological change.	○	○	○	○	○
2. Ability to assess an organization's readiness for technological change.	○	○	○	○	○
3. Ability to implement technological change.	○	○	○	○	○
4. Ability to scan significant technological changes occurring within the external environment of the organization.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.1

5. Management of Organizational Change

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess the need for organizational change.	○	○	○	○	○
2. Understanding of how to integrate new organizational processes.	○	○	○	○	○
3. Ability to implement organizational change.	○	○	○	○	○
4. Ability to plan for and implement various forms of cross-functional teams and processes.	○	○	○	○	○
5. Ability to assess and implement requisite changes in human resource management.	○	○	○	○	○
6. Understanding of leadership strategies and methods.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.1

6. Technology Project Management

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to plan and organize projects.	○	○	○	○	○
2. Ability to effectively implement projects.	○	○	○	○	○
3. Ability to work effectively with functional groups within the organization to plan and implement projects.	○	○	○	○	○
4. Ability to schedule projects effectively and within the constraints of the organization.	○	○	○	○	○
5. Ability to gather data on the task, schedule, budget, monitor, and evaluate the total effort.	○	○	○	○	○
6. Ability to reduce implementation costs of new projects	○	○	○	○	○
7. Ability to manage and lead the project team.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.1

7. Assessment and Evaluation of Technology

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to assess training needs in association with the implementation of new technologies.	◯	◯	◯	◯	◯
2. Ability to assess cost and benefits of new technologies.	◯	◯	◯	◯	◯
3. Ability to do a SWOT (strengths, weaknesses, opportunities, and threats) analysis associated with new technologies.	◯	◯	◯	◯	◯
4. Ability to assess the effect of technologies on society.	◯	◯	◯	◯	◯
5. Ability to identify technologies important to the business.	◯	◯	◯	◯	◯
6. Ability to anticipate how new technologies may effect the organization.	◯	◯	◯	◯	◯
7. Ability to assess the integrative effects of technology on the organization (customer-related factors, market-related factors, process-related factors, employee-related factors, vendor-related factors, and owner-related factors).	◯	◯	◯	◯	◯
8. Understanding of Porter's Five Forces Model (buyer power, supplier power, threat of substitute products and services, threat of new entrants, and rivalry among existing competitors) in assessing technology.	◯	◯	◯	◯	◯

Additional Comments (optional)

Technology Management Education Survey 1.1

8. Quality Management of Technology

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to manage for quality outcomes.	○	○	○	○	○
2. Ability to manage for performance excellence.	○	○	○	○	○
3. Understanding of the tools used in process improvement.	○	○	○	○	○
4. Understanding of the principles of Six Sigma.	○	○	○	○	○
5. Understanding of the Baldrige criteria for quality.	○	○	○	○	○
6. Understanding of the Deming philosophy of quality improvement.	○	○	○	○	○
7. Understanding of ISO 9000 standards.	○	○	○	○	○
8. Understanding of principles of total quality management (which has a focus on customers and stakeholders; participation and teamwork by organization members; and continuous improvement and learning).	○	○	○	○	○
9. Ability to implement process improvement schemes.	○	○	○	○	○

Additional Comments

Technology Management Education Survey 1.1

9. Information/Knowledge Management

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization.	◯	◯	◯	◯	◯
2. Ability to use online collaboration systems.	◯	◯	◯	◯	◯
3. Understanding of ethical, security, and privacy issues surrounding the use of electronic information.	◯	◯	◯	◯	◯
4. Ability to use and manage databases.	◯	◯	◯	◯	◯
5. Ability to use spreadsheets for quantitative analysis of information.	◯	◯	◯	◯	◯
6. Understanding of electronic commerce applications and principles.	◯	◯	◯	◯	◯
7. Understanding of information technology and system development.	◯	◯	◯	◯	◯
8. Ability to integrate and use information technology to increase the competitive stance of an organization.	◯	◯	◯	◯	◯
9. Understanding of business-to-business e-commerce.	◯	◯	◯	◯	◯

Additional Comments

Technology Management Education Survey 1.1

10. Management of Innovation and Product Development

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Understanding of the platform approach to product development.	○	○	○	○	○
2. Ability to predict new product success.	○	○	○	○	○
3. Understanding of processes used to launch new products.	○	○	○	○	○
4. Ability to plan for and implement team-based management systems used in the development and launching of new products.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.1

11. Strategic Management of Technology

1. Please indicate the extent of your agreement or disagreement, that technology management program graduates should have core competencies in the following areas.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. Ability to develop an effective technology strategy for achieving competitive advantage.	○	○	○	○	○
2. Ability to develop effective planning procedures for selecting new technology.	○	○	○	○	○
3. Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization.	○	○	○	○	○
4. Ability to align the organization's structure and processes with its core technologies.	○	○	○	○	○
5. Ability to create value through the use of technology.	○	○	○	○	○

Additional Comments (optional)

Technology Management Education Survey 1.1

12. Thank You!

Thank you very much for taking the time to complete this important survey. Your name is now entered into a drawing to receive a $100.00 Visa gift certificate.

If you would like to receive summary results of the research study, please email Pamela R. Becker at pam.becker@emich.edu .

The following sources used in the development of this survey:

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Yanez, Jr. M., & Khalil, T. M. (2007). An accreditation program for MOT graduate education: Recognition of need and a body-of-knowledge framework. In International Association for Management of Technology IAMOT 2007 Proceedings. (pp. 786-796). Coral Gables, FL.

Appendix I

Invitation to Participate in Survey

May 12, 2008

Dear: Survey Participant,

Within a few days you will receive by electronic mail a request from Pamela Becker focused on identifying the optimal core curricular components of an effective undergraduate technology management program in a college or university. This dissertation research is being completed as part of the requirements for my doctoral degree in educational leadership at Eastern Michigan University where I also serve as Assistant Professor and Program Coordinator in the Technology Management Program. Needless to say I hope you will help me complete this research for several important reasons which I will enumerate below.

In a study that Feinstein and McAlinden (2002) conducted for the Michigan Economic Development Corporation, they found that “Michigan rank[ed] fourth among the fifty states in 2001 in terms of total employment in high-tech industries as defined by the U.S. Department of Labor Statistics” (p. 1). In another study prepared for the Michigan Economic Development Corporation, “Benchmarks for the Next Michigan” it was noted that while Michigan has a “high percentage of workers with technical degrees,” there are only a relatively small number of people with bachelor’s degrees in the state, and we must continue “to increase the skills and education levels of the workforce” (2002, p. 8).

Undergraduate programs in technology management can serve as a vital mechanism in preparing Michigan’s workforce for the move to a knowledge-based economy. Most undergraduate technology management education programs in the United States accept transfer credit from community colleges. In fact, Eastern Michigan University's Technology Management Program has 3 + 1 articulation agreements with nine area community colleges and agreements with six additional community colleges are currently being developed. Students can transfer up to 94 college credits to Eastern Michigan University from these articulated programs. The program articulation process makes higher education more affordable for members of the Michigan workforce and increases the percentage of workers with baccalaureate degrees.

I am notifying you in advance of my need for your help with this research because I believe many people like to know ahead of time that they will be asked to provide their opinions so they can reflect on the topic clearly. The study is an important one that will enable us to prepare qualified undergraduate students in the technology management field and the purpose of the research coincides with the mission of the Michigan Economic Development Council in preparing a qualified work force. Participation in this study is voluntary and you may withdraw from the study at any time.

I will be most appreciative of your assistance and support. If you have questions or concerns when you receive the survey materials, please contact me directly at pam.becker@emich.edu or at 734.487.1161.

Sincerely,

Pamela R. Becker
Assistant Professor, Program Coordinator
Technology Management
Eastern Michigan University

P.S. Upon submission of your survey your name will be entered into a drawing for a $100.00 Visa gift certificate.

