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Perceptions and Rankings of Technology Management Competencies

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Management

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Introduction

According to Thamhain (2005) the "Management of technology is the art and science of creating value by using technology together with other resources of an organization" (p. 6). A technology manager should have some minimum level of *technical knowledge*, *applied abilities* in systems design, application, products or processes, and *skills* in one or more contextual areas (ITEA, 2000/2002). Technology managers must have certain competencies that are agreed-upon or measurable, preferably both. At the university level, technology management programs are distinctly different from engineering or engineering technology programs (i.e., mechanical, electrical, civil, etc.). A required management curriculum is what distinguishes ATMAE accredited four-year programs from two-year programs (ATMAE, 2009, para. 6). Minty (2003) asserted that historical comparisons of the technological and managerial perspectives are closely aligned.

In order for technology management programs to succeed, they must produce graduates who possess the requisite knowledge, abilities, and skills. What are the competencies of a technology manager and what does an entry-level technology leader need to know? The *ATMAE Accreditation Handbook* (2009) lists content areas such as quality, finance, accounting, safety, legal, project management, and other courses consistent with the definition of industrial technology. Of these, what are the most important competencies of technology management? Are there others? Without a recognized and accepted body of knowledge for technology management, the discipline of industrial technology, applied technology, and applied engineering will continue to be confused with other technical disciplines. Clarity regarding the required competencies for an entry-level technology manager is imperative. The critical competencies within a body of knowledge should be congruent with ATMAE accreditation standards and the Certified Technology Manager exam. In order for technology management programs to be relevant, their competencies should be recognized and agreed-upon.

In 2010, the ATMAE Management Division set out to define an applicable technology management body of knowledge using a collection of core competencies. The research incorporated existing models, industry opinions, and educator experts. ATMAE members at both the 2010 and 2011 conferences reviewed initial versions of the competency model. In addition, the model was benchmarked against existing literature and research. The researchers found consistency within the initial versions of the competency model. Interested scholars may find the initial model and supporting rationale in the 2011 ATMAE conference proceedings. This paper presents additional supporting data regarding the validity of the ATMAE Technology Management Competency Model and its revisions based on recent ATMAE member feedback.

Research on Technology Management Competencies

The need for a body of knowledge for technical-professional competencies is well documented, particularly with the advent of outcomes-based accreditation and industry's desire for certified employees (SME, ASQ, APICS, PMI, etc.). Teodorescu (2004) defined competencies as successful observable behaviors that enable both positive processes and results. Meier, Williams, and Humphreys (1997) and Meier and Brown (2008) summarized the competencies essential for the success of new employees. Calhoun (2008) created the Health Leadership Competency Model that identified outcomes, appropriate behaviors, and core technical-managerial competencies. Rifkin, Fineman, and Ruhnke (1999) developed a competency model containing a hierarchical framework of the technical manager's role, critical accomplishments, work activities, skills, knowledge and personal attributes. Other published literature regarding management competencies includes manufacturing and industrial management (Barber, 2000; Earshen, 1995; Ferguson, 1991), general management (Abraham, Karns, Shaw, & Mena, 2001; Ferketich, 1998; Kaufman, 1994; Maes, Weldy, & Icenogle, 1997; Martell, & Carroll, 1994), safety (Blair, 1997), project management (Golob, 2002), retail management (Keech, 1998), and sports administration (Kuo, 1998).

Increasingly, competencies are the basis for determining if programs are offering appropriate content and if students are meeting the competency criteria. ABET accreditation is based on students acquiring specific competencies as measured by student outcomes (ABET.org). Since 2009, ATMAE has encouraged the use of outcomes-based assessment for program accreditation. In 2013, outcomes-based assessment will be required for all programs seeking ATMAE accreditation. The development of a common body of knowledge for technology management competencies provides rationale for a common management core that distinguishes ATMAE accredited four-year programs and gives graduate degrees focus. Thus, a conceptual model is useful when attempting to describe the common elements.

Methodology

The purpose of this research was to validate a core body of knowledge using competencies as the basis for a technology management model. To accomplish the purpose, the following question was of relevance. What are the important core competencies for an entry-level technology manager?

This research sought to validate or refute the previously developed technology management competency model. The survey asked respondents to rank the importance of the competencies in various technology management thematic areas. The survey population was approximately 700 ATMAE members invited to participate using the professional member listserve. The ATMAE listserve consists of all ATMAE members who can send and receive email in order to share and gather information on current developments in the field of technology, technology management, and applied engineering.

