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Introduction

A key theme in the 1990s has been that science, mathematics engineering, and technological (SMET) workers require vastly broader training and educational experiences than have been provided by traditional educational curricula (Reich, 1993; Johnston, 1991; SCANS, 1991). While business and industry are adopting new competitive strategies in response to changing environmental conditions, technological training programs remain narrowly focused and very specialized. To close the gap between what is needed and what is being delivered, the competencies required of the 21st century workforce must be identified, understood, and incorporated into reformed technological curricula. A previous article (Meier, Humphreys, & Williams, in press) provided an overview of a unique grant funded by the National Science Foundation that seeks to provide practical solutions to closing the gap. A critical first step in the grant project was to gather significant input from business and industry practitioners regarding three basic research questions:

Research Question 1: According to mid- and upper-level managers, what competencies are <u>important</u> for today's community college and university SMET graduates?

Research Question 2: According to mid- and upper-level managers, how well are today's community college and university SMET graduates <u>performing</u> on important competency issues?

Research Question 3: According to mid- and upper-level managers, where are the largest competency gaps (<u>importance</u> vs. <u>performance</u>) in today's community college and university SMET graduates?

Addressing these questions will provide exploratory data to begin identifying the workforce competencies that need to be targeted for curricular reform. Initially, this process involved gathering data from a broad-based sample of industry representatives. In order to accomplish this goal, a valid data-gathering instrument was required that accurately reflected the domain of workforce competencies required by industry and identifies those competencies not being delivered by technological training programs. The following sections describe exploratory research that was conducted in order to develop this instrument.

Methodology for Survey Development

In line with accepted scale-development methodology (Churchill, 1979; Nunnally, 1978) a multi-step process was used. The process began with a review of existing resources to begin to define the domain of the subject area. Then, multiple rounds of content analysis, item generation, and purification were performed. This procedure relied heavily on input form "expert panels" comprised of diverse industry practitioners.

Literature Review

To begin, a broad review of existing knowledge, skills, and attitudes was conducted to establish the domain of relevant workforce competencies. This process incorporated two parallel methods of inquiry. First, a comprehensive search of literature and previous research was utilized for the purpose of discovering competencies described as being important for the success of today's advanced technological workers. At the same time, research and other evidence was reviewed that detailed the SMET workers' current level of expertise in each of the specific competencies identified as important for personal and organizational success (Drucker, 1995; Goldman, Nagel, & Preiss, 1995; U.S. Department of Labor, 1992).

Personal interviews with SMET workers, supervisors, human resource and training specialists, and community college educators and career counselors were the second method of inquiry. These interviews were utilized to validate and further clarify information collected from the literature. Further, they provided a more contemporary and up-to-date perspective than what was available in the literature.

Findings from these investigations were recorded and subjected to content analysis for the purpose of categorizing the wide range of knowledge, skills, and attitudes into a set of competencies. Although highly qualitative in nature, this initial information allowed comparison of identified competencies' perceived importance with perceived levels of performance.

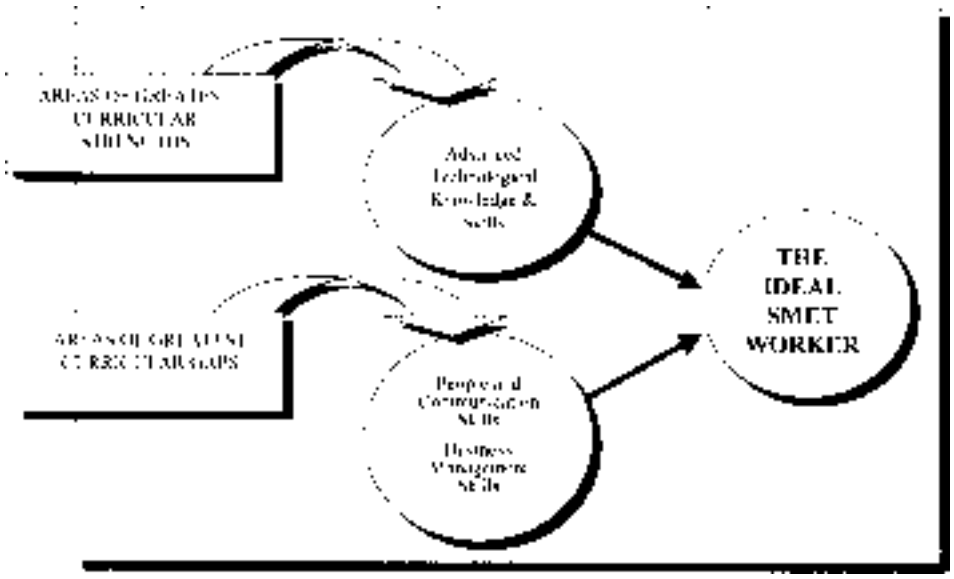
A content analysis of this resource base began to reveal how practitioners view the ideal SMET worker and where strengths and limitations exist in current training of these workers. The picture (Figure 1) that emerged showed strengths in areas of technological knowledge and skills and limitations in interpersonal communication skills and business knowledge required to contribute to a firm's overall competitiveness and performance (SME, 1997; Brock, 1993; Reich, 1993). Current technological training programs appeared to have their greatest strengths in delivering the technical knowledge and skills needed by SMET workers to perform in their specialized disciplines. Programs provide good exposure to current technology within disciplines and give students ample hands-on experience. Thus, given high demand in many fields for technological workers, students have great success in acquiring jobs in entry-level positions.

