EIA Skill Standards – to EET or not to EET? That is the Question

Stephen R. Fleeman
Rock Valley College

With the publication of the Secretary's Commission on Achieving Necessary Skills (SCANS) initial report [Ref. 1] in 1991, the need for a set of national skill standards materialized. As part of the nation's response to establish the skill standards, the United States Departments of Education and Labor initiated 22 public-private partnerships to develop sets of voluntary skill standards for various industries. In the electronics technology area, two major efforts were completed. One set of standards has been developed by the American Electronics Association (AEA), which was underwritten by the United States Department of Labor. A second set of standards has been created by the Electronics Industries Foundation (EIF), which is the philanthropic arm of the Electronics Industries Association (EIA). The EIA standards have been underwritten by the United States Department of Education.

The purpose of this paper is to examine the use of national skill standards to promote the assessment of the effectiveness of an Electronics Engineering Technology (EET) program. To this end, the paper addresses five separate areas. First, the significance of skill standards is reviewed. Second, the rationale for the selection of the EIA skill standards over the AEA skill standards is developed. Third, an overview of the selected standard is provided. Fourth, suggestions for the application of the standard to a two-year electronics program that leads to an Associate in Applied Science degree are presented. The fifth area of discussion presents a possible approach to student skills assessment. In its totality, a complete model is presented which features an approach to the *external* outcomes assessment of an electronics program.

What is the SCANS Report?

In July 1992 the SCANS final report *Learning a Living: A Blueprint for High Performance* [Ref. 2] was issued. The Secretary's Commission on Achieving Necessary Skills (SCANS) included distinguished representatives from education, business, labor, and government. The goal of the report was "to encourage a high performance economy characterized by high skills, high wage employment." The requirements identified by SCANS consist of 23 workplace competencies and 14 foundation skills competencies along with the personal qualities needed for solid job performance.

A student who possesses necessary technical knowledge and skills will certainly be hired. However, if the student lacks many of the attributes described in the SCANS report, the student is just as likely to be *fired*. Regardless of the immediate goals of one's educational niche, we all need to be aware of what business requires of its workers.

What is a Skill Standard?

A *skill standard* defines the specific knowledge, competencies, and level of attainment required to perform successfully in the work place. The Goals 2000 Act states that a skill standard "specifies the level of knowledge and competency required to successfully perform work-related functions within an occupational cluster."

With the goal of turning out "job-ready" electronics technicians and technologists, most EET programs embrace these concepts naturally. In fact, many might argue that this is the premise upon which the engineering technology discipline is based.

Why Apply National Skill Standards?

The North Central Accreditation (NCA) agency has required that technology programs (including Electronic Engineering Technology programs) at community colleges and senior institutions demonstrate a concerted effort to assess their effectiveness through outcomes assessment. Subsequently, a prudent strategy would seem to be to investigate national skill standards, interpret their application to a given program, and investigate possible external methods for evaluating student levels of achievement of the skill standards. Regardless of the NCA requirement, this makes good sense strategically.

Some community colleges might argue that *national* skill standards serve to prohibit their effectiveness to gear their technology programs to the needs of their local industrial community. Along a similar vein, senior institutions might counter that their primary objective is to satisfy the TAC/ABET (Technology Accreditation Commission of the Accreditation Board for Engineering and Technology) accreditation criteria.

However, we must remind ourselves that business and industry, as well as academia, face global competition. Either we do our jobs using a global perspective, or someone else will do our jobs for us. It is that simple.

It is self-evident that technological superiority is the key to American economic superiority. Our economic survival depends on the ability of our workers to meet global standards for the manufacture of products and their performance. The development of meaningful national skill standards and their effective incorporation to measure and promote competency represent a significant step to achieving global economic competitiveness.

This can only serve to complement local industry needs and TAC/ABET accreditation criteria.

