ELECTRONICS MANUFACTURING CURRICULUM: WHAT INDUSTRY WANTS

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BACKGROUND

Electronics manufacturing is a major industry, one of the largest in the United States. Even though the electronics industry is well established, industry representatives claim there is a lack of qualified employees [1]. Many technical positions are filled by people who have little or no preparation in manufacturing equipment, problems, and processes. Programs are needed to train and retrain people for this fast growing field, but few exist. Traditional electronics curriculum focuses on circuit design, analysis, and proto-typing, but seldom includes manufacturing processes and quality control. Manufacturing curriculum does cover processes and equipment, but often focuses solely on metal working processes. This paper proposes a new curriculum that draws from both areas, as well as including material not covered in any other discipline.

Design and delivery of academic programs must aim for customer satisfaction and meet quality expectations the same as any other well designed, manufactured, and delivered product or service that industry requires. The design and implementation of an electronics manufacturing program is no different. The days when Henry Ford said, "Give them any color they want so long as its black," are gone from the automobile industry as well as the education process. In the development of this electronics manufacturing associate degree program, industry requirements and needs take *top priority*. Faculty must keep focused on the industry requirements as well as their own specifications. The Technology Accreditation Commission (TAC) of Accreditation Board for Engineering and Technology (ABET) criteria is necessary in today's academic/industry community. But, as one industry respondent to a program said, "You have to insure high quality graduates. If ABET accreditation will help do that, then get it." The equation for a quality designed and implemented program becomes:

Industry Needs + Faculty Requirements+ ABET Criteria=> Quality Program

Industry needs are established by surveys, face to face meetings, and continual monitoring of the course content and quality against their requirements. ***Faculty and academic requirements*** come from qualified and motivated faculty to create and deliver quality service to the students and to the industrial community. ***ABET criteria*** assist in the process by supplying third party standards.

INDUSTRY INPUT

Because of the emphasis on meeting industry needs with this new curriculum, input from manufacturing firms was sought from the outset. During the initial planning stages, a survey was created to find out what type of training they were looking for in potential employees. What level of degree (Certificate, Associates, Bachelors, etc.) was appropriate for most of their employees? What topics should be covered in this degree? Participants were asked to rank material as “essential”, “desirable”, or “not needed” from a list of topics. Selections included topics from mathematics, physics, computers, humanities, general manufacturing, general electronics, and electronics assembly. This survey was distributed and results obtained from a variety of electronics manufacturing companies: large, mid-size and small; national, regional and local. Results from the local companies were also compiled separately from the national fins, to indicated the local market for graduates.

The degree level that was selected as most appropriate was the associates degree. Out of the three choices, it received over half of all the votes. An even higher percentage of the local, mid- to small companies showed an interest in hiring associate graduates.

The topics listed as essential were very different than those found in traditional manufacturing or electronics technology curriculum. See Table 1 for a list of how some of the topics listed on the survey stacked up. (Please note that almost all of the electronics manufacturers in Indiana are involved in board level fabrication and assembly, and not integrated circuit fabrication. Obviously, some of the needs of IC manufacturers would be different.) These results showed a unique mix of skills required in electronics manufacturing. Neither an existing electrical engineering technology curriculum, nor a manufacturing engineering technology curriculum concentrating in metal working could meet these needs.

FOCUS GROUP

After compiling the survey results, members of the Indiana Electronics Manufacturers Association were brought together as a focus group to discuss the outcomes of the survey. The purpose was to further investigate the reasons behind some of the results.

First, the participants listed what skills they were looking for in employees and why. There was general support for the outcomes of the survey. Not surprisingly, given what many have said lately, communication skills and team work were very important [2, 3]. These are necessary because concurrent engineering and total quality management are an essential part of manufacturing today. Employees should start the job with a basic understanding of the electronics manufacturing process. They need the math, statistics, and computer skills to support quality control and reporting systems, and to use and maintain highly automated equipment. And they must have enough general manufacturing and electronics background to understand the use and limitations of the equipment and the product.

Second, the industry representatives discussed why an associates degree was most appropriate. People explained that they need skilled people to fill entry level positions. Because there are few or no schools teaching electronics manufacturing, there is a large amount of time and money spent on training employees before their performance can even be evaluated. If employers could find people with training, who have already been evaluated in some way (e.g. grades) it would save an enormous amount of resources. But, they want employees that are motivated to improve themselves - not to be stuck in a

TABLE 1: Subject Areas in Electronics Manufacturing

Subject Area	Voted Essential	Voted Not Essential	In Curriculum
Mathematics:	Algebra Statistics	Calculus	Algebra & Trig. Applied Statistics Differential Calculus
Physics:	Mechanics	Light, Sound	Mechanics Light, Sound
Computer:	Spreadsheets Word Processing	C Programming Fortran Programming	Spreadsheets C programming
Humanities:	English Composition Speech		English Composition Speech Human Relations
General Manufacturing:	Blueprint reading Drafting Estimated cost and Cost control Inventory control Statistical quality control	Multiview Drawing Metallurgy Robotics and Automated Material Handling Basic Machining Strengths of Materials	Elect.. Drafting Materials Eng. Mechanics Quality Techniques Industrial Organization
General Electronics:	DC& AC Circuits Analysis Logic Circuits	**	Digital Fundamentals Electrical Circuits Indus. Control Systems
PCB Fabrication:	Single sided PCB Double sided PCB Multilayer PCB	Hybrid	***
Solder Processes:	Materials Wave solder Reflow Surface Mount Technology		***
Manufacturing Test:	In-process inspection Assembly inspection	Automated inspection equipment	***
** There was a widely mixed response on the need for the study of microprocessors, relay controls, and programmable logic controllers.			
*** There are two Electronics Manufacturing processes courses which cover this material, and a project (capstone) course			

"dead-end" position. Therefore, whatever degree the employees come in with should not be terminal. The associates degree fits all those needs.