On the other hand, advanced technological education programs appeared to have their greatest limitations in preparing students to see the big picture of the organization and its environment and solve problems related to diverse aspects of the organization. Their knowledge and skill set is typically very narrowly focused and often not linked to other aspects of business in general. Thus, once students gain employment in their specialized area of study, they must be trained in important fundamentals of success within the firm and market. They typically have difficulty making critical lateral and upward moves within the organization necessary to sustain long-term careers (Reich, 1993; Johnson, 1991). Weaknesses exist in students' ability to work in cross-functional teams and interact within the larger organizational environment in ways that foster long-term career growth within the firm for the SMET worker. These are the attributes required of all workers in order for the firm to compete in rapidly changing markets.

Measurement Development

Following the review of literature, the content was analyzed and an initial pool of 30 items was created. A triangulation methodology across multiple sources, methods, and researchers was employed. Triangulation methodologies using different informants, data collection methods, and members of the research team are commonly used to establish content and construct validity (Douglas 1976; Wallendorf & Belk 1989) in the early stages of survey measurement development.

Figure 1. Current research: Business & industry perceptions of needed educational competencies for SMET workers.



Triangulation methodologies require that subsequent informants be routinely asked the same questions as a previous group in an effort to check the accuracy of the responses and the degree to which opinions and perceptions are commonly shared. The use of multiple data collection methods is especially useful for comparing interview based statements with more objective individual assessments collected through paper-and-pencil self assessment surveys. Similarly, triangulation with multiple researchers assists the assessment and enhancement of data integrity by taking advantage of the differing abilities and backgrounds of researchers of different ages, experiences, and personalities to obtain information from participants.

Different Informants. This study gathered data from two different groups of business/industry managers. Group number one (N = 9) was located in central Iowa and represented small business firms employing less than 50 people. Group number two (N = 10) was located in central Illinois and represented Fortune 500 companies. Both groups met at separate times and had no interaction with one another. Participants were selected through a convenience sampling technique. A sampling frame was established using existing lists of firms employing technological workers in central Iowa and central Illinois. Companies were contacted and asked to participate in this study. Managers within participating organizations provided a member from their management team to participate in this study.

Different Data Collection Methods. The first collection of data was conducted using a paper-and-pencil survey containing the original 30-item pool. A second collection of data was conducted using a focus group methodology from each of the two-business/industry groups previously described.

For the paper-and-pencil survey, each participant was mailed a survey packet consisting of a cover letter, the questionnaire, and a pre-addressed, postage paid return envelope. Participants completed the survey independently from the others and mailed their responses to the researchers prior to the meeting of each group. Each participant made two assessments regarding each item. In the first section of the paper-and-pencil questionnaire, participants were asked to evaluate the importance of each individual item on a six point Likert style scale (1 = Not at all Important; 6 = Very Important). The second section of the questionnaire recorded the participants' evaluation of technological workers' possession of the competencies described by the item statements. Responses to the performance evaluation were made using a six point Likert style scale (1 = Very Poor Performance; 6 = Excellent Performance). Space was also provided for respondents to record any items that they felt were important but not included in the survey.

