AC 2008-552: CHARACTERIZING THE ENGINEERING TECHNOLOGISTS: IMPLICATIONS FOR PROGRAM ASSESSMENT

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Characterizing the Engineering Technologists: Implications for Program Assessment

Abstract

Several sources of instructional and occupational information were examined for their potential to produce and validate statements that describe the expected accomplishments of engineering technology graduates during the first few years after graduation, or objectives, and statements that describe what engineering technology students are expected to know and be able to do upon fulfilling their graduation requirements, or outcomes. The sources examined included crosswalks, the Classification of Instructional Programs, the Occupational Information Network, and the Standard Occupational Classification system. The results indicated that these information sources can serve as valuable and viable adjuncts to other means engineering technology programs use for producing and validating statements that describe the expected accomplishments of engineering technology students are expected to know and be able to do upon fulfilling their graduation requirements.

Introduction

Engineering technology programs exist to prepare their products, their graduates, to fulfill roles in economic endeavors as technicians or technologists. That is, engineering technology programs exist to prepare their graduates to function effectively in given occupations. As a result, the need to assess the results of the instruction delivered is at the very least a value added step in the instructional process. Instructional programs should be able to identify the standards to which they are teaching and the extent to which their graduates meet those standards.

Most instructional programs seek feedback and respond to the feedback at the course, program, and product performance levels. The standards established by most programs are based on good and well established practices—ie focus groups, advisory boards, surveys, and the like, as are their measurement techniques.

The current literature, however, suggests that engineering technology has not taken advantage of what appears to be a wealth of selected bits instructional and occupational information housed in readily accessible databases. Perhaps it is because the information deals with engineering technology occupations as they are presently rather than what they ought to be or will be. Another reason that could be given is the findings are a result of data that are collapsed from numerous national sources and may not be as applicable to a particular community. The information, never-the-less, appears to be valuable and, at the very least, can serve as an adjunct to what's being used and done.

Purpose

The purpose of this study was to examine those sources of instructional and occupational information for their potential to produce and validate (a) objectives—statements that describe

the expected accomplishments of engineering technology graduates during the first few years after graduation and (b) outcomes—statements that describe what engineering technology students are expected to know and be able to do upon fulfilling their graduation requirements.¹

Occupational Information Network

The ubiquitous Dictionary of Occupational Titles,² or DOT, was once the principle resource used to match job seekers to jobs based on occupational definitions. The DOT organized jobs by groups call occupations based on similarities and defined the structure and content of all the occupations listed. These definitions were a result of comprehensive studies on how similar jobs were performed in economic endeavors across the nation and were composites of data collected from diverse sources. The term "occupation," as defined by the DOT, referred to this collective description of a number of individual jobs performed, with minor variations, in the economic endeavors surveyed.

While the DOT is still a standard reference in some circles, it has since been replace by the Occupational Information Network or O*NET.³ As the replacement for the DOT, O*NET is the nation's primary source of occupational information. It exists to help employers, workers, educators, and students make informed decisions about education, training, career choices, and work. Its existence is realized by a database that contains information on hundreds of standardized and occupation-specific descriptors.

Key to O*NET's effectiveness is the O*NET database. The database, which is available to the public at no cost, is continually updated by surveying a broad range of workers from each occupation. Information from this database forms the heart of O*NET OnLine,⁴ an interactive application for exploring and searching occupations.

Standard Occupational Classification

Embedded in O*NET are Standard Occupational Classification (SOC) codes, which is one of the means by which O*NET users negotiate the O*NET database. The SOC system is used by federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. All workers are classified into one of over 820 occupations according to their occupational definition. To facilitate classification, occupations are combined to form 23 major groups, 96 minor groups, and 449 broad occupations. Each broad occupation includes detailed occupation(s) requiring similar job duties, skills, education, or experience.⁵

Classification of Instructional Programs

The Classification of Instructional Programs, or CIP, is a taxonomic coding scheme that contains titles and descriptions of primarily postsecondary instructional programs that supports the accurate tracking, assessment, and reporting of fields of study and program completion activity.⁶ Virtually all instructional programs are assigned CIP codes, which is the principal means for negotiating the CIP database.