In February 2012, the links to the survey were sent and were available for approximately four weeks. After week 1 and week 2, a follow-up email reminder was sent. Qualtrics, a third party survey software provider, automatically collected 93 anonymous responses. At the end of the survey period, 66 surveys were fully completed and validated (9-13% response rate). In April 2012, faculty and industry professionals from engineering, engineering technology, technology, operations management, and advisory boards outside of ATMAE were invited to participate. Additional responses were collected until May 2012 resulting in 124 total responses, of which 75 were fully completed surveys.

Survey participants were first given a glossary of terms relevant to the survey based on the previously developed Technology Management Competency Model and asked a series of questions regarding the applied and managerial contexts of technology management. This was followed by questions that asked participants to check the competencies applicable in each managerial context. The glossary of terms follows:

Technology Management Applied Contexts
Operations-Management of technology within a specific industrial specialty.
Systems-Management of technology across disciplines and companies in an integrated fashion for the purpose of business venture and development.
Project-The one-time application of a process to produce a unique product or service.
Process- The transformation of input elements into output elements with specific properties, within defined parameters or constraints.

Technology Management Managerial Contexts
Quality Management- The use of quality assurance and control of processes and products to achieve consistent and predictable quality.
Risk Management- The identification, assessment, and prioritization of risk followed by coordinated and economical application of resources to minimize, monitor, and control their probability and/or impact.
Self-Management- Methods, skills, and strategies by which individuals can effectively direct their own activities toward the achievement of goals and objectives.
People Management- The deployment and handling of human resources to work together to accomplish desired goals and objectives using available resources efficiently and effectively.

Findings

The survey responses and findings follow. The responses among the participating groups (ATMAE, non-ATMAE, industry advisory groups, etc.) were not significantly different and did not change the results.

Question 1. Participants were asked to select relevant applied contexts of technology management and could check all that applied. The purpose of this question was to validate the top level of the Technology Management Competency Model as shown in Figure 10. A total of 99 individuals responded to the question. See Figure 1. Eighty-four percent of the respondents checked systems and projects while 83% checked processes and operations.

Question 2. Participants were asked to select the relevant management contexts that are applied to processes. Once again, the respondents could check all that applied. The purpose of this question was to determine if technology management in the areas of quality management, risk management, people management, and self-management is applicable to processes. Seventy-seven individuals responded to the question. See Figure 2. Ninety-nine percent of the respondents checked quality management and 81% checked people management. Seventy-three percent checked risk management while 55% checked self-management.

Figure 1. Applied contexts of technology management

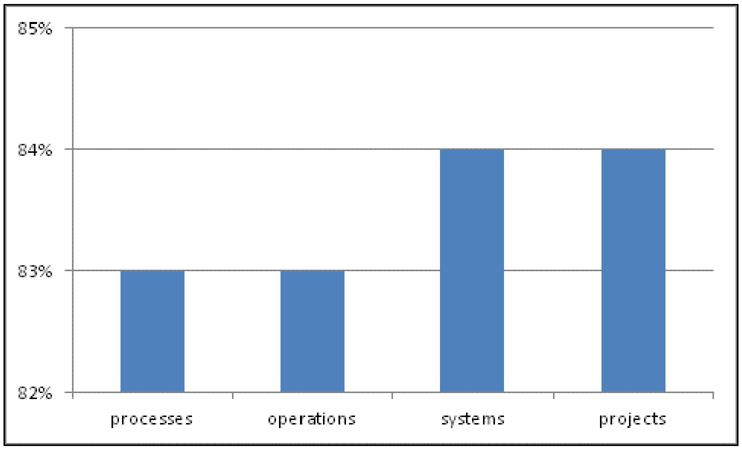
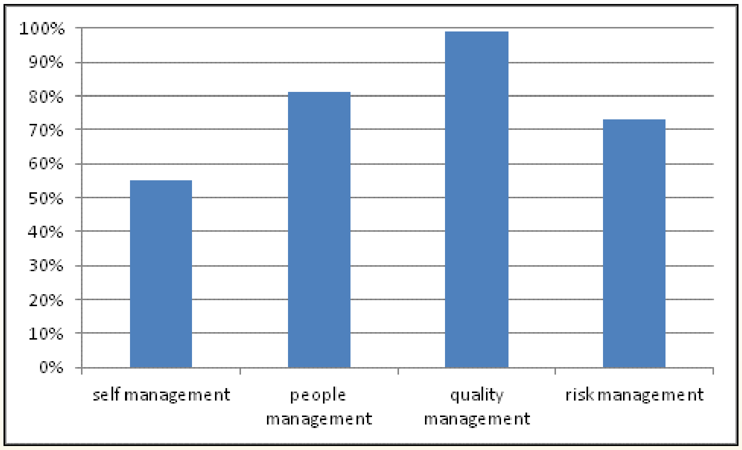
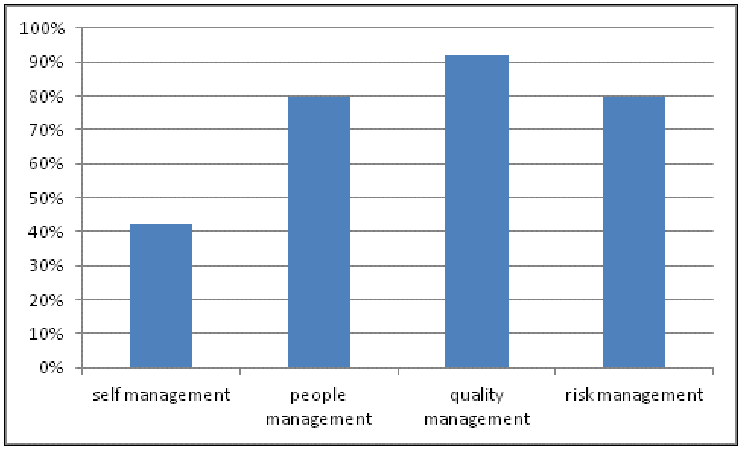