Appendix J

Request to Participate in
Technology Management Education Survey

May 15, 2008

Dear Survey Participant,

This is a request from Pamela Becker to participate in a survey focused on identifying the optimal core curricular components of an effective undergraduate technology management program in a college or university. This dissertation research is being completed as part of the requirements for her doctoral degree in educational leadership at Eastern Michigan University where she also serves as Assistant Professor and Program Coordinator in the Technology Management Program. Needless to say she hopes that you will help her complete this research for several important reasons which she will enumerate below.

In a study that Feinstein and McAlinden (2002) conducted for the Michigan Economic Development Corporation, they found that "Michigan rank[ed] fourth among the fifty states in 2001 in terms of total employment in high-tech industries as defined by the U.S. Department of Labor Statistics" (p. 1). In another study prepared for the Michigan Economic Development Corporation, "Benchmarks for the Next Michigan" it was noted that while Michigan has a "high percentage of workers with technical degrees," there are only a relatively small number of people with bachelor's degrees in the state, and we must continue "to increase the skills and education levels of the workforce" (2002, p. 8).

Undergraduate programs in technology management can serve as a vital mechanism in preparing Michigan's workforce for the move to a knowledge-based economy. Most undergraduate technology management education programs in the United States accept transfer credit from community colleges. In fact, Eastern Michigan University's Technology Management Program has 3 + 1 articulation agreements with nine area community colleges and agreements with six additional community colleges are currently being developed. Students can transfer up to 94 college credits to Eastern Michigan University from these articulated programs. The program articulation process makes higher education more affordable for members of the Michigan workforce and increases the percentage of workers with baccalaureate degrees.

The study is an important one that will enable us to prepare qualified undergraduate students in the technology management field and the purpose of the research coincides with the mission of the Michigan Economic Development Council in preparing a qualified work force. Participation in this study is voluntary and you may withdraw from the study at any time.

Pamela Becker will be most appreciative of your assistance and support. If you have questions or concerns when you receive the survey materials, please contact her directly at pam.becker@emich.edu or at 734.487.1161. You may access the survey directly by clicking on the following link

http://www.surveymonkey.com/s.aspx?sm=mm1OyeKhe0l5nXJoiLmxKw_3d_3d

Sincerely,

Pamela R. Becker
Assistant Professor, Program Coordinator
Technology Management
Eastern Michigan University

P.S. Upon submission of your survey your name will be entered into a drawing for a $100.00 Visa gift certificate.

Appendix K

First Reminder to Participate in Survey

May 21, 2008

Dear Survey Participant,

Last week you received an email containing a request that you complete a brief survey about what the core curriculum in undergraduate technology management education programs in colleges and universities should include.

If you have not yet had the time to complete the survey, I hope you will do so today, because your expertise in helping us determine what our "workforce of tomorrow" should know in the arena of technology management is essential to the economic transformation of our state, national, and global enterprises.

I have attached a link to the survey below. By clicking on the link, you can either complete an electronic form of the survey or request that a copy of the survey be mailed to you.

If you have any questions, please feel free to contact me at pam.becker@emich.edu or at 734.487.1161.

Pamela R. Becker
Assistant Professor, Program Coordinator
Technology Management
Eastern Michigan University

LINK TO SURVEY

Appendix L

Second Reminder to Participate in Survey

May 27, 2008

Dear Survey Participant,

Recently I sent you an email with an invitation to complete a survey regarding your opinion about the optimal core curricular elements that should be included in undergraduate technology management education programs.

The comments received from other survey participants have been very useful. I am writing to you again because of the importance that your opinion has in helping to get accurate results. (It is very important to hear from nearly everyone in the sample to ensure that the results of the research are accurate.)

Your responses to the survey will be kept confidential at all times and will only be presented in aggregate form; your name will never be associated with any particular responses. To ensure confidentially all electronic survey responses will be kept on a secure server, and paper-based responses will be kept by the researcher in a locked file. Protecting the confidentially of respondents is very important to me as well as to the University officials.

As an important employee in the technology management field your pivotal position and special expertise have a critical bearing on the development of technology management academic programs. I need to bring your expertise to bear on the development of a curriculum that can potentially have a dramatically positive effect on the financial outlook of the nation. I hope you will please take ten minutes to share what you believe is essential in technology management education, and complete the survey and return it to me as soon as possible. If for any reason you prefer not to provide answers, please let me know by email or by choosing the "opt out" button from the link below.

If you wish to speak with me personally about your concerns, please call me at 734.487.1161.

Pamela R. Becker
Assistant Professor, Program Coordinator
Technology Management
Eastern Michigan University
pam.becker@emich.edu

LINK TO SURVEY

"OPT OUT" OF SURVEY

Appendix M

Informed Consent Document

March 25, 2008

I agree to participate in a dissertation research study that focuses on undergraduate technology management education programs. I understand that my participation in this study is voluntary and that I may withdraw from the study at any time.

I understand that no harm or discomfort should occur since my identity will be kept confidential at all times. To ensure confidentiality email survey responses will be stored on a secure server, and paper-based responses will be kept by the researcher in a locked file cabinet at her residence. Upon completion of the study, the consent forms, the responses, and any identifying information will be destroyed. In addition, when the study is complete, I know I may request a copy of the findings. I further understand that data collected may be used for presentations and publications, but that neither my name nor my organization will be associated with any responses and that material will be presented only in aggregate form at presentations or in publications.

For questions about this research, please contact Pamela Becker, Assistant Professor, Eastern Michigan University at 734.487.1161, or her dissertation chair, Dr. Martha W. Tack, Professor, Eastern Michigan University, at 734.487.0255.

This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from April 14, 2008 to April 12, 2009. If you have questions about the approval process, please contact Dr. Deb deLaski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSRC, human.subjects@emich.edu).

I confirm that I know the purpose and parameters of the research study outlined above. I understand that the duration of my participation in this research study will be limited to the completion of the survey. I am aware that participation is completely voluntary and that I may withdraw from the study at any time without penalty. I hereby provide consent for the use of my responses and wish to participate in this research endeavor.

____I agree to participate in this study.

____I do not agree to participate in this study.

Name_____________________ Telephone____________________

Signature___________________ Date___________________________

Appendix N

Frequency Analysis of *Management of Technological Change* Scale and Items within Scale

Frequency Analysis of *Management of Technological Change* Scale

		Ability to assess the need for technological change	Ability to assess an organization's readiness for technological change	Ability to implement technological change	Ability to scan significant technological changes occurring within the external environment of the organization
N	Valid	127	127	127	127
	Missing	0	0	0	0
	Mean	1.42	1.49	1.33	1.54
	Median	1.00	1.00	1.00	1.00
	Mode	1	1	1	1

Frequency Analysis of Ability to Assess the Need for Technological Change Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	84	66.1	66.1	66.1
	Somewhat agree	37	29.1	29.1	95.3
	Neither agree nor disagree	3	2.4	2.4	97.6
	Somewhat disagree	2	1.6	1.6	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Assess an Organization's Readiness for Technological Change Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	75	59.1	59.1	59.1
	Somewhat agree	44	34.6	34.6	93.7
	Neither agree nor disagree	6	4.7	4.7	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Implement Technological Change Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	89	70.1	70.1	70.1
	Somewhat agree	34	26.8	26.8	96.9
	Neither agree nor disagree	4	3.1	3.1	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Scan Significant Technological Changes Occurring within the External Environment of the Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	70	55.1	55.1	55.1
	Somewhat agree	46	36.2	36.2	91.3
	Neither agree nor disagree	11	8.7	8.7	100.0
	Total	127	100.0	100.0	

Appendix O

Frequency Analysis of *Management of Organizational Change* Scale and Items within Scale

Frequency Analysis of *Management of Organizational Change* Scale

Statistics

		Ability to assess the need for organizational change	Understanding of how to integrate new organizational processes	Ability to implement organizational change	Ability to plan for and implement various forms of cross-functional teams and processes	Ability to assess and implement requisite changes in human resource management	Understanding of leadership strategies and methods
N	Valid	127	127	127	127	125	126
	Missing	0	0	0	0	2	1
	Mean	1.43	1.44	1.57	1.53	1.82	1.37
	Median	1.00	1.00	1.00	1.00	2.00	1.00
	Mode	1	1	1	1	2	1