Crosswalks

Crosswalks were developed to facilitate the linkage between classification systems. SOC, as an example, is a Bureau of Labor Statistics classification system; CIP, as an example, is a classification system developed by the Department of Education. The National Crosswalk Service Center (NCSC) refers to crosswalks as specialized computer files that are used to relate systems to one another.⁷

Among the crosswalks maintained by NCSC, is the SOC-to-CIP Crosswalks. A result of a joint effort between the Department of Education and the Department of Labor, the purpose of the SOC-to-CIP Crosswalk is to show the relationships between instructional program content and their equivalent Federal Standard Occupational Classification codes, based on the descriptions of each.⁸

Method

The purpose of this study was to examine several sources of instructional and occupational information for their potential to produce and validate objectives and outcomes. For the purpose of this study, the investigation was limited to industrial engineering technology, as this study's procedures can be applied to other engineering technology programs—ie civil engineering technology, electrical engineering technology, mechanical engineering technology, and the like.



Figure 1. Keyword Search of O*NET OnLine

Procedure

A keyword search was conducted with the aid of the O*NET Online⁹ using the phrase "industrial engineering technologist"—see Figure 1. The purpose was to identify the SOC code for

industrial engineering technologist and its associated occupational information. Once the SOC code and its associated occupational information were identified, the SOC code was used in conjunction with a CIP to SOC Crosswalk¹⁰ to identify all CIP codes aligned with the industrial engineering technologist SOC code, as an adjunct to this study, and thus all instructional programs associated with the production of industrial engineering technologists.

Results

The results of an O*NET OnLine search yielded a list of occupations ranked based on how well they matched the keyword—see Figure 2. Each occupation is provided a relevance score. The search strategy used in the keyword search uses a combination of occupational information, such as associated alternate titles, description, and tasks. A raw score is calculated based on the number of matches across the different data elements and their respective weights. The raw score is then translated to a 0 to 100 relevance ranking.

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Figure 2. Keyword Search Results

Additional information on any of the occupations listed can be displayed by selecting the respective occupation. For the purpose of this study, the occupation that received a relevance score of 100, was selected. The next relevant occupation, the second in terms of relevance, had a relevance score of 72.

Once an occupation is selected, the user may exam a summary report, a details report, or produce a custom report by selecting the respective tab—see Figure 3. Summary reports provide the user with the most important descriptors associated with that occupation. Details reports display all descriptors for the occupation selected, definitions of descriptors, and ratings for each descriptor in terms of how important each descriptor is to the occupation. The custom report menu

provides users with the means for selecting desired descriptor(s), scales, and minimum score levels to include in a report.

The Industrial Engineering Technologists

For the purpose of this study, selected data were chosen for examination from a summary report produced from the original keyword search on "industrial engineering technologist"—see Figure 3. Specifically, the following were retrieved for examination: (a) Occupation code, title, and definition; (b) Sample of Reported Job Titles; (c) Tasks; (d) Tools and Technology; (e) Knowledge; (f) Skills; (g) Abilities; (h) Work Activities; (i) Work Styles; and (j) Wage data.

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17-3026.00 - Industrial Engineering Technicians		
Apply engineering theory and principles to problems of industrial layout or manufacturing production, usuals method, and speed involved in performance of production, maintenance, clerical, and other worker operation efficiency.	under the direction of engineering staff. May study and record time, motion is for such purposes as establishing standard production rates or improving	1,
Sample of reported job titles: Manufacturing Engineer, Engineering Technician, Industrial Engineering Te Analyst, Process Documentation and Methods Analyst, Manufacturing Technician, Quality Control Engineer	shnician, Production Staff Worker, Project Engineer, Industrial Engineering ng Technician (QC Engineering Technician), Quality Process Engineer	
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Tasks		
Recommend revision to methods of operation, material handling, equipment layout, or other changes	to increase production or improve standards.	
 Study time, motion, methods, and speed involved in maintenance, production, and other operations to 	establish standard production rate and improve efficiency.	
 Interpret engineering drawings, schematic diagrams, or formulas and conter with management or engineering man	ineering statt to determine quality and reliability standards.	
 Aid in planning work assignments in accordance with worker performance, machine capacity, produced in the planning work assignments in accordance with worker performance. 	tion schedules, and anticipated delays.	
Observe worker using equipment to verify that equipment is being operated and maintained according	to quality assurance standards.	
Observe workers operating equipment or performing tasks to determine time involved and fatigue rate	using timing devices.	
 Prepare charts, graphs, and diagrams to illustrate workflow, routing, floor layouts, material handling, a Evolute data and write reports to volidate or indicate deviations from existing standards. 	nd machine utilization.	
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Figure 3. Summary Report