The EIA Skill Standards versus the AEA Skill Standards

The AEA project resulted in a publication entitled *Setting the Standard – A Handbook on Skill Standards for the High-Tech Industry* [Ref. 3]. The EIA project produced a publication entitled *Raising the Standard – Electronics Technician Skills for Today and Tomorrow* [Ref 4]. These two publications provide considerable insight into the role and the expectations placed on electronics technicians. Copies of the AEA publication are available to public institutions for a charge of $25. The EIA publication is also available for a charge of $25. However, the EIA package is bundled with a 3½-inch floppy disk entitled *Characteristics of Competency Measurement Criteria for Entry-Level Electronics Technicians Skills* [Ref 5]. This floppy disk is in Word Perfect 5.1+ format and includes a complete breakdown of the individual skill standards. The completeness of this package and its utility gives the EIA skill standards a slight edge over the AEA creation.

A more objective contrast between the AEA and the EIA skill standards was developed by Milkala L. Rahn and entitled *Profiles of the National Industry Skills Standards Projects* [Ref 6]. The National Center for Research in Vocational Education (NCRVE) posed the same questions to the AEA and EIA projects. The questions and the project responses are summarized in Table 1.

The EIA skill standards are structured to permit their incorporation into EET curricula to develop entry-level electronics technicians. The AEA standards were designed to define the standards required for workers already in the workplace.

The AEA approach does not lend itself to direct incorporation in a classical EET program. However, the EIA project offers more of a balance between the hard and soft skills. The project is geared toward incorporation of the recommended skill standards within academia. Its stated (and demonstrated) concern toward evaluation and certification from the onset of the project ensures concrete evaluation methods can be created.

What is the definition of industry for your project? What criteria did you use to define the boundaries of your industry? What approach are you using to organize your industry in order to set standards?	
AEA National Skills Standards Project	**EIA** National Skills Standards Project
The membership categories of the American Electronics Association (AEA) are used to define "industry," but those categories are shifting as the industry changes and moves more into software, services, and telecommunications.	The electronics industry is defined by membership in the Electronics Industry Association or being on the Association's mailing list. One occupational cluster that is currently being considered by the project is the Electronics Technician. The project has identified 11 specialty occupations that make up this cluster. The target is to develop skill standards for the entry-level electronics technician.

Table 1. AEA versus EIA Skill Standards.

What definition of a standard are you using for your project?	
AEA National Skills Standards Project	**EIA** National Skills Standards Project
Occupational standards tell us which are the critical functions in a given occupation and how to identify good on-the-job performance. (See the publication entitled "Setting the Standard: A Handbook on Skill Standards for the High-Tech Industry" published by the American Electronics Association.)	A skill standard is the knowledge, skills, and level of ability needed to perform a job satisfactorily. These standards may be specific to an occupation, cross occupational lines, or apply to groupings of occupations. The concept of skill standards can be tailored to any industry to reflect its particular needs and economic development.

Please give an example of a standard for your project.	
AEA National Skills Standards Project	**EIA** National Skills Standards Project
Critical function: Assure production process meets business requirements. **Key activities (one example):** Meet health, safety, and legal requirements with regard to product, process, and people. **Performance criteria:** Health and safety requirements and procedures are implemented and followed at all times. • Potential health and safety hazards are identified through continuous safety reviews. • Confidentiality of proprietary information is protected according to company policy. • Company standards of business conduct are followed.	• Demonstrate an understanding of acceptable soldering/desoldering techniques, including through-hole and surface-mount devices. • Demonstrate an understanding of the technical basis for the workings of a product/device circuit/procedure and be able to apply that knowledge.