Figure 2. The applicability of specific technology management contexts to processes.



Question 3. Participants were asked to select the relevant management contexts applicable to systems and could check all that applied. The purpose of this question was to determine if technology management in the previously mentioned areas of quality, risk, people, and self is applicable to systems. Seventy-six individuals responded to the question. See Figure 3. Ninety-two percent of the respondents checked quality management and 80% checked people and risk management. Forty-two percent checked self-management.

Figure 3. The applicability of specific technology management contexts to systems.



Question 4. Participants were asked to select the relevant management contexts applied to operations as above. The purpose of this question was to determine if technology management in quality, risk, people, and self is applicable to operations. Seventy-five individuals responded to the question. See Figure 4. Ninety-two percent of the respondents checked people and quality. Seventy-seven percent checked risk management. Fifty-nine percent checked self-management.

Question 5. Participants were asked to select the relevant management contexts applied to projects. The purpose of this question was to determine if technology management is applicable to projects. Seventy-six individuals responded to the question. See Figure 5. Eighty-nine percent checked people and 88% checked quality. Seventy-six percent checked self-management and 71% checked risk management.

Figure 4. The applicability of specific technology management contexts to operations.

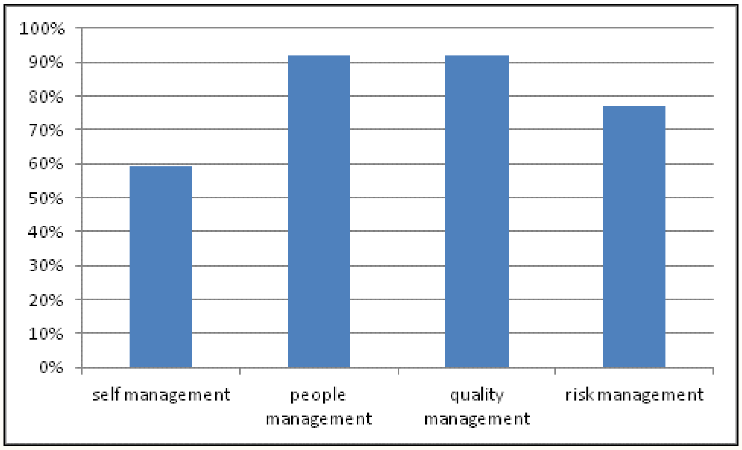
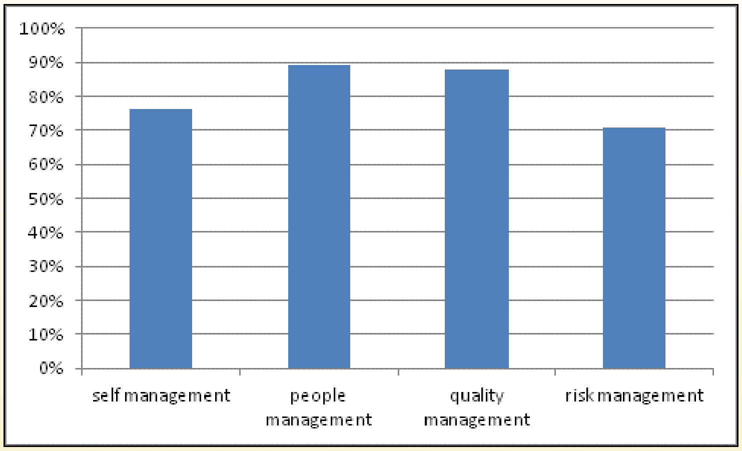