In delineating the appropriate process for focus group research, Krueger (1994) suggests using multiple and distinct meetings of small groups of 7 to 10 persons having knowledge of the subject area. These groups are assembled and encouraged to "discuss" their ideas with one another. Following the groups meeting, the discussion was analyzed for patterns in opinions, ideas and feelings which provided for meaningful interpretation of the results. Focus groups have become widely accepted procedures for explaining how people perceive an event or idea and why.

In this study, researchers conducted separate focus groups with the Iowa group of managers and the Illinois group of managers. Both groups were comprised of individuals possessing knowledge and expertise in the area of technological workers. The researchers served as facilitators in creating a permissive environment that nurtured the exchange and discussion of different points of view without pressuring the participants to vote, plan, or reach consensus on any of the topics. Full transcripts of the meetings were transcribed from video recordings of each of the sessions.

Different Researchers. Four different researchers having different backgrounds of experience and education were used within this study. For the purpose of enhancing the interpretability of the research findings and to offset, potential bias in interpretation – two researchers came from a technological background and two researchers came from a business management and marketing background.

Data Analysis

Analysis of the data was made according to the collection methodology used. For the data collected through the paper-and-pencil surveys, means were computed for both the "importance" evaluations and the "performance" assessments. Performance means were subtracted from Importance means to compute a difference or "gap" score. Higher gap scores indicated items which were rated as being higher in Importance than in Performance – items of high priority for development. On the other hand, low (possibly negative) gap scores would denote items where importance and performance were more closely aligned, resulting in a lower priority for development.

Focus group data were analyzed by scrutinizing transcripts from the video recordings. These transcripts were first analyzed for their content – patterns and similarities in comments. This was done through independent examination of the words and meanings of those words by each of the four researchers. Consistent with focus group analysis (Krueger, 1998) This examination assessed (1) what was said; (2) how many times it was said; (3) how many participants said it; and (4) how strong was the opinion or point of view. As a result of this methodology, the 30 original items were revised for clarity and specificity. The results from the survey analysis were then compared to those from the focus groups to identify:

- the "big idea" items — items of key importance where respondents agreed that items had very high importance but very low performance scores. These items would have a high priority for being retained in subsequent data collection.
- The "missing" items that are not reflected in the pre-existing item pool constructed from existing literature, but identified by

respondents as being important. These items would need to be added in subsequent studies.

To examine the three research questions that are the focus of this paper, mean values for each item's score on importance and performance were computed. The raw importance and performance data were then transformed from the basic 6-point, Likert-type format to an indexed scale of 0 to 100. This was accomplished by subtracting 1 from each item score, dividing by 5 and multiplying by 100. The competency gap was then computed by subtracting the average indexed performance score from the average indexed importance score for each item.

Survey and Focus Group Findings

Results of the data analysis begin to reveal what industry practitioners perceive to be critical issues to be addressed by curriculum reform in technological education programs. Items exhibiting the highest importance, performance, and gap scores are summarized in the chart on the bottom right.

The key question inherent in this research project is very practical: "What are the highest priority topics to be addressed in reforming technological curricula in order to close the gaps between what industry needs and what is being delivered. Tables 1, 2, and 3 separately illustrate how importance and performance compare with each item's gap score.

The summary data alone were not sufficient to address this question because both perceived level of importance and the gap between importance and performance are both relevant and must impact curricular decisions. That is, it is possible for an item to be highly important but have a relatively small gap between importance and performance. Thus, such an item would not be as high a priority for targeting in curriculum revision as an item that is slightly less important but also exhibits a very large competency gap. Therefore, a priority score was calculated that captured both importance and gap data to identify the items that were the highest priority for

Table 1. Advisory council survey averages for importance, performance, and the associated gap.