Frequency Analysis of Ability to Assess the Need for Organizational Change Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	82	64.6	64.6	64.6
	Somewhat agree	36	28.3	28.3	92.9
	Neither agree nor disagree	8	6.3	6.3	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of How to Integrate New Organizational Processes Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	81	63.8	63.8	63.8
	Somewhat agree	39	30.7	30.7	94.5
	Neither agree nor disagree	5	3.9	3.9	98.4
	Somewhat disagree	1	.8	.8	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Implement Organizational Change Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	69	54.3	54.3	54.3
	Somewhat agree	46	36.2	36.2	90.6
	Neither agree nor disagree	11	8.7	8.7	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Plan for and Implement Various Forms of Cross-functional Teams and Processes Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	70	55.1	55.1	55.1
	Somewhat agree	48	37.8	37.8	92.9
	Neither agree nor disagree	8	6.3	6.3	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Assess and Implement Requisite Changes in Human Resource Management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	47	37.0	37.6	37.6
	Somewhat agree	57	44.9	45.6	83.2
	Neither agree nor disagree	18	14.2	14.4	97.6
	Somewhat disagree	3	2.4	2.4	100.0
	Total	125	98.4	100.0	
Missing	System	2	1.6		
Total		127	100.0		

Frequency Analysis of Understanding of Leadership Strategies and Methods Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	85	66.9	67.5	67.5
	Somewhat agree	37	29.1	29.4	96.8
	Neither agree nor disagree	3	2.4	2.4	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Appendix P

Frequency Analysis of *Technology Project Management* Scale and Items within Scale

Frequency Analysis of Technology Project Management Scale

		Ability to plan and organize projects	Ability to implement projects effectively	Ability to work effectively with functional groups within the organization to plan and implement projects	Ability to schedule projects effectively and within the constraints of the organization	Ability to gather data on the task, schedule, budget, monitor and evaluate the total effort	Ability to reduce implementation costs of new projects	Ability to manage and lead the project team
N	Valid	127	127	127	127	127	127	127
	Missing	0	0	0	0	0	0	0
	Mean	1.25	1.31	1.31	1.31	1.30	1.62	1.35
	Median	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Mode	1	1	1	1	1	1	1

Frequency Analysis of Ability to Plan and Organize Projects Items

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	97	76.4	76.4	76.4
	Somewhat agree	28	22.0	22.0	98.4
	Neither agree nor disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Implement Projects Effectively Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	92	72.4	72.4	72.4
	Somewhat agree	31	24.4	24.4	96.9
	Neither agree nor disagree	3	2.4	2.4	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Work Effectively with Functional Groups within the Organization to Plan and Implement Projects Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	91	71.7	71.7	71.7
	Somewhat agree	32	25.2	25.2	96.9
	Neither agree nor disagree	4	3.1	3.1	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Schedule Projects Effectively and within the Constraints of the Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	92	72.4	72.4	72.4
	Somewhat agree	31	24.4	24.4	96.9
	Neither agree nor disagree	3	2.4	2.4	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Gather Fata on the Task, Schedule, Budget, Monitor and Evaluate the Total Effort Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	95	74.8	74.8	74.8
	Somewhat agree	29	22.8	22.8	97.6
	Neither agree nor disagree	1	.8	.8	98.4
	Somewhat disagree	1	.8	.8	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Reduce Implementation Costs of New Projects Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	67	52.8	52.8	52.8
	Somewhat agree	42	33.1	33.1	85.8
	Neither agree nor disagree	17	13.4	13.4	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Manage and Lead the Project Team Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	92	72.4	72.4	72.4
	Somewhat agree	28	22.0	22.0	94.5
	Neither agree nor disagree	5	3.9	3.9	98.4
	Somewhat disagree	1	.8	.8	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Appendix Q

Frequency Analysis of *Assessment and Evaluation of Technology* Scale and Items within Scale

Frequency Analysis of *Assessment and Evaluation of Technology* Scale

		Ability to assess training needs in association with the implementation of new technologies	Ability to assess cost and benefits of new technologies	Ability to do a SWOT analysis associated with new technologies	Ability to assess the effects of technologies on society	Ability to identify technologies important to the business	Ability to anticipate how new technologies may effect the organization	Ability to assess the integrative effects of technology on the organization	Understanding of Porter's Five Forces Model
N	Valid	126	127	127	127	127	126	127	127
	Missing	1	0	0	0	0	1	0	0
	Mean	1.54	1.49	1.50	1.83	1.32	1.39	1.65	1.98
	Median	1.00	1.00	1.00	2.00	1.00	1.00	2.00	2.00
	Mode	1	1	1	2	1	1	1	2

Frequency Analysis of Ability to Assess Training Needs in Association with the Implementation of New Technologies Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	70	55.1	55.6	55.6
	Somewhat agree	45	35.4	35.7	91.3
	Neither agree nor disagree	10	7.9	7.9	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Ability to Assess Cost and Benefits of New Technologies Items

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	75	59.1	59.1	59.1
	Somewhat agree	44	34.6	34.6	93.7
	Neither agree nor disagree	7	5.5	5.5	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to do a strengths, weaknesses, opportunities, and threats (SWOT) Analysis Associated with New Technologies Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	76	59.8	59.8	59.8
	Somewhat agree	41	32.3	32.3	92.1
	Neither agree nor disagree	8	6.3	6.3	98.4
	Somewhat disagree	1	.8	.8	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Assess the Effects of Technologies on Society Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	45	35.4	35.4	35.4
	Somewhat agree	64	50.4	50.4	85.8
	Neither agree nor disagree	13	10.2	10.2	96.1
	Somewhat disagree	4	3.1	3.1	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Identify Technologies Important to the Business Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	88	69.3	69.3	69.3
	Somewhat agree	37	29.1	29.1	98.4
	Neither agree nor disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Anticipate How New Technologies May Effect the Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	81	63.8	64.3	64.3
	Somewhat agree	42	33.1	33.3	97.6
	Neither agree nor disagree	2	1.6	1.6	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Ability to Assess the Integrative Effects of Technology on the Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	60	47.2	47.2	47.2
	Somewhat agree	53	41.7	41.7	89.0
	Neither agree nor disagree	12	9.4	9.4	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of Porter's Five Forces Model Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	42	33.1	33.1	33.1
	Somewhat agree	56	44.1	44.1	77.2
	Neither agree nor disagree	21	16.5	16.5	93.7
	Somewhat disagree	6	4.7	4.7	98.4
	Strongly disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Appendix R

Frequency Analysis of *Quality Management of Technology* Scale and Items within Scale

Frequency Analysis of *Quality Management of Technology* Scale

		Ability to manage for quality outcomes	Ability to manage for performance excellence	Understanding of the tools used in process improvement	Understanding of the principles of Six Sigma	Understanding of the Baldrige criteria for quality	Understanding of the Deming philosophy of quality improvement	Understanding of ISO 9000 standards	Understanding of principles of total quality management	Ability to implement process improvement schemes
N	Valid	127	127	127	126	126	125	127	125	127
	Missing	0	0	0	1	1	2	0	2	0
	Mean	1.53	1.50	1.38	1.82	2.02	1.83	1.94	1.46	1.45
	Median	1.00	1.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00
	Mode	1	1	1	1	2	1	1	1	1