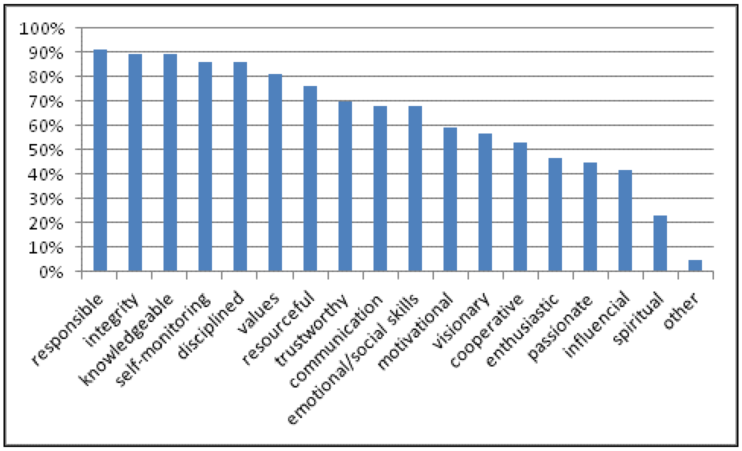
Figure 5. The applicability of specific technology management contexts to projects.



Respondents were given the opportunity to select applicable entry-level technology management competencies in each of the management contextual areas (i.e., quality, risk, people, and self). The competency lists were taken from the previously published literature used to develop the initial Technology Management Competency Model. Each contextual management area listed between 16-19 generic competencies and included a field labeled other, where respondents could add additional competencies. The purpose of these questions was to validate or refute the published competencies and determine which were the most important. In addition, thematic areas could begin to be identified. For self-management, people management, quality management, and risk management, the number of responses was 74, 72, 71, and 71, respectively.

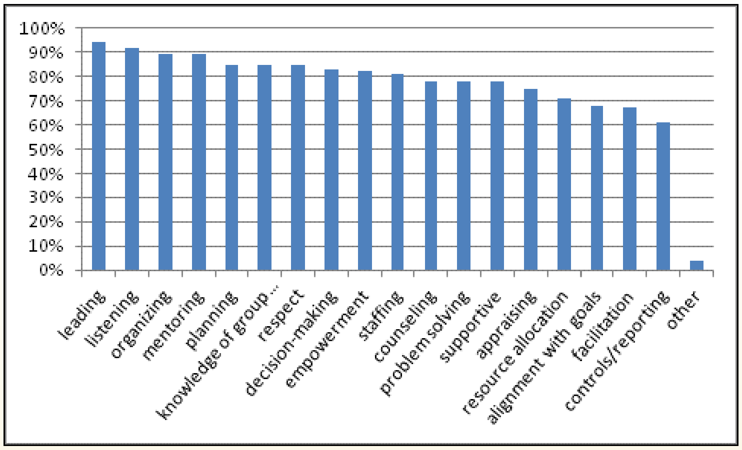
Question 6. Participants were asked to select the competencies applicable to self-management. In Figure 6, the percentage of responses is sorted from highest to lowest. Five percent of respondents added these additional competencies: Innovative, ethical, monitoring quality or the ability to discern quality, family, company, and society.

Figure 6. Applicable self-management competencies sorted by percentage of responses.



Question 7. Participants were asked to select the competencies applicable to people management. The sorted percentage of responses is shown in Figure 7. Four percent of respondents added the following competencies: Open communications, training and development, and their personal needs, company, and society.

Figure 7. Applicable people management competencies sorted by percentage response.