How will performance against the standards be assessed (i.e., assessment instruments, certification systems)?	
AEA National Skills Standards Project	**EIA** National Skills Standards Project
Performance against occupational standards is most generally assessed in the workplace or, at a minimum, in "simulated" work environments. There may be some aspects of what we call "underlying skill, knowledge, and work readiness skills" that could or would be assessed in the context of education and organization (e.g., technical understanding such as Computer Aided References or a work reaction literacy level, and so on). Both will be incorporated into a Portfolio of Professional Competence that would enable an individual to assemble and renew credentials throughout a lifetime of learning.	The project will define the criteria for successfully meeting the standards. Educators will be expected to use these criteria as their measurements of the students. A certification process will also be defined that may include assessment of graduates using tests and/or practical exercises, accreditation of training institutions, and/or practical work experiences. The assessment certification system will be defined in Phase II of the project.

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Hundreds of individuals from companies representing all segments of the electronics industry and from industry associations like the Vocational Industrial Clubs of America (VICA) and the International Society of Certified Electronics Technicians (ISCET) participated in developing 300 skill standards. Further, experts from international companies measured the standards against international benchmarks to assure that U.S. workers can meet standards set anywhere in the world.

The EIA national skill standards are recommended over the AEA national skill standards for integration into EET programs.

An Overview of the EIA Skill Standards

The EIA skill standards focus on five separate areas: *desirable behaviors and work habits*, *technical skills*, *test equipment and tool skills*, *basic and practical skills*, and *additional skills*. *Desirable behavior and work habits*, while not objectively measurable, are critical to the worker's overall employability and success. This area includes work ethics and behavior, interpersonal relationships, and teamwork - in short, the SCANS recommendations.

The area of *technical skills* includes general skills, dc circuits, ac circuits, discrete solid-state circuits, analog circuits, digital circuits, microprocessors, and microcomputers. The area of *test equipment and tools* concentrates on the worker's ability to know and understand how the test equipment or tool works and when, where, and how to use it.

Basic and practical skills concern technical literacy, communicating on the job, solving problems and critical thinking, proficiency in mathematics, and proficiency in physics. *Additional skills* include (electronic) communications, electromechanics, and LASER applications.

A Suggested Method to Apply the EIA Skill Standards to an AAS Degree Program

In *Raising the Standard – Electronics Technician Skills for Today and Tomorrow* [Ref. 4], the time required to train students to meet the standards by skill category was estimated by using "experienced electronics instructors." The cited hours are provided in Table 2.

The total number of hours often gives educators, students, and employers a significant case of "sticker shock." Let us take a closer look at the requisite number of hours versus a typical two-year Associate in Applied Science degree in EET. In many academic institutions, a contact (classroom) hour is defined to be 50 minutes long. For the purpose of clarity, let us remove this distinction.

Technical Skills	1200 to 1620 hours	77 to 74%
Test Equipment and Tools	50 to 100 hours	3 to 5%
Basic and Practical Skills	250 to 350 hours	16%
Additional Skills	65 to 105 hours	4 to 5%
Total	**1565 to 2175 hours**	**100%**

Table 2. Summary of EIA Training Time Estimates.

The EET program at Rock Valley College in Rockford, Illinois, is typical and will be used as an example here. The program and the number of contact hours are provided in Table 3. One credit hour is awarded for each lecture hour. In contrast, two laboratory hours are required to produce one credit hour. These general guidelines are modified occasionally in unique course situations.

The class hours listed in Table 3 are given on a *per-week* basis. Each semester is 15 weeks long (not including final examination periods). Consequently, we must multiply each of the total class hours by 15. When the number of class hours is tallied, we obtain a total of 1,392 hours. While this seems to be woefully short of the total training hours provided in Table 2, we must remember that most programs rely on work *outside* of the classroom.

We expect (hope) that students will be reading, studying, solving homework problems, writing papers, and constructing projects. An extremely conservative estimate places a times-two rule-of- thumb on the student. Specifically, students are expected to spend one hour outside of the classroom for each hour they are in the classroom. This takes the program detailed in Table 3 to ***2,784 hours***. This is equivalent to spending 40 hours a week for 70 weeks (about one year and four months). The minimum level of the EIA training requirement of 1565 hours equates to 40 hours a week for about 30 weeks. The maximum level of the EIA training requirement of 2175 hours translates to 40 hours a week for 54 weeks.