Frequency Analysis of Ability to Manage for Quality Outcomes Items

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	74	58.3	58.3	58.3
	Somewhat agree	41	32.3	32.3	90.6
	Neither agree nor disagree	11	8.7	8.7	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Manage for Performance Excellence Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	76	59.8	59.8	59.8
	Somewhat agree	40	31.5	31.5	91.3
	Neither agree nor disagree	10	7.9	7.9	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of the Tools Used in Process Improvement Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	85	66.9	66.9	66.9
	Somewhat agree	37	29.1	29.1	96.1
	Neither agree nor disagree	4	3.1	3.1	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of the Principles of Six Sigma Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	52	40.9	41.3	41.3
	Somewhat agree	47	37.0	37.3	78.6
	Neither agree nor disagree	25	19.7	19.8	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Understanding of the Baldrige Criteria for Quality Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	42	33.1	33.3	33.3
	Somewhat agree	43	33.9	34.1	67.5
	Neither agree nor disagree	38	29.9	30.2	97.6
	Somewhat disagree	3	2.4	2.4	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Understanding of the Deming Philosophy of Quality Improvement Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	50	39.4	40.0	40.0
	Somewhat agree	48	37.8	38.4	78.4
	Neither agree nor disagree	25	19.7	20.0	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	125	98.4	100.0	
Missing	System	2	1.6		
Total		127	100.0		

Frequency Analysis of Understanding of ISO 9000 Standards Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	49	38.6	38.6	38.6
	Somewhat agree	42	33.1	33.1	71.7
	Neither agree nor disagree	31	24.4	24.4	96.1
	Somewhat disagree	5	3.9	3.9	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of Principles of Total Quality Management Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	76	59.8	60.8	60.8
	Somewhat agree	42	33.1	33.6	94.4
	Neither agree nor disagree	6	4.7	4.8	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	125	98.4	100.0	
Missing	System	2	1.6		
Total		127	100.0		

Frequency Analysis of Ability to Implement Process Improvement Schemes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	80	63.0	63.0	63.0
	Somewhat agree	38	29.9	29.9	92.9
	Neither agree nor disagree	8	6.3	6.3	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Appendix S

Frequency Analysis of *Information and Knowledge Management* Scale and Items within Scale

Frequency Analysis of *Information/Knowledge Management* Scale

		Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	Ability to use online collaboration systems	Understanding of ethical, security, and privacy issues surrounding the use of electronic information	Ability to use and manage databases	Ability to use spreadsheets for quantitative analysis of information	Understanding of electronic commerce applications and principles	Understanding of information technology and system development	Ability to integrate and use information technology to increase the competitive stance of an organization	Understanding of business to business e-commerce
N	Valid	127	127	127	127	127	126	126	126	127
	Missing	0	0	0	0	0	1	1	1	0
	Mean	1.54	1.49	1.32	1.46	1.35	1.69	1.44	1.41	1.72
	Median	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00
	Mode	1	1	1	1	1	1	1	1	1

Frequency Analysis of Understanding of Knowledge Management Systems that Support the Capturing, Organization, and Dissemination of Knowledge throughout an Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	69	54.3	54.3	54.3
	Somewhat agree	49	38.6	38.6	92.9
	Neither agree nor disagree	7	5.5	5.5	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Use Online Collaboration Systems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	77	60.6	60.6	60.6
	Somewhat agree	38	29.9	29.9	90.6
	Neither agree nor disagree	12	9.4	9.4	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of Ethical, Security, and Privacy Issues Surrounding the Use of Electronic Information Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	90	70.9	70.9	70.9
	Somewhat agree	33	26.0	26.0	96.9
	Neither agree nor disagree	4	3.1	3.1	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Use and Manage Databases Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	74	58.3	58.3	58.3
	Somewhat agree	47	37.0	37.0	95.3
	Neither agree nor disagree	6	4.7	4.7	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Use Spreadsheets for Quantitative Analysis of Information Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	86	67.7	67.7	67.7
	Somewhat agree	38	29.9	29.9	97.6
	Neither agree nor disagree	3	2.4	2.4	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of e-Commerce Applications and Principles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	60	47.2	47.6	47.6
	Somewhat agree	48	37.8	38.1	85.7
	Neither agree nor disagree	15	11.8	11.9	97.6
	Somewhat disagree	3	2.4	2.4	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Understanding of Information Technology and System Development Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	82	64.6	65.1	65.1
	Somewhat agree	34	26.8	27.0	92.1
	Neither agree nor disagree	9	7.1	7.1	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Ability to Integrate and Use Information Technology to Increase the Competitive Stance of an Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	82	64.6	65.1	65.1
	Somewhat agree	37	29.1	29.4	94.4
	Neither agree nor disagree	6	4.7	4.8	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	126	99.2	100.0	
Missing	System	1	.8		
Total		127	100.0		

Frequency Analysis of Understanding of Business to Business e-Commerce Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	60	47.2	47.2	47.2
	Somewhat agree	45	35.4	35.4	82.7
	Neither agree nor disagree	20	15.7	15.7	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Appendix T

Frequency Analysis of *Management of Innovation and Product Development* Scale and Items within Scale

Frequency Analysis of *Innovation and Product Development* Scale

		Understanding of the platform approach to product development	Ability to predict new product success	Understanding of processes used to launch new products	Ability to plan for and implement team-based management systems used in the development and launching of new products
N	Valid	127	127	125	127
	Missing	0	0	2	0
	Mean	1.84	1.85	1.65	1.59
	Median	2.00	2.00	2.00	1.00
	Mode	2	2	1	1

Frequency Analysis of Understanding of the Platform Approach to Product Development Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	47	37.0	37.0	37.0
	Somewhat agree	55	43.3	43.3	80.3
	Neither agree nor disagree	23	18.1	18.1	98.4
	Somewhat disagree	2	1.6	1.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Plan for and Implement Team-based Management Systems Used in the Development and Launching of New Products Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	68	53.5	53.5	53.5
	Somewhat agree	43	33.9	33.9	87.4
	Neither agree nor disagree	16	12.6	12.6	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Predict New Product Success Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	44	34.6	34.6	34.6
	Somewhat agree	63	49.6	49.6	84.3
	Neither agree nor disagree	16	12.6	12.6	96.9
	Somewhat disagree	3	2.4	2.4	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Understanding of Processes Used to Launch New Products Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	58	45.7	46.4	46.4
	Somewhat agree	54	42.5	43.2	89.6
	Neither agree nor disagree	12	9.4	9.6	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	125	98.4	100.0	
Missing	System	2	1.6		
Total		127	100.0		

Appendix U

Frequency Analysis of *Strategic Management of Technology*
Scale and Items within Scale

Frequency Analysis of Strategic Management of Technology Scale

Statistics

		Ability to develop an effective technology strategy for achieving competitive advantage	Ability to develop effective planning procedures for selecting new technology	Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	Ability to align the organization's structure and processes with its core technologies	Ability to create value through the use of technology
N	Valid	127	127	127	127	127
	Missing	0	0	0	0	0
	Mean	1.56	1.46	1.61	1.56	1.41
	Median	1.00	1.00	1.00	1.00	1.00
	Mode	1	1	1	1	1

Frequency Analysis of Ability to Develop an Effective Technology Strategy for Achieving Competitive Advantage Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	71	55.9	55.9	55.9
	Somewhat agree	44	34.6	34.6	90.6
	Neither agree nor disagree	10	7.9	7.9	98.4
	Somewhat disagree	1	.8	.8	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Develop Effective Planning Procedures for Selecting New Technology Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	78	61.4	61.4	61.4
	Somewhat agree	40	31.5	31.5	92.9
	Neither agree nor disagree	8	6.3	6.3	99.2
	Somewhat disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Assess the Internal Strengths and Weaknesses of the Organization with Respect to Changes Occurring within the External Environment of the Organization Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	65	51.2	51.2	51.2
	Somewhat agree	48	37.8	37.8	89.0
	Neither agree nor disagree	13	10.2	10.2	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Align the Organization's Structure and Processes with its Core Technologies Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	70	55.1	55.1	55.1
	Somewhat agree	45	35.4	35.4	90.6
	Neither agree nor disagree	11	8.7	8.7	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Frequency Analysis of Ability to Create Value Through the Use of Technology Item

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	81	63.8	63.8	63.8
	Somewhat agree	42	33.1	33.1	96.9
	Neither agree nor disagree	3	2.4	2.4	99.2
	Strongly disagree	1	.8	.8	100.0
	Total	127	100.0	100.0	

Appendix V

One-way Analysis of Variance and Hochberg's GT2 and Games-Howell Post-Hoc Statistics