Question 8. Participants were asked to select the competencies applicable to quality management. The sorted percentage of responses is shown in Figure 8. Four percent of respondents added the following competencies: teaming, benchmarking, communication, documentation/ISO 9000, compensation systems, ethics, tools of Ishikawa in addition to SPC, assessment, etc. - TQM is more than control or assurance, innovation, finance, environment, and responsibility.

Question 9. Participants were asked to select the competencies applicable to risk management. The sorted percentage is shown in Figure 9. Three percent of respondents added that all the above apply, but some more important than others, such as people, society, and environment.

Figure 8. Applicable quality management competencies sorted by percentage response.

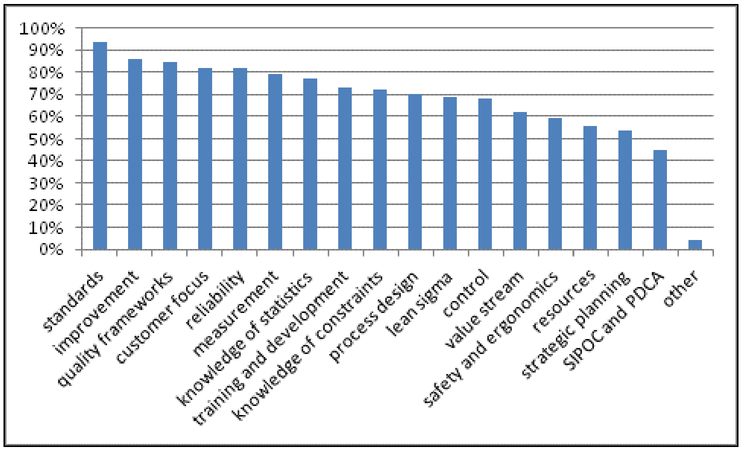
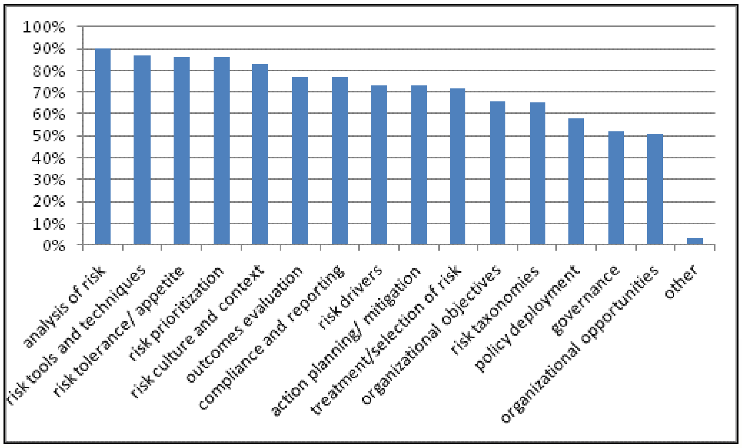


Figure 9. Applicable risk management competencies sorted by percentage response.