It is reasonable to state that according to the Electronics Industry Association national skill standards an entry-level electronics technician requires one full year of training at 40 hours per week.

(Employers often contact academic institutions to develop a "wonder course" that takes workers with very weak mathematics skills and turns them into entry-level electronics technicians in 16 hours. Is it any wonder they are often dissatisfied with the results? The one-year training statement provides them with a credible reality check.)

The percentages provided in Table 2 can be used to guide the weighting of the various areas.

Most programs are weighted to comply with state, accrediting agency, and institutional guidelines. Consequently, the EIA weights cannot be used to alter the number of specific courses or their credit hours. However, this does not free us from our responsibility to make a cursory examination. The important point is to ensure the *minimum* number of hours in each area is met or exceeded.

The sample EET program provided in Table 3 has been reorganized as illustrated in Table 4. The courses have been grouped according to the four skill standards areas defined by the EIA project. The class hours and respective weights are also included in Table 4.

First Year - Fall Semester				First Year - Spring Semester			
COURSE	TITLE	CREDIT HRS	CLASS HRS	COURSE	TITLE	CREDIT HRS	CLASS HRS
ENG 101	**Comp**	**3**	**3**	**SPH 131**	**Fund Speech**	**3**	**3**
CIS 128	**Fund Com-puter**	**3**	**4**	**EET 140 / CIS 186**	**Micro Assy Prog**	**4**	**5**
MTH 125	**Plane Trig**	**3**	**3**	**EET 134**	**Elect I**	**4**	**6**
PSY 170	**Gen Psych**	**3**	**3**	**EET 135**	**Digital I**	**4**	**5**
EET 133	**DC & AC Networks**	**4**	**6**				
	Sem Total	**16**	**19**		**Sem Total**	**15**	**19**

Second Year - Fall Semester				Second Year - Spring Semester			
COURSE	TITLE	CREDIT HRS	CLASS HRS	COURSE	TITLE	CREDIT HRS	CLASS HRS
PHY 201	**Mech & Heat**	**4**	**6**	EET 255	Trouble-shooting	3	5
MTH 135	**Calculus I**	**5**	**5**	EET XXX	EET Elect	3	5
EET 240	**Elect II**	**4**	**6**	EET 225	Com and CET Prep	4	5
EET 241	Micro Interface	3	4	EET 270	Proj Des & Fab	2	4
EET 250	Fab Skills - SMT	1	2	CDT 101	CAD	3	4
EET 260	Electronic CAD	1	2	EET 280	PC Service and Repair	3	4
	Sem Total	**18**	**25**		**Sem Total**	**18**	**27**

Table 3. Associate in Applied Science (AAS) in EET (67 credits)