Analysis of Variance for Weighted Means of Technology Management Scales

		Sum of Squares	*df*	Mean Square	*F*	*p**
Management of Technological Change	Between Groups	.979	3	.326	1.552	.205
	Within Groups	25.242	120	.210		
	Total	26.222	123			
Management of Organizational Change	Between Groups	.987	3	.329	1.387	.250
	Within Groups	27.757	117	.237		
	Total	28.744	120			
Technology Project Management	Between Groups	.508	3	.169	.861	.464
	Within Groups	23.590	120	.197		
	Total	24.098	123			
Assessment and Evaluation of Technology	Between Groups	.343	3	.114	.514	.674
	Within Groups	26.283	118	.223		
	Total	26.627	121			
Quality Management of Technology	Between Groups	2.216	3	.739	2.440	.068
	Within Groups	35.426	117	.303		
	Total	37.642	120			
Information/ Knowledge Management	Between Groups	2.224	3	.741	3.656	.015
	Within Groups	23.726	117	.203		
	Total	25.951	120			
Management of Innovation and Product Development	Between Groups	1.008	3	.336	.965	.412
	Within Groups	41.084	118	.348		
	Total	42.092	121			
Strategic Management of Technology	Between Groups	.718	3	.239	.696	.556
	Within Groups	41.301	120	.344		
	Total	42.019	123			

Multiple Comparisons of Weighted Quality Management of Technology Scale

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Quality Management of Technology	Hochberg	Business Services	Education	-.21532	.15485	.660	-.6294	.1988
			Government	-.34765*	.12942	.048	-.6938	-.0015
			Manufacturing	-.26566	.16355	.488	-.7030	.1717
		Education	Business Services	.21532	.15485	.660	-.1988	.6294
			Government	-.13233	.13821	.915	-.5019	.2373
			Manufacturing	-.05034	.17059	1.000	-.5065	.4058
		Government	Business Services	.34765*	.12942	.048	.0015	.6938
			Education	.13233	.13821	.915	-.2373	.5019
			Manufacturing’	.08199	.14789	.994	-.3135	.4775
		Manufacturing	Business Services	.26566	.16355	.488	-.1717	.7030
			Education	.05034	.17059	1.000	-.4058	.5065
			Government	-.08199	.14789	.994	-.4775	.3135
	Games-Howell	Business Services	Education	-.21532	.16128	.547	-.6493	.2186
			Government	-.34765*	.11426	.017	-.6486	-.0467
			Manufacturing	-.26566	.14390	.270	-.6540	.1227
		Education	Business Services	.21532	.16128	.547	-.2186	.6493
			Government	-.13233	.15924	.839	-.5607	.2961
			Manufacturing	-.05034	.18169	.992	-.5374	.4367
		Government	Business Services	.34765*	.11426	.017	.0467	.6486
			Education	.13233	.15924	.839	-.2961	.5607
			Manufacturing	.08199	.14162	.938	-.2998	.4638
		Manufacturing	Business Services	.26566	.14390	.270	-.1227	.6540
			Education	.05034	.18169	.992	-.4367	.5374
			Government	-.08199	.14162	.938	-.4638	.2998

Multiple Comparisons of Weighted Information and Knowledge Management Scale

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Information and Knowledge Management	Hochberg	Business Services	Education	-.07300	.12778	.993	-.4147	.2687
			Government	-.19898	.10718	.332	-.4856	.0876
			Manufacturing	-.41358*	.13285	.014	-.7689	-.0583
		Education	Business Services	.07300	.12778	.993	-.2687	.4147
			Government	-.12598	.11311	.841	-.4285	.1765
			Manufacturing	-.34058	.13768	.085	-.7088	.0276
		Government	Business Services	.19898	.10718	.332	-.0876	.4856
			Education	.12598	.11311	.841	-.1765	.4285
			Manufacturing	-.21460	.11881	.363	-.5323	.1031
		Manufacturing	Business Services	.41358*	.13285	.014	.0583	.7689
			Education	.34058	.13768	.085	-.0276	.7088
			Government	.21460	.11881	.363	-.1031	.5323
	Games-Howell	Business Services	Education	-.07300	.11483	.920	-.3793	.2333
			Government	-.19898	.09893	.195	-.4601	.0622
			Manufacturing	-.41358*	.13790	.025	-.7862	-.0409
		Education	Business Services	.07300	.11483	.920	-.2333	.3793
			Government	-.12598	.10911	.658	-.4166	.1647
			Manufacturing	-.34058	.14538	.107	-.7319	.0507
		Government	Business Services	.19898	.09893	.195	-.0622	.4601
			Education	.12598	.10911	.658	-.1647	.4166
			Manufacturing	-.21460	.13318	.387	-.5756	.1464
		Manufacturing	Business Services	.41358*	.13790	.025	.0409	.7862
			Education	.34058	.14538	.107	-.0507	.7319
			Government	.21460	.13318	.387	-.1464	.5756

Weighted Quality Management of Technology

	Industry Sector	N	Subset for alpha=0.05
			1
Hochberg[a]	Business Services	28	1.4127
	Education	23	1.6280
	Manufacturing	19	1.6784
	Government	51	1.7603
	Sig.		.132

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=26.415

Weighted Information and Knowledge Management

	Industry Sector	N	Subset for alpha=0.05	
			1	2
Hochberg[a]	Business Services	27	1.3086	
	Education	23	1.3816	
	Government	51	1.5076	1.5076
	Manufacturing	20		1.7222
	Sig.		.496	.407

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=26.645

Analysis of Variance for Management of Technological Change Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to assess the need for technological change	Between Groups	2.934	3	.978	2.778	.044
	Within Groups	42.251	120	.352		
	Total	45.185	123			
Ability to assess an organization's readiness for technological change	Between Groups	.740	3	.247	.567	.638
	Within Groups	52.187	120	.435		
	Total	52.927	123			
Ability to implement technological change	Between Groups	1.569	3	.523	1.872	.138
	Within Groups	33.528	120	.279		
	Total	35.097	123			
Ability to scan significant technological changes occurring within the external environment of the organization	Between Groups	1.005	3	.335	.806	.493
	Within Groups	49.866	120	.416		
	Total	50.871	123			

Multiple Comparisons of Management of Technological Change: Ability to Assess the Need for Technological Change Items

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ability to Assess the Need for Technological Change	Hochberg	Business Services	Education	-.010	.166	1.000	-.45	.43
			Government	-.244	.138	.388	-.61	.12
			Manufacturing	-.412	.170	.096	-.87	.04
		Education	Business Services	.010	.166	1.000	-.43	.45
			Government	-.234	.149	.529	-.63	.16
			Manufacturing	-.402	.179	.149	-.88	.08
		Government	Business Services	.244	.138	.388	-.12	.61
			Education	.234	.149	.529	-.16	.63
			Manufacturing	-.168	.154	.853	-.58	.24
		Manufacturing	Business Services	.412	.170	.096	-.04	.87
			Education	.402	.179	.149	-.08	.88
			Government	.168	.154	.853	-.24	.58
	Games-Howell	Business Services	Education	-.010	.160	1.000	-.44	.42
			Government	-.244	.111	.135	-.54	.05
			Manufacturing	-.412	.179	.120	-.90	.07
		Education	Business Services	.010	.160	1.000	-.42	.44
			Government	-.234	.162	.480	-.67	.20
			Manufacturing	-.402	.214	.253	-.97	.17
		Government	Business Services	.244	.111	.135	-.05	.54
			Education	.234	.162	.480	-.20	.67
			Manufacturing	-.168	.181	.789	-.66	.32
		Manufacturing	Business Services	.412	.179	.120	-.07	.90
			Education	.402	.214	.253	-.17	.97
			Government	.168	.181	.789	-.32	.66

Management of Technological Change: Ability to Assess the Need for Technological Change

	Industry Sector	N	Subset for alpha=0.05 1
Hochberg[a]	Business Services	29	1.21
	Education	23	1.22
	Government	51	1.45
	Manufacturing	21	1.62
	Sig.		.065