The occupation code, title, and definition were as follows: 17-3026.00; Industrial Engineering Technicians; Apply engineering theory and principles to problems of industrial layout or manufacturing production, usually under the direction of engineering staff. May study and record time, motion, method, and speed involved in performance of production, maintenance, clerical, and other worker operations for such purposes as establishing standard production rates or improving efficiency.

Sample of reported job titles included: Manufacturing Engineer, Engineering Technician, Industrial Engineering Technician, Production Staff Worker, Project Engineer, Industrial Engineering Analyst, Process Documentation and Methods Analyst, Manufacturing Technician, Quality Control Engineering Technician (QC Engineering Technician), Quality Process Engineer.

The specific work activities unique to industrial engineering technologists, or Tasks, are listed in Figure 4. According the details report, these specific work activities are the most important to

the industrial engineering technologists and are required of industrial engineering technologists.

Recommend revision to methods of operation, material handling, equipment layout, or other changes to increase production or improve standards.

Study time, motion, methods, and speed involved in maintenance, production, and other operations to establish standard production rate and improve efficiency.

Interpret engineering drawings, schematic diagrams, or formulas and confer with management or engineering staff to determine quality and reliability standards.

Recommend modifications to existing quality or production standards to achieve optimum quality within limits of equipment capability. **Aid** in planning work assignments in accordance with worker performance, machine capacity, production schedules, and anticipated delays.

Observe worker using equipment to verify that equipment is being operated and maintained according to quality assurance standards. Observe workers operating equipment or performing tasks to determine time involved and fatigue rate using timing devices. Prepare charts, graphs, and diagrams to illustrate workflow, routing, floor layouts, material handling, and machine utilization. Evaluate data and write reports to validate or indicate deviations from existing standards.

Read worker logs, product processing sheets, and specification sheets, to verify that records adhere to quality assurance specifications.

Figure 4. Tasks

The machines, equipment, tools, and software, or Tools and Technology, an industrial engineering technologists may use are listed in Figure 5.

Tools used in this occupation: Coordinate measuring machines CMM—Direct computer-controlled coordinate measuring machines DCC-CMM; Forklifts; Gauges or inspection fixtures—Dial indicators; Lathes—Computerized numerical control CNC lathes; Milling machines—Computerized numerical control CNC milling machines Technology used in this occupation: Analytical or scientific software—ProMODEL software, Statistical software, Wilcox Associates PC-DMIS; Computer aided design CAD software—Autodesk AutoCAD, SolidWorks CAD; Data base user interface and query software—Data entry software, Microsoft Access; Spreadsheet software—Microsoft Excel; Word processing software—Microsoft Word

Figure 5. Tools and Technology

The organized sets of principles and facts that apply to a wide range of situations, or Knowledge, associated with industrial engineering technology are listed in Figure 6. These principles and facts are the most important to and are required of industrial engineering technologists.

Production and Processing (Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.) Engineering and Technology (Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.) Mathematics (Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.) English Language (Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.) Clerical (Knowledge of administrative and clerical procedures and systems such as word processing, managing files and records, stenography and transcription, designing forms, and other office procedures and terminology.) Design (Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.) Computers and Electronics (Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.) Mechanical (Knowledge of machines and tools, including their designs, uses, repair, and maintenance.) Education and Training (Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.) Administration and Management (Knowledge of business and management principles involved in strategic planning, resource allocation, human resources modeling, leadership technique, production methods, and coordination of people and resources.)

Figure 6. Knowledge

The developed capacities that facilitate learning and the performance of activities that occur across industrial engieering technology jobs, or Skills, are listed in Figure 7. These developed capacities are the most important to and are required of industrial engineering technologists.