Technical Skills (General Skills, DC/AC Circuits, Solid-State, Analog/Digital, Micros)			
EET 133 – DC & AC Networks	6 Hrs	**Program Total X15 X2 = 1530 Hours** **(EIA Recommendation 1200 to 1620 Hours)**	**Program Percentage = 55%** **(EIA Recommendations 77 to 74%)**
CIS 128 – Fund. Computers	4 Hrs		
EET 134 – Electronics I	6 Hrs		
EET 135 – Dig.	5 Hrs		
EET 140 - Micro processor	5 Hrs		
EET 240 – Electronics II	6 Hrs		
EET 241 – Micro interface	4 Hrs		
EET 260 – Electronic CAD	2 Hrs		
EET 255 - Troubleshooting	5 Hrs		
EET 280 – PC Service & Repair	4 Hrs		
CDT 101 – Mech. CAD	4 Hrs		
Test Equipment and Tools			
EET 250 – Fab. Skills - SMT	2 Hrs	**Program Total = 6 X15 X2 = 180 Hours** **(EIA Recommendation 50 to 100 Hours)**	**Program Percentage = 6%** **(EIA Recommendations 3 to 5%)**
EET 270 – Proj. Des. & Fab.	4 Hrs		
Basic and Practical Skills (Tech. Literacy, Communications, Prob. Solving, Math, Physics)			
ENG 101 - Composition	3 Hrs	**Program Total = 23 X15 X2 = 690 Hours** **(EIA Recommendation 250 to 350 Hours)**	**Program Percentage = 25%** **(EIA Recommendations 16%)**
PSY 170 – Gen Psychology	3 Hrs		
MTH 125 – Plane Trig	3 Hrs		
SPH 131 – Fund. Speech	3 Hrs		
PHY 201 – Mech & Heat	6 Hrs		
MTH 135 – Calculus I	5 Hrs		
Additional Skills (Electronic Communications, Electromechanical, LASER Apps)			
EET 225 – Electronic Com.	5 Hrs	**Program Total = 10 X15 X2 = 300 Hours** **(EIA Recommendation 65 to 105 Hours)**	**Program Percentage = 11%** **(EIA Recommendations 4 to 5%)**
EET Elective	5 Hrs		

Table 4. A Typical EET Program Organized into Skill Standards Areas and Time Estimates.

The next step, although not presented here, is to examine the individual course outlines and their objectives to ensure the various skill standards are covered. The skill standards are detailed in the

Characteristics of Competency Measurement Criteria for Entry-Level Electronics Technicians Skills [Ref. 5], as mentioned previously.

While reviewing an electronics program, it is important to include the (not objectively measurable) *Desirable behavior and work habits* area in the assessment. Recall that this area includes work ethics and behavior, interpersonal relationships, and teamwork. This area can be addressed with *how* particular courses or modules within the course are designed. For example, the microprocessor course (EET 140) in Table 4 includes a problem-based project (*Designing a Microprocessor Based Programmable Thermostat*) that is structured to place the students in a teaming environment. Industrial Advisory Committees are often a good source of ideas in this regard.

Skills-Based Versus Knowledge-Based Programs

A genuine concern of engineering technology educators is the fact that their programs are knowledge-based rather than skills-based. They are quick to dismiss any mention of skills standards as inappropriate to engineering technology. Indeed, some of the skill standards efforts have resulted in unwieldy, micro-management approaches to education.

The National Skill Standards Project for Advanced Manufacturing is an unfortunate example. Consider the sample standard below [Ref. 7]:

"Working alone with a calculator, add 10 two or three digit numbers five times in three minutes with 100% accuracy, in order to perform necessary calculations for Statistical Process Control (SPC) during the manufacturing process. To be documented by third party or performance assessment."

It is difficult to imagine any engineering technology professor rushing to embrace this approach to education. A valid argument (deleting explicatives) is to suggest that calculator skills are so fundamental to an EET student that they do not need to be measured in this fashion. A timed examination on dc circuit theory provides an indirect measure. Any EET student with poor calculator skills probably will not succeed in an EET program.

The EIA skill standards are much more open to interpretation and implementation. This is by design. Educators worked with industry representatives to develop the standards. Don Hatton (of the EIA) shared his perspective of the EIA approach with this writer on October 29, 1997.

"Industry requires workers to perform. Knowledge without the skills necessary to implement that knowledge effectively and efficiently is useless. However, the EIA recognized the importance of leaving enough latitude to permit and encourage educators to integrate the standards into their curricula."

Obviously, it is pointless to develop skill standards that educators are unable or unwilling to adopt and implement.

A sample EIA skill standard is provided in Table 5. With very little analysis, it is most likely that a typical electronics program already incorporates this skill. Further, educators are given complete freedom to

evaluate the results and define a "reasonable time frame." This is considerable departure from the approach offered by the National Skill Standards Project for Advanced Manufacturing.