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Analysis of Variance for Management of Organizational Change Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to assess the need for organizational change	Between Groups	1.899	3	.633	1.568	.201
	Within Groups	48.448	120	.404		
	Total	50.347	123			
Understanding of how to integrate new organizational processes	Between Groups	2.674	3	.891	2.160	.096
	Within Groups	49.520	120	.413		
	Total	52.194	123			
Ability to implement organizational change	Between Groups	1.916	3	.639	1.263	.290
	Within Groups	60.689	120	.506		
	Total	62.605	123			
Ability to plan for and implement various forms of cross-functional teams and processes	Between Groups	.299	3	.100	.228	.877
	Within Groups	52.572	120	.438		
	Total	52.871	123			
Ability to assess and implement requisite changes in human resource management	Between Groups	3.904	3	1.301	2.254	.086
	Within Groups	68.129	118	.577		
	Total	72.033	121			
Understanding of leadership strategies and methods	Between Groups	.736	3	.245	.734	.534
	Within Groups	39.800	119	.334		
	Total	40.537	122			

Analysis of Variance for Technology Project Management Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to plan and organize projects	Between Groups	1.364	3	.455	2.108	.103
	Within Groups	25.886	120	.216		
	Total	27.250	123			
Ability to implement projects effectively	Between Groups	2.167	3	.722	2.371	.074
	Within Groups	36.566	120	.305		
	Total	38.734	123			
Ability to work effectively with functional groups within the organization to plan and implement projects	Between Groups	1.640	3	.547	2.136	.099
	Within Groups	30.715	120	.256		
	Total	32.355	123			
Ability to schedule projects effectively and within the constraints of the organization	Between Groups	.401	3	.134	.418	.740
	Within Groups	38.333	120	.319		
	Total	38.734	123			
Ability to gather data on the task, schedule, budget, monitor and evaluate the total effort	Between Groups	1.059	3	.353	.944	.422
	Within Groups	44.900	120	.374		
	Total	45.960	123			
Ability to reduce implementation costs of new projects	Between Groups	.794	3	.265	.478	.698
	Within Groups	66.392	120	.553		
	Total	67.185	123			
Ability to manage and lead the project team	Between Groups	.175	3	.058	.125	.945
	Within Groups	56.212	120	.468		
	Total	56.387	123			

Analysis of Variance for Assessment and Evaluation of Technology Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to assess training needs in association with the implementation of new technologies	Between Groups	.813	3	.271	.578	.630
	Within Groups	55.772	119	.469		
	Total	56.585	122			
Ability to assess cost and benefits of new technologies	Between Groups	.921	3	.307	.657	.580
	Within Groups	56.079	120	.467		
	Total	57.000	123			
Ability to do a SWOT (strengths, weaknesses, opportunities, and threats) analysis associated with new technologies	Between Groups	.922	3	.307	.594	.620
	Within Groups	62.069	120	.517		
	Total	62.992	123			
Ability to assess the effects of technologies on society.	Between Groups	5.702	3	1.901	3.151	.028*
	Within Groups	72.394	120	.603		
	Total	78.097	123			
Ability to identify technologies important to the business	Between Groups	.311	3	.104	.404	.750
	Within Groups	30.786	120	.257		
	Total	31.097	123			
Ability to anticipate how new technologies may effect the organization	Between Groups	.496	3	.165	.508	.678
	Within Groups	38.772	119	.326		
	Total	39.268	122			
Ability to assess the integrative effects of technology on the organization	Between Groups	.102	3	.034	.066	.978
	Within Groups	62.285	120	.519		
	Total	62.387	123			
Understanding of Porter's Five Forces Model	Between Groups	3.349	3	1.116	1.331	.267
	Within Groups	100.619	120	.838		
	Total	103.968	123			

Multiple Comparisons of Assessment and Evaluation of Technology: Ability to Assess the Effects of Technologies on Society Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ability to Assess the Effects of Technologies on Society	Hochberg	Business Services	Education	-.657*	.217	.018	-1.24	-.08
			Government	-.287	.181	.515	-.77	.20
			Manufacturing	-.388	.223	.406	-.98	.21
		Education	Business Services	.657*	.217	.018	.08	1.24
			Government	.370	.195	.308	-.15	.89
			Manufacturing	.269	.234	.822	-.36	.90
		Government	Business Services	.287	.181	.515	-.20	.77
			Education	-.370	.195	.308	-.89	.15
			Manufacturing	-.101	.201	.997	-.64	.44
		Manufacturing	Business Services	.388	.223	.406	-.21	.98
			Education	-.269	.234	.822	-.90	.36
			Government	.101	.201	.997	-.44	.64
	Games-Howell	Business Services	Education	-.657*	.237	.041	-1.29	-.02
			Government	-.287	.147	.221	-.68	.10
			Manufacturing	-.388	.247	.410	-1.06	.28
		Education	Business Services	.657*	.237	.041	.02	1.29
			Government	.370	.224	.364	-.24	.98
			Manufacturing	.269	.299	.804	-.53	1.07
		Government	Business Services	.287	.147	.221	-.10	.68
			Education	-.370	.224	.364	-.98	.24
			Manufacturing	-.101	.235	.973	-.74	.54
		Manufacturing	Business Services	.388	.247	.410	-.28	1.06
			Education	-.269	.299	.804	-1.07	.53
			Government	.101	.235	.973	-.54	.74

Assessment and Evaluation of Technology: Ability to Assess the Effects of Technologies on Society

	Industry Sector	N	Subset for alpha=0.05	
			1	2
Hochberg[a]	Business Services	29	1.52	
	Government	51	1.80	1.80
	Manufacturing	21	1.90	1.90
	Education	23		2.17
	Sig.		.335	.388

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Analysis of Variance for Quality Management of Technology Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to manage for quality outcomes	Between Groups	2.137	3	.712	1.405	.245
	Within Groups	60.831	120	.507		
	Total	62.968	123			
Ability to manage for performance excellence	Between Groups	1.289	3	.430	.863	.462
	Within Groups	59.703	120	.498		
	Total	60.992	123			
Understanding of the tools used in process improvement	Between Groups	3.151	3	1.050	3.149	.028*
	Within Groups	40.034	120	.334		
	Total	43.185	123			
Understanding of the principles of Six Sigma	Between Groups	1.175	3	.392	.586	.625
	Within Groups	79.525	119	.668		
	Total	80.699	122			
Understanding of the Baldrige criteria for quality	Between Groups	3.266	3	1.089	1.477	.224
	Within Groups	87.726	119	.737		
	Total	90.992	122			
Understanding of the Deming philosophy of quality improvement	Between Groups	1.981	3	.660	1.033	.381
	Within Groups	75.404	118	.639		
	Total	77.385	121			
Understanding of ISO 9000 standards	Between Groups	7.028	3	2.343	3.041	.032*
	Within Groups	92.456	120	.770		
	Total	99.484	123			
Understanding of principles of total quality management	Between Groups	1.567	3	.522	1.384	.251
	Within Groups	44.531	118	.377		
	Total	46.098	121			
Ability to implement process improvement schemes	Between Groups	2.529	3	.843	2.016	.115
	Within Groups	50.180	120	.418		
	Total	52.710	123			

Multiple Comparisons of Quality Management of Technology: Tools Used in Process Improvement Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Tools Used in Process Improvement	Hochberg	Business Services	Education	-.045	.161	1.000	-.48	.39
			Government	-.337	.134	.077	-.70	.02
			Manufacturing	-.351	.166	.195	-.79	.09
		Education	Business Services	.045	.161	1.000	-.39	.48
			Government	-.292	.145	.244	-.68	.10
			Manufacturing	-.306	.174	.395	-.77	.16
		Government	Business Services	.337	.134	.077	-.02	.70
			Education	.292	.145	.244	-.10	.68
			Manufacturing	-.014	.150	1.000	-.41	.39
		Manufacturing	Business Services	.351	.166	.195	-.09	.79
			Education	.306	.174	.395	-.16	.77
			Government	.014	.150	1.000	-.39	.41
	Games-Howell	Business Services	Education	-.045	.124	.983	-.37	.28
			Government	-.337*	.128	.050	-.67	.00
			Manufacturing	-.351	.157	.134	-.78	.07
		Education	Business Services	.045	.124	.983	-.28	.37
			Government	-.292	.129	.117	-.63	.05
			Manufacturing	-.306	.158	.230	-.73	.12
		Government	Business Services	.337*	.128	.050	.00	.67
			Education	.292	.129	.117	-.05	.63
			Manufacturing	-.014	.162	1.000	-.45	.42
		Manufacturing	Business Services	.351	.157	.134	-.07	.78
			Education	.306	.158	.230	-.12	.73
			Government	.014	.162	1.000	-.42	.45