Active Listening (Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.) Complex Problem Solving (Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.) Critical Thinking (Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.) Judgment and Decision Making (Considering the relative costs and benefits of potential actions to choose the most appropriate one.) Coordination (Adjusting actions in relation to others' actions.) Active Learning (Understanding the implications of new information for both current and future problem-solving and decision-making.) Instructing (Teaching others how to do something.) Speaking (Talking to others to convey information effectively.) Monitoring (Monitoring/Assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action.)

Figure 7. Skills

The enduring attributes that influence performance, or Abilities, of industrial engineering technologists are listed in Figure 8. These enduring attributes are the most important to and are required of industrial engineering technologists.

Deductive Reasoning (The ability to apply general rules to specific problems to produce answers that make sense.) Inductive Reasoning (The ability to combine pieces of information to form general rules or conclusions—includes finding a relationship among seemingly unrelated events). Near Vision (The ability to see details at close range—within a few feet of the observer). Oral Comprehension (The ability to listen to and understand information and ideas presented through spoken words and sentences.) Problem Sensitivity (The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.) Oral Expression (The ability to communicate information and ideas in speaking so others will understand.) Selective Attention (The ability to speak clearly so others can understand you.) Category Flexibility (The ability to generate or use different sets of rules for combining or grouping things in different ways.) Information Ordering (The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules eg patterns of numbers, letters, words, pictures, mathematical operations.)

Figure 8. Abilities

The kinds of tasks that may be performed by industrial engineering technologists, or Work Activities, are listed in Figure 9. These kinds of tasks, or Work Activities, are the most important to and are required of industrial engineering technologists.

Communicating with Supervisors, Peers, or Subordinates (Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.) Identifying Objects, Actions, and Events (Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events.) Establishing and Maintaining Interpersonal Relationships (Developing constructive and cooperative working relationships with others, and maintaining them over time.) Documenting/Recording Information (Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form.) Interacting With Computers (Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information.) Getting Information (Observing, receiving, and otherwise obtaining information from all relevant sources.) Monitor Processes, Materials, or Surroundings (Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.) Analyzing Data or Information (Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts.) Processing Information (Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.) Thinking Creatively (Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic

Figure 9. Work Activities

contributions.)

The physical and social factors that influence the nature of work, or Work Context, for industrial engineering technologists are listed in Figure 10.

 Face-to-Face Discussions (How often do you have to have face-to-face discussions with individuals or teams in this job?)

 Contact With Others (How much does this job require the worker to be in contact with others—ie face-to-face, by telephone, or otherwise—in order to perform it?)

 Work With Work Group or Team (How important is it to work with others in a group or team in this job?)

 Telephone (How often do you have telephone conversations in this job?)

 Wear Common Protective or Safety Equipment such as Safety Shoes, Glasses, Gloves, Hearing Protection, Hard Hats, or Life Jackets (How much does this job require wearing common protective or safety equipment such as safety shoes, glasses, gloves, hard hats or life jackets?)

 Letters and Memos (How often does the job require written letters and memos?)

 Freedom to Make Decisions (How much decision making freedom, without supervision, does the job offer?)

 Duration of Typical Work Week (Number of hours typically worked in one week.)

 Frequency of Decision Making (How frequently is the worker required to make decisions that affect other people, the financial resources, and/or the image and reputation of the organization?)

 Importance of Being Exact or Accurate (How important is being very exact or highly accurate in performing this job?)

Figure 10. Work Context

The personal characteristics that can affect how well an industrial engineering technologist does a job, or Work Styles, are listed in Figure 11. These are the most important personal characteristices an industrial engineering technologist can possess.

Analytical Thinking (Job requires analyzing information and using logic to address work-related issues and problems.0 Dependability (Job requires being reliable, responsible, and dependable, and fulfilling obligations.) Attention to Detail (Job requires being careful about detail and thorough in completing work tasks.) Integrity (Job requires being honest and ethical.) Achievement/Effort (Job requires establishing and maintaining personally challenging achievement goals and exerting effort toward mastering tasks.) Initiative (Job requires a willingness to take on responsibilities and challenges.) Persistence (Job requires persistence in the face of obstacles.) Adaptability/Flexibility (Job requires being open to change (positive or negative) and to considerable variety in the workplace.) Innovation (Job requires creativity and alternative thinking to develop new ideas for and answers to work-related problems.) Stress Tolerance (Job requires accepting criticism and dealing calmly and effectively with high stress situations.)