Q#	Statement	Importance	Performance	Gap
1	process and individual skills vs. teams and systems thinking	[illegible]	[illegible]	[illegible]
2	the nature of competition in the industry	71.05	30.66	40.39
3	the business impact of job activities and decisions	81.87	[illegible]	[illegible]
4	the big picture of the organization: thinking beyond details to see goals and results	86.58	34.61	[illegible]
5	a firm's mission, strategies, and performance objectives	77.37	26.71	[illegible]
6	current trends in business and industry	[illegible]	[illegible]	[illegible]
7	technology trends and their applications	[illegible]	62.63	[illegible]
8	how their own actions impact the overall performance of the firm	[illegible]	[illegible]	[illegible]
9	how one's function in the firm integrates with other functions to achieve performance goals	[illegible]	[illegible]	46.71
10	business financial information	[illegible]	[illegible]	[illegible]
11	concepts of value-added processes	[illegible]	[illegible]	[illegible]
12	concepts of entrepreneurship and business	[illegible]	[illegible]	[illegible]
13	how to recognize and utilize cultural differences and cultural behaviors	73.29	28.02	45.27
14	team working skills	91.98	37.37	54.61
15	interpersonal relationship skills	91.98	36.05	55.93
16	leadership skills	[illegible]	[illegible]	[illegible]
17	problem identification and problem solving skills	96.05	[illegible]	[illegible]
18	written communication skills	85.99	63.95	22.04
19	oral communication skills	[illegible]	[illegible]	[illegible]
20	listening skills	[illegible]	[illegible]	[illegible]
21	organizing and planning skill	[illegible]	[illegible]	[illegible]
22	utilizing information systems	[illegible]	60.00	[illegible]
23	strategic analysis and planning	[illegible]	[illegible]	[illegible]
24	cooperation among co-workers	91.98	30.66	61.32
25	the welfare of the group over self	[illegible]	[illegible]	60.00
26	[illegible]	[illegible]	[illegible]	[illegible]
27	innovation and creativity in problem solving	94.61	[illegible]	[illegible]
28	ethical behavior and decision making	[illegible]	[illegible]	[illegible]
29	customer satisfaction over task completion	91.98	34.61	57.37
30	loyalty and commitment to the organization	[illegible]	[illegible]	[illegible]

Data Analysis of Survey and Focus Group Findings

Most Important Items		Index
Question 17	Problem identification and problem solving skills	96.05
Question 27	Innovation and creativity in problem solving skills	94.61
Question 29	Customer satisfaction over task completion	91.98
Question 24	Cooperation among co-workers	91.98
Question 15	Interpersonal relationship skills	91.98
Question 14	Team working skills	91.98

Highest Scoring Performance Items		Index
Question 18	Written communication skills	63.95
Question 7	Technology trends and their applications	62.63
Question 22	Utilizing information systems	60.00

Items With the Largest Competency Gaps		Index
Question 24	Cooperation among co-workers	61.32
Question 25	The welfare of the group over self	60.00
Question 29	Customer satisfaction over task completion	57.37
Question 15	Interpersonal relationship skills	55.93
Question 14	Team working skills	54.61

inclusion in future curriculum development. This score was computed by adding the transformed importance index and competency gap score for each item and dividing by 2. The highest resulting numbers reflect items that are both highly important and exhibit the largest gaps between importance and performance. Thus, these are the highest priority for curricular attention and are summarized below. Table 4 provides the computed priority scores for all the items.

Highest Priority Items
Question 24 -
Cooperation among co-workers
Question 25 -
The welfare of the group over self
Question 29 -
Customer satisfaction over task completion
Question 15 - Interpersonal communication skills
Question 14 - Team working skills

Priority Score
Question 24 - 76.65
Question 25 - 74.67
Question 29 - 74.67
Question 15 - 73.95
Question 14 - 73.29

Implications for Industrial Technology Curricular Reform

The results of this exploratory study indicated that advanced technological programs (SMET) must continue to emphasize such issues as group project skills and quality concepts. But they must also be sure to emphasize cooperation among co-workers, the welfare of the group over self, customer satisfaction over task completion, interpersonal communications skills, and team working skills in all aspects of their curriculum. Industrial Technology programs that want to elevate their programs to the next level must now begin to examine how to improve their graduate's abilities to understand items such as: (a) how a firm's vision, strategies, and performance outcomes effect overall organizational performance; (b) how the organization's culture influences individual behaviors; and (c) how the welfare of group over self must be instilled into the organizational culture. These last items (a-c) need to be integrated and synthesized into the entire curriculum not just specific courses.