One of the most resounding themes (and interesting from an academic point of view) to come out of the focus group was the demand for "high quality" employees. This was defined by terms such as "dependable", "prompt", "responsible", and "self starting". Employers almost seemed more concerned that the people they hired showed up ready to work than with what skills they brought with them.

ACCREDITATION REQUIREMENTS

From the beginning, it was desired to have a program that could be accredited by TAC - ABET. This would help demonstrate the quality of the program and the graduates, as well as ensuring that the graduates would be able to pursue a bachelors degree.

ABET guidelines are strict as to the number of credit hours of math, science, and humanities. Technical science and technical specialty requirements also must be meet. These standards might restrict the time left to teach students the specific skills that industry needs. Few existing, accredited degree programs can be found that satisfy the needs of the electronics manufacturing industry. By developing new courses, and drawing on a mix of existing courses, ABET requirements and industry goals can be meet.

CURRICULUM: CIMT - ELECTRONICS MANUFACTURING OPTION

The survey results show that the electronics industry wants a graduate that can understand and perform certain functions. Generally, these requirements are partly electronics technology based and partly based on manufacturing and mechanical technology. To deliver this required mix of courses, traditional CIMT and EET courses are used, and new courses are being developed. A "cross disciplinary" curriculum will be created. The last column in TABLE 1 lists the courses included by general topic area.

Three new courses in electronics manufacturing are being developed. These are not design based courses, but fabrication based courses, concerned with producing electronic components and systems with the design as an input to the manufacturing process. CIMT and IET courses are being modified and mixed with EET courses to give the student skills and understanding that will make him/her productive in a manufacturing environment. This cross disciplinary requirement also results in the creation of two new courses relating to process and product quality. One quality course deals with the statistical and quantitative requirements of electronic manufacturing (Applied Statistics) and the other covers quality organization, documentation, and applications (Quality Techniques).

To mix faculty and existing courses together requires flexible faculty as well as understanding administration. Administration of academic departments are often based on degree programs, teaching loads, and other internal criteria, not industry needs. CIMT faculty and EET faculty must work together to satisfy the industrial customer's needs, not just offer traditional classes in traditional departments. For example, the faculty is creating the new courses with content different from what either department has offered in the past, blending ideas and concepts from both disciplines.

The best "fit" for this new associate degree program seemed to be as either a separate, new degree/department, as a different "track" within the CIMT program, or within the existing design based

EET program. Within the university structure in Indiana, all new degree programs have to be approved by not only the academic community within the university, but the Board of Higher Education, created by the state legislature. It may take 12 to 24 months of justification and approval effort to meet this external requirement. Long term, this program may be moved through this approval process. But short term, and for accreditation purposes, the program will be within an existing program. As the program matures and evolves, it is planned that it will stand alone as much as possible within the School and University structure.

First, the TAC - ABET guidelines for "electronics" were studied, since many companies will hire EET graduates and train them in manufacturing. However, after meeting all the specific requirements for electrical circuits, circuit analysis, microcontrollers, and controls, there is little room for any manufacturing topics. Then the guidelines for a "manufacturing" program were considered. These specifications spell out various general manufacturing requirements, but do leave room for specialized manufacturing topics and general electronics. Placing this degree within an existing CIMT program, but as a separate track from the traditional "metal cutting" course curriculum, becomes a good fit. Finally, the curriculum not only follows the ABET program criteria for manufacturing engineering technology programs, but also addresses many of the key components of the skill standards set by the American Electronics Association for a manufacturing specialist. [4]

CONCLUSIONS

In order to meet industry requirements, the graduate of an associates degree program in electronics manufacturing has to have skills and understanding from traditional EET, CIMT, IET, MET courses that are mixed in such a way to make the student/employee useful on the floor of an electronics manufacturing facility. The model equation is:

EET + CIMT + NEW COURSES => Electronics Manufacturing

The simple model equation requires administration flexibility, cross-functional faculty, large industry input of their requirements, and a structure that meets TAC - ABET criteria. Also, all components must be designed and implemented to yield a quality service delivered to the students and the employees. Simple equation, but difficult to implement!

By carefully selecting existing courses and creating new courses, the ABET criteria can be met. Although, TAC - ABET does look at existing and past graduates as well as surveying employers of the graduates, this electronics manufacturing program is based on ***continuous*** monitoring of industry requirements. This is an industrial customer driven program. Faculty, administration, state, and accreditation organizations must maintain continual focus on the outcome of a quality services that meet the industrial customer's needs. Or, as one involved faculty member stated, "The program should exceed ***and excite*** the customer's expectations ***not*** just meet academic or accreditation criteria!"

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