Multiple Comparisons of Quality Management of Technology: ISO 9000 Standards Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ISO 9000 Standards	Hochberg	Business Services	Education	-.439	.245	.372	-1.09	.22
			Government	-.561*	.204	.041	-1.11	-.02
			Manufacturing	-.626	.252	.082	-1.30	.05
		Education	Business Services	.439	.245	.372	-.22	1.09
			Government	-.122	.220	.994	-.71	.47
			Manufacturing	-.186	.265	.980	-.89	.52
		Government	Business Services	.561*	.204	.041	.02	1.11
			Education	.122	.220	.994	-.47	.71
			Manufacturing	-.064	.228	1.000	-.67	.54
		Manufacturing	Business Services	.626	.252	.082	-.05	1.30
			Education	.186	.265	.980	-.52	.89
			Government	.064	.228	1.000	-.54	.67
	Games-Howell	Business Services	Education	-.439	.229	.234	-1.05	.17
			Government	-.561*	.185	.018	-1.05	-.07
			Manufacturing	-.626	.260	.095	-1.33	.08
		Education	Business Services	.439	.229	.234	-.17	1.05
			Government	-.122	.222	.946	-.71	.47
			Manufacturing	-.186	.287	.915	-.96	.58
		Government	Business Services	.561*	.185	.018	.07	1.05
			Education	.122	.222	.946	-.47	.71
			Manufacturing	-.064	.254	.994	-.75	.62
		Manufacturing	Business Services	.626	.260	.095	-.08	1.33
			Education	.186	.287	.915	-.58	.96
			Government	.064	.254	.994	-.62	.75

Quality Management of Technology: Tools Used in Process Improvement

	Industry Sector	N	Subset for alpha=0.05 1
Hochberg[a]	Business Services	29	1.17
	Education	23	1.22
	Government	51	1.51
	Manufacturing	21	1.52
	Sig.		.144

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Quality Management of Technology ISO 9000 Standards

	Industry Sector	N	Subset for alpha=0.05 1
Hochberg[a]	Business Services	29	1.52
	Education	23	1.96
	Government	51	2.08
	Manufacturing	21	2.14
	Sig.		.054

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Analysis of Variance for Information and Knowledge Management Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Understanding of knowledge management systems that support the capturing, organization, and dissemination of knowledge throughout an organization	Between Groups	2.470	3	.823	2.037	.112
	Within Groups	48.498	120	.404		
	Total	50.968	123			
Ability to use online collaboration systems	Between Groups	3.844	3	1.281	3.275	.024*
	Within Groups	46.954	120	.391		
	Total	50.798	123			
Understanding of ethical, security, and privacy issues surrounding the use of electronic information	Between Groups	1.045	3	.348	1.334	.266
	Within Groups	31.310	120	.261		
	Total	32.355	123			
Ability to use and manage databases	Between Groups	3.239	3	1.080	3.270	.024*
	Within Groups	39.632	120	.330		
	Total	42.871	123			
Ability to use spreadsheets for quantitative analysis of information	Between Groups	1.975	3	.658	2.652	.052
	Within Groups	29.799	120	.248		
	Total	31.774	123			
Understanding of electronic commerce applications and principles	Between Groups	4.788	3	1.596	2.799	.043
	Within Groups	67.846	119	.570		
	Total	72.634	122			
Understanding of information technology and system development	Between Groups	2.990	3	.997	2.317	.079
	Within Groups	51.173	119	.430		
	Total	54.163	122			

Ability to integrate and use information technology to increase the competitive stance of an organization.	Between Groups	2.803	3	.934	2.605	.055
	Within Groups	42.677	119	.359		
	Total	45.480	122			
Understanding of business to business e-commerce	Between Groups	3.893	3	1.298	2.114	.102
	Within Groups	73.656	120	.614		
	Total	77.548	123			

Multiple Comparisons of Information and Knowledge Management: Ability to Use Online Collaboration Systems Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Ability to Use Online Collaboration Systems	Hochberg	Business Services	Education	-.072	.175	.999	-.54	.39
			Government	-.195	.145	.698	-.58	.19
			Manufacturing	-.534*	.179	.021	-1.01	-.05
		Education	Business Services	.072	.175	.999	-.39	.54
			Government	-.123	.157	.967	-.54	.30
			Manufacturing	-.462	.189	.091	-.97	.04
		Government	Business Services	.195	.145	.698	-.19	.58
			Education	.123	.157	.967	-.30	.54
			Manufacturing	-.339	.162	.209	-.77	.09
		Manufacturing	Business Services	.534*	.179	.021	.05	1.01
			Education	.462	.189	.091	-.04	.97
			Government	.339	.162	.209	-.09	.77
	Games-Howell	Business Services	Education	-.072	.154	.966	-.48	.34
			Government	-.195	.130	.445	-.54	.15
			Manufacturing	-.534	.203	.059	-1.08	.02
		Education	Business Services	.072	.154	.966	-.34	.48
			Government	-.123	.147	.837	-.51	.27
			Manufacturing	-.462	.214	.155	-1.04	.11
		Government	Business Services	.195	.130	.445	-.15	.54
			Education	.123	.147	.837	-.27	.51
			Manufacturing	-.339	.197	.332	-.88	.20
		Manufacturing	Business Services	.534	.203	.059	-.02	1.08
			Education	.462	.214	.155	-.11	1.04
			Government	.339	.197	.332	-.20	.88

Multiple Comparisons of Information and Knowledge Management: Ability to Use and Manage Databases Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ability to Use and Manage Databases	Hochberg	Business Services	Education	-.342	.160	.192	-.77	.09
			Government	-.062	.134	.998	-.42	.30
			Manufacturing	-.404	.165	.089	-.84	.04
		Education	Business Services	.342	.160	.192	-.09	.77
			Government	.280	.144	.285	-.11	.67
			Manufacturing	-.062	.173	.999	-.53	.40
		Government	Business Services	.062	.134	.998	-.30	.42
			Education	-.280	.144	.285	-.67	.11
			Manufacturing	-.342	.149	.132	-.74	.06
		Manufacturing	Business Services	.404	.165	.089	-.04	.84
			Education	.062	.173	.999	-.40	.53
			Government	.342	.149	.132	-.06	.74
	Games-Howell	Business Services	Education	-.342	.168	.193	-.79	.11
			Government	-.062	.122	.956	-.38	.26
			Manufacturing	-.404	.186	.151	-.91	.10
		Education	Business Services	.342	.168	.193	-.11	.79
			Government	.280	.151	.269	-.13	.69
			Manufacturing	-.062	.207	.990	-.62	.49
		Government	Business Services	.062	.122	.956	-.26	.38
			Education	-.280	.151	.269	-.69	.13
			Manufacturing	-.342	.171	.212	-.81	.12
		Manufacturing	Business Services	.404	.186	.151	-.10	.91
			Education	.062	.207	.990	-.49	.62
			Government	.342	.171	.212	-.12	.81