Table 2. Importance vs. gap

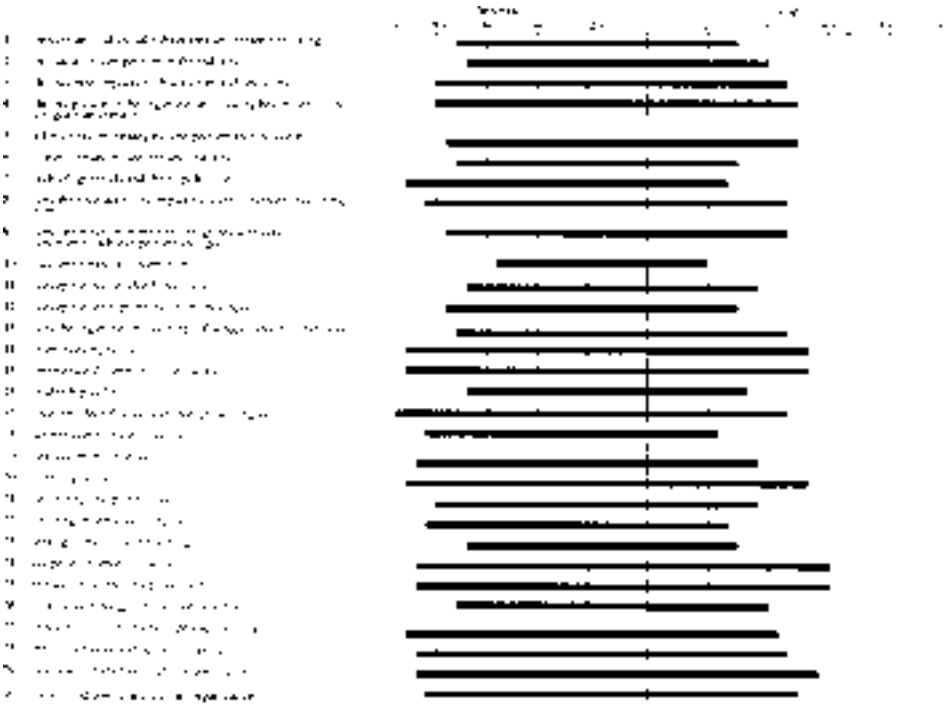
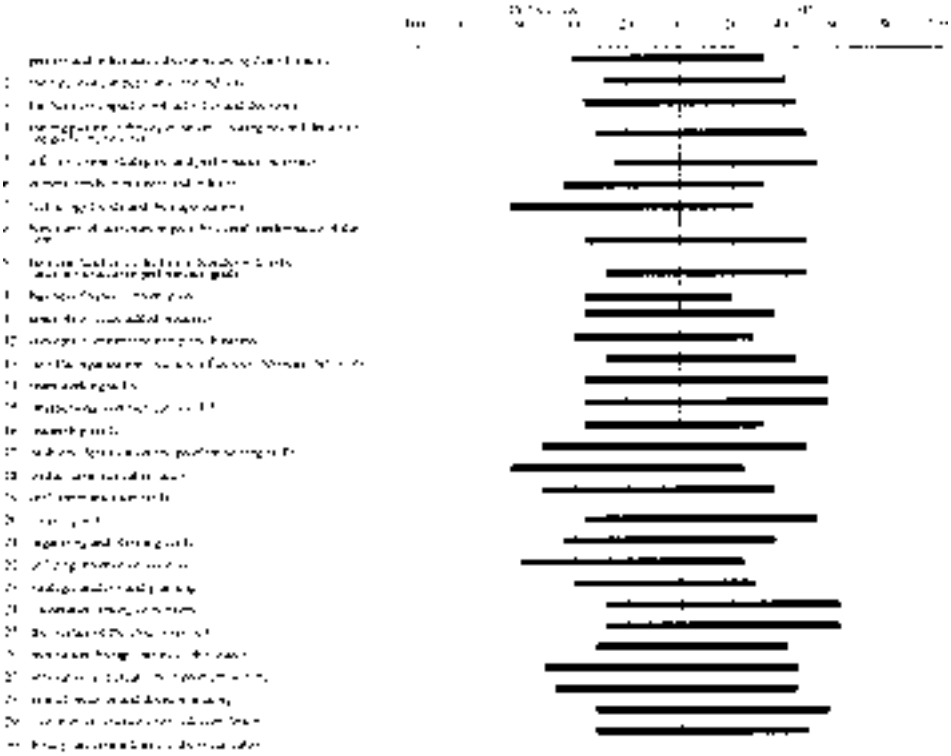