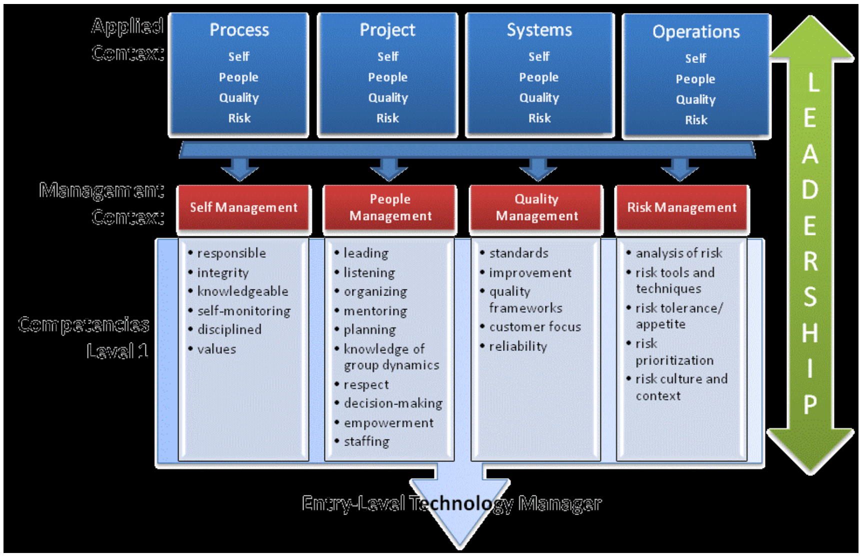


The Technology Management Competency Model

The Technology Management Competency model shown in Figure 10 shows the generic entry-level competencies for a technology manager within a category of knowledge for a specific managerial context. The competencies are applicable to systems, operations, processes, and projects and linked throughout by accepted leadership principles. The operational definitions of these competencies were provided in the Methodology section of the paper. The findings indicate that the Technology Management Competency Model has a degree of validity, particularly with regard to the applied contexts of process, project, systems, and operations. Respondents overwhelmingly agreed on these applied contexts. In terms of the quality, people, risk, and self-management contexts, a majority of the respondents agreed that they apply to process, project, systems, and operations. The only exception was the applicability of self-management to systems (defined as the management of technology across disciplines and companies in an integrated fashion for the purpose of business venture and development). However, over two-fifths of the respondents perceived a degree of applicability. Thus, the applied and management contexts of the model appear to have merit and a degree of support from the academic and industrial communities. The researchers found that the relevance of competencies varied by respondents. Because of the variance of responses to the competencies, they were stratified into three levels.

In terms of the competencies, the greatest response variation (23%-91%) was in regards to the self-management context. The least amount of variation was in response to people management with responses ranging from 61% to 94% on all competencies. All competencies for risk management had greater than 50% response. For quality management, only one competency received less than 50% response - suppliers, inputs, process, outputs, and customers (SIPOC) and plan, do, check, act (PDCA). Any competency receiving less than 50% response was deleted. The competencies were then stratified by the level of response rather than by the original generic themes. This stacked ranking keeps the important the competencies at the forefront for outcomes assessment and reinforces the critical entry-level knowledge, skills, and abilities of technology managers. The competencies are purposely broad to allow for flexibility, interpretation, and justification for the use of popular synonyms.

Figure 10. Technology Management Competency Model with level 1 competencies shown



To illustrate, the entire competencies for quality management are shown in Table 1. Competencies receiving greater than 80% response were categorized level one (1). Competencies receiving between 60-80% were designated level two (2) and competencies greater than 50%, but less than 70% were labeled level three (3). The stratified tables for risk, people, and self-management are shown in Tables 2, 3, and 4, respectively.

Table 1. Quality Management Competencies

Level	Competency
1	standards improvement quality frameworks customer focus reliability
2	measurement knowledge of statistics training and development knowledge of constraints process design
3	lean sigma control value stream safety and ergonomics resources strategic planning

Table 2. Risk Management Competencies

Level	Competency
1	analysis of risk risk tools and techniques risk tolerance/ appetite risk prioritization risk culture and context
2	outcomes evaluation compliance and reporting risk drivers action planning/ mitigation treatment/selection of risk
3	organizational objectives risk taxonomies policy deployment governance organizational opportunities

Table 3. People Management Competencies

Level	Competency
1	leading listening organizing mentoring planning knowledge of group dynamics respect decision-making empowerment staffing
2	counseling problem solving supportive appraising resource allocation
3	alignment with goals facilitation controls/reporting

Table 4. Self-Management Competencies

Level	Competency
1	responsible integrity knowledgeable self-monitoring disciplined values
2	resourceful trustworthy
3	communication emotional/social skills motivational visionary cooperative

GAPS: Competancies, Outcomes, Assessments, Standards and Certification

ATMAE sets standards for academic program accreditation, professional certification, and development for educators and industry professionals involved in technology, leadership, and systems design (ATMAE, 2011). The development of a common and recognized body of knowledge starts with an understanding of the technology management entry-level competencies. The operational effectiveness of accredited technology programs depends on identifying outcomes, competencies, and measures. The lack of an agreed-upon technology management competencies results in confusion and a further weakening of the discipline. Without a recognized and accepted body of knowledge for technology management, the discipline of industrial technology, engineering technology, and applied engineering will continue to be confused with other technical disciplines. Clarity regarding the competencies is imperative.

Next Steps

The ATMAE accreditation standards and the Certified Technology Manager (CTM) exam should recognize and incorporate these competencies. ATMAE membership and industry advisory boards should ratify and adopt these technology management competencies. In particular, the Management Division of ATMAE must take a lead role in its adoption. With an agreed upon and certified body of knowledge, educational learning outcomes that are congruent with industry needs and revised accreditation standards for technology management will result. The next steps are to submit the model for a vote of the ATMAE membership and align with certification/ accreditation standards.

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