Figure 11. Work Styles

National wage figures for industrial engineering technologists in 2006 and for industrial engineering technologists in the state of Indiana in 2006 are provided in Table 1. These figures are among data compile and published by the Bureau of Labor Statistics.

Loootion		2006					
Location	Pay Period	10%	25%	Median	75%	90%	
United States	Hourly	\$14.52	\$17.81	\$22.51	\$29.26	\$38.07	
	Yearly	\$30,200	\$37,000	\$46,800	\$60,900	\$79,200	
Indiana	Hourly	\$14.20	\$17.10	\$20.68	\$25.40	\$30.92	
	Yearly	\$29,500	\$35,600	\$43,000	\$52,800	\$64,300	

Table 1.	Wage Figures fo	r Industrial	Engineering	Technologists	in 2006
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SOC to CIP Crosswalk

A SOC to CIP crosswalk was conducted on the industrial engineering technologist SOC code, 17-3026. The crosswalk yielded the following CIP codes and program titles: 15.0612, Industrial Technology/Technicians; 15.0613, Manufacturing Technology/Technicians; 15.0699, Industrial Production Technologies/Technicians, Others; 15.0702, Quality Control Technology/Technician; 15.0799, Quality Control & Safety Technologies/Technicians; 15.1501, Engineering/Industrial Management¹⁰.

Discussion

SOC to CIP Crosswalk

Crosswalking can serve as a viable adjunct for validating the intent of instructional programs in engineering technology. A simple item on a questionnaire administered to alumni, as an example, that elicits alumni job titles that, hopefully, match those alternative job titles found in the summary report for industrial engineering technologists, can help validate the intent of an instructional program.



Figure 12. Survey Items Intended to Ascertain Alumni Work Activities

Occupational Information Network

A survey of industrial engineering technology alumni, administered within a year or two following graduation, can query program alumni regarding their work activities (see Figure 12) using a Likert Scale. Programs should be asking about the frequency with which alumni engaged in these work activities as they are valid work activities for industrial engineering technologists.

The scale depicted in Figure 13 can solicit the extent to which program alumni are engaged in selected work activities.

Γ	Indicate the extent to which you are involved in the following work activiti	es by coloring in the co	rresponding b	ubble.	
	Soveral times deily O	Once or se daily O	Several tir	nes a: Month O	Voor O
L	Several lines daily O		Week U		



For assessing program alumni advancement, a simple survey item, similar to that which is depicted in Figure 14, which has been abbreviated, can be used to collect data. Once the data are compiled, the summary data can be compared to the national and state wage figures—see Table 1.

Color in the bubble in the first column that best describes your per-year salary in your first job after graduating. Then color in the bubble in the second column that best describes your per-year current salary. If either job is/was part-time, give the approximate full-time equivalent per-year salary.				
First job	pre-tax gros	s annual salary		
Ţ	Current	iob pre-tax gross annual salary		
•	Ļ			
0	0	30.000-34.999		
Ó	Ó	35,000-39,999		
•	•			
0	0	60,000-64,999		
0	0	100,000 or more annually		

Figure 14. Sample Survey Item for Assessing Program Alumni Advancement

Conclusion

The purpose of this study was to examine selected sources of instructional and occupational information for their potential to produce and validate statements that describe (a) the expected accomplishments of engineering technology graduates during the first few years after graduation, or objectives and (b) what engineering technology students are expected to know and be able to do upon fulfilling their graduation requirements, or outcomes. The results indicated that these information sources can serve as valuable and viable adjuncts to other means engineering technology programs use for producing and validating program objectives and outcomes. User enthusiasm for employing what has been advocated as a result of the findings should however be tempered by the findings limitations. The data that support the various descriptors that characterize the industrial engineering technologist originated from and represent a snapshot in time. Furthermore, the descriptors describe what was rather than perhaps what ought to be.

Finally, the data are also collapsed from numerous sources and may not necessarily reflect a particular economic endeavor or locale.

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