Table 3. Performance vs. gap



Current National Association of Industrial Technology (NAIT) accreditation minimum– maximum foundation requirements for associate degree programs require the student to complete 36-42 hours of coursework in a

combination of management and/or technical coursework. The baccalaureate degree program accreditation minimum–maximum foundation requirements require the student to complete 24-36 hours in technical coursework as well as 12-24 hours of coursework within the category of management. This management category is defined in the Industrial Technology Accreditation Handbook (NAIT, 1997, pp. 21 and 30) as:

> "quality control, production planning and control, industrial supervision, industrial finance and accounting, industrial safety management, facilities layout and materials handling, time and motion study, industrial communications, business law, marketing, etc."

Traditionally industrial technology departments have produced graduates with very strong technical skills. And, since the mid to late 1980's many programs have increased their emphasis on developing teamwork and/or group projects skills and problem solving skills as a result of the increased global emphasis on total quality management and statistical quality control concepts. Many industrial technology programs offer multiple courses to help their students prepare for the heavy demand placed on quality related issues.

However, minimal coursework has focused on concepts such as cooperation among co-workers, the welfare of the group over self, customer satisfaction over task completion, and interpersonal communication skills. The knowledge, skills, and attitude competencies of 21st century industrial technology graduates needs to reflect the demands described by Drucker (1995) and Goldman, Nagel, & Preiss (1995). We will need "knowledge workers" capable of being integrators that tie everything together and create the customer-defined economic value that ultimately pays for everything and everybody (Meier, Humphreys, & Williams; in press).

As the need for these "knowledge workers" increases, the industrial technology profession may want to examine the minimum-maximum foundation requirements for accreditation. With the increase in management and people skills expected by business and industry leaders there is a need to examine the balance between the technical and management foundation requirements. Clearly, technological education must maintain the highest level of technical competencies. However, technical proficiency levels represent the minimum level expected by business and industry leaders. It is now necessary to infuse a broader range of business management, marketing, and interpersonal communication competencies that will comprise the "knowledge worker" of the 21st century.

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Table 4. Priority Scores.

Q #	Statement	Importance	Gap	Priority Score
24	[illegible]	91.56	61.32	76.67
25	the welfare of the group over self	89.34	60.80	74.67
20	customer satisfaction over task completion	91.56	57.32	74.67
18	interpersonal communications skills	91.56	55.03	73.95
12	team working skills	91.98	54.61	73.29
21	[illegible] skills	90.66	53.20	71.93
17	problem identification and problem solving skills	90.05	53.39	71.72
27	innovation and creative problem solving	94.67	43.95	69.28
31	loyalty and commitment to the organization	85.39	50.78	68.05
28	ethical behavior and decision making	90.05	45.27	67.96
8	how each job activity impact the overall performance of the firm	86.71	46.02	66.37
4	looking beyond details to set goals and tasks	82.63	45.02	63.83
5	[illegible]	77.37	50.66	64.01
1	the business impact of corporate values and decisions	81.32	45.27	63.29
29	[illegible]	88.37	[illegible]	62.59
9	how each function in the firm interfaces with other functions to achieve performance goals	77.37	46.71	62.04
7	technology trends and their applications	90.66	35.02	62.84
30	how the organization's culture influences individual behaviors	73.20	45.27	59.24
2	[illegible] planning skills	80.38	39.05	58.02
26	motivation through intrinsic job rewards	76.61	[illegible]	57.96
11	concepts of value added processes	80.38	33.07	56.71
33	[illegible]	86.71	26.71	56.71
3	the nature of competition in the marketplace	70.66	40.00	55.33
15	written communication skills	85.09	22.01	53.01
1	[illegible]	73.20	31.95	52.63
6	[illegible]	74.61	30.66	52.63
16	[illegible]	71.98	33.29	52.63
13	concepts of entrepreneurship and business	70.66	30.66	50.66
23	[illegible]	61.80	39.66	50.73
10	business horizontal [illegible]	58.98	20.00	39.49

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