Occupation: Entry-Level Electronics Technician

Proficiency Area: Technical Skills
F. Digital Circuits
Skill: F.08 Understand principles and operations of combinational logic circuits
MEASUREMENT CRITERIA
1. Described how gating or switching logic circuits operate in combination including AND, NAND, NOR, and OR.
2. Calculated the output of a combinational circuit by applying the appropriate truth tables to the individual logic circuits.
3.Listed applications for combinational logic circuits.
RESULTS:
Demonstrated understanding of principles and operations of combination logic circuits by completing above activities . Work was completed in a reasonable time frame.

Table 5. A Sample EIA Standard.

Using the National Skill Standards for Student and Program Assessment

On August 15, 1996, the Electronics Industries Association (EIA) announced plans to develop a pool of test questions to be used in the certification of work-ready electronics technicians. EIA included the Consumer Electronics Manufacturers Association (CEMA) and the Electronic Industries Foundation (EIF) in establishing the approach to develop an assessment tool.

The groups selected the Chauncey Group International, a subsidiary of Educational Testing Service (ETS), to develop and validate the test questions. ETS is best known as a long-time administrator of the SAT exams.

The Chauncey Group was selected because of its experience in the development of testing processes to measure effectively and fairly the competencies required for a variety of types of work. Chauncey's experience in developing certification tests safeguards both potential employers and employees by ensuring the tests do not discriminate in regards to race, sex, ethnic origin, or disability.

The EIA has invited the industry organizations that participated in the development of the standards to become partners in the certification process when the EIA decides how to implement a national testing program.

When interviewed on October 29, 1997, Mr. Don Hatton of the EIA indicated that the Chauncey Group had developed the required pool of test questions. In fact, the project has moved to the next phase.

The Computer Adaptive Testing Service (CATS) (located in Chicago) is in the process of developing the national testing program. The current strategy is to train on-site examination administrators. All examinations will be conducted by downloading the test using the Internet. The administrator will be familiar with the software and the procedures for proctoring the examination. This approach offers a number of advantages.

First, the exam will always be current. Second, the exam can be randomized using the pool of test questions. Third, the examination can be graded automatically, which means the student will not have to wait an extended period for results. Fourth, a data base can be generated automatically based on the examination site. This means that if EET students take the EIA Skills Standards Examination, their institution could receive feedback regarding their success.

Mr. Hatton explained that the examination will be designed to partition content areas. Therefore, if students tend to have trouble with the digital electronics portion of the exam, their institution can receive feedback. Similarly, if the students do well in the area of basic dc/ac circuit theory, their institution will also have that information. This possibility closes the loop around an EET program. The curriculum content and/or teaching methods can be adjusted based on this feedback.

An EET curriculum can be designed to satisfy the EIA national skill standards and receive automatic external feedback as to how well the program performs nationally. The students can obtain a nationally recognized certification based on their successful completion of the EIA examination. Institutional effort to obtain a meaningful outcomes assessment is minimal and virtually automatic.

Further, we have attempted to satisfy the needs of industry in this process. Everyone wins. Industry receives employees with the necessary skills, the institution receives immediate external feedback, and the students obtain a nationally-recognized credential. Surely, the gods of accreditation shall make their faces to shine upon us.

References

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Steve Fleeman is an Associate Professor in the EET Program at Rock Valley College where he teaches courses in the areas of circuits, solid-state devices, analog and digital electronic systems, communications electronics, controls, and instrumentation. He is employed concurrently by Sundstrand Aerospace as a circuit designer in the area of test equipment design. For more information about the EIA Skill Standards Project at Rock Valley College, please contact Professor Steve Fleeman.

Department of Electronic Engineering Technology
Division of Technology
Rock Valley College
3301 N. Mulford Road
Rockford, Illinois 61114-5699
(815) 654-5510
email: fate3sf@rvcux1.rvc.cc.il.us