Multiple Comparisons of Information and Knowledge Management: Ability to Use and Manage Spreadsheets for Quantitative Analysis Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ability to Use and Manage Spreadsheets for Quantitative Analysis	Hochberg	Business Services	Education	-.045	.139	1.000	-.42	.33
			Government	-.259	.116	.152	-.57	.05
			Manufacturing	-.304	.143	.193	-.69	.08
		Education	Business Services	.045	.139	1.000	-.33	.42
			Government	-.214	.125	.427	-.55	.12
			Manufacturing	-.259	.150	.420	-.66	.14
		Government	Business Services	.259	.116	.152	-.05	.57
			Education	.214	.125	.427	-.12	.55
			Manufacturing	-.045	.129	1.000	-.39	.30
		Manufacturing	Business Services	.304	.143	.193	-.08	.69
			Education	.259	.150	.420	-.14	.66
			Government	.045	.129	1.000	-.30	.39
	Games-Howell	Business Services	Education	-.045	.113	.979	-.35	.26
			Government	-.259	.100	.055	-.52	.00
			Manufacturing	-.304	.165	.273	-.75	.14
		Education	Business Services	.045	.113	.979	-.26	.35
			Government	-.214	.112	.240	-.51	.08
			Manufacturing	-.259	.172	.448	-.73	.21
		Government	Business Services	.259	.100	.055	.00	.52
			Education	.214	.112	.240	-.08	.51
			Manufacturing	-.045	.164	.993	-.49	.40
		Manufacturing	Business Services	.304	.165	.273	-.14	.75
			Education	.259	.172	.448	-.21	.73
			Government	.045	.164	.993	-.40	.49

Multiple Comparisons of Information and Knowledge Management: Understanding of Electronic Commerce Applications and Principles Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Understanding of Electronic Commerce Applications and Principles	Hochberg	Business Services	Education	.014	.212	1.000	-.55	.58
			Government	-.131	.178	.975	-.61	.34
			Manufacturing	-.560	.218	.067	-1.14	.02
		Education	Business Services	-.014	.212	1.000	-.58	.55
			Government	-.145	.190	.970	-.65	.36
			Manufacturing	-.573	.228	.076	-1.18	.04
		Government	Business Services	.131	.178	.975	-.34	.61
			Education	.145	.190	.970	-.36	.65
			Manufacturing	-.429	.196	.168	-.95	.09
		Manufacturing	Business Services	.560	.218	.067	-.02	1.14
			Education	.573	.228	.076	-.04	1.18
			Government	.429	.196	.168	-.09	.95
	Games-Howell	Business Services	Education	.014	.210	1.000	-.55	.58
			Government	-.131	.172	.871	-.58	.32
			Manufacturing	-.560*	.201	.039	-1.10	-.02
		Education	Business Services	-.014	.210	1.000	-.58	.55
			Government	-.145	.199	.885	-.68	.39
			Manufacturing	-.573	.225	.066	-1.17	.03
		Government	Business Services	.131	.172	.871	-.32	.58
			Education	.145	.199	.885	-.39	.68
			Manufacturing	-.429	.189	.122	-.93	.08
		Manufacturing	Business Services	.560*	.201	.039	.02	1.10
			Education	.573	.225	.066	-.03	1.17
			Government	.429	.189	.122	-.08	.93

Multiple Comparisons of Information and Knowledge Management: Ability to Integrate and Use Information Technology to Increase the Competitive Stance of an Organization Item

Dependent Variable		(I) Industry Sector	(J) Industry Sector	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Ability to Integrate/Use Info. Technology to Increase the Competitive Stance of an Organization	Hochberg	Business Services	Education	.112	.169	.985	-.34	.56
			Government	-.185	.141	.716	-.56	.19
			Manufacturing	-.333	.173	.290	-.80	.13
		Education	Business Services	-.112	.169	.985	-.56	.34
			Government	-.297	.150	.266	-.70	.11
			Manufacturing	-.445	.181	.087	-.93	.04
		Government	Business Services	.185	.141	.716	-.19	.56
			Education	.297	.150	.266	-.11	.70
			Manufacturing	-.148	.155	.915	-.56	.27
		Manufacturing	Business Services	.333	.173	.290	-.13	.80
			Education	.445	.181	.087	-.04	.93
			Government	.148	.155	.915	-.27	.56
	Games-Howell	Business Services	Education	.112	.119	.782	-.20	.43
			Government	-.185	.122	.434	-.51	.14
			Manufacturing	-.333	.208	.392	-.90	.23
		Education	Business Services	-.112	.119	.782	-.43	.20
			Government	-.297	.118	.066	-.61	.01
			Manufacturing	-.445	.205	.158	-1.01	.12
		Government	Business Services	.185	.122	.434	-.14	.51
			Education	.297	.118	.066	-.01	.61
			Manufacturing	-.148	.207	.890	-.71	.42
		Manufacturing	Business Services	.333	.208	.392	-.23	.90
			Education	.445	.205	.158	-.12	1.01
			Government	.148	.207	.890	-.42	.71

Information and Knowledge Management: Ability to Use Online Collaboration Systems

	Industry Sector	N	Subset for alpha=0.05 1	2
Hochberg[a]	Business Services	29	1.28	
	Education	23	1.35	
	Government	51	1.47	1.47
	Manufacturing	21		1.81
	Sig.		.818	.246

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Information and Knowledge Management: Ability to Use and Manage Databases

	Industry Sector	N	Subset for alpha=0.05 1
Hochberg[a]	Business Services	29	1.31
	Government	51	1.37
	Education	23	1.65
	Manufacturing	21	1.71
	Sig.		.060

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Information and Knowledge Management: Ability to Use and Manage Spreadsheets for Quantitative Analysis

	Industry Sector	N	Subset for alpha=0.05
			1
Hochberg[a]	Business Services	29	1.17
	Education	23	1.22
	Government	51	1.43
	Manufacturing	21	1.48
	Sig.		.142

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.551

Information and Knowledge Management: Understanding of Electronic Commerce Applications and Principles

	Industry Sector	N	Subset for alpha=0.05	
			1	2
Hochberg[a]	Education	23	1.52	
	Business Services	28	1.54	
	Government	51	1.67	1.67
	Manufacturing	21		2.10
	Sig.		.979	.206

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.319

Information and Knowledge Management: Ability to Integrate and Use Information Technology to Increase the Competitive Stance of an Organization

	Industry Sector	N	Subset for alpha=0.05	
			1	2
Hochberg[a]	Education	23	1.17	
	Business Services	28	1.29	1.29
	Government	51	1.47	1.47
	Manufacturing	21		1.62
	Sig.		.348	.224

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size=27.319

Analysis of Variance for Innovation and Product Development Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Understanding of the platform approach to product development	Between Groups	1.356	3	.452	.746	.527
	Within Groups	72.733	120	.606		
	Total	74.089	123			
Ability to predict new product success	Between Groups	3.882	3	1.294	2.151	.097
	Within Groups	72.207	120	.602		
	Total	76.089	123			
Understanding of processes used to launch new products	Between Groups	1.488	3	.496	1.039	.378
	Within Groups	56.356	118	.478		
	Total	57.844	121			
Ability to plan for and implement team-based management systems used in the development and launching of new products	Between Groups	1.388	3	.463	.918	.434
	Within Groups	60.451	120	.504		
	Total	61.839	123			

Analysis of Variance for Strategic Management of Technology Items

		Sum of Squares	*df*	Mean Square	*F*	*p**
Ability to develop an effective technology strategy for achieving competitive advantage	Between Groups	1.819	3	.606	1.122	.343
	Within Groups	64.890	120	.541		
	Total	66.710	123			
Ability to develop effective planning procedures for selecting new technology	Between Groups	.523	3	.174	.417	.741
	Within Groups	50.187	120	.418		
	Total	50.710	123			
Ability to assess the internal strengths and weaknesses of the organization with respect to changes occurring within the external environment of the organization	Between Groups	1.446	3	.482	.874	.457
	Within Groups	66.192	120	.552		
	Total	67.637	123			
Ability to align the organization's structure and processes with its core technologies	Between Groups	2.343	3	.781	1.508	.216
	Within Groups	62.141	120	.518		
	Total	64.484	123			
Ability to create value through the use of technology	Between Groups	.712	3	.237	.607	.612
	Within Groups	46.925	120	.391		
	Total	47.637	123			