A Modular Approach To Semiconductor Curriculum Development

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It has been estimated that by the year 2000, the U.S. semiconductor manufacturing industry will need over 40,000 new workers (120,000 workers worldwide). Most of these workers will have earned a two-year technical degree from a community college or technical school. The unprecedented demand for degreed technicians in semiconductor manufacturing has caused competitors to join forces in assisting educators in developing their workforce. Through SEMATECH and SEMI/SEMATECH, the national consortia of semiconductor manufacturers and their suppliers, industry representatives are actively encouraging and helping community colleges convert existing electronics or industrial technology programs into Semiconductor Manufacturing Technician (SMT) programs. These new programs require knowledge, skills and abilities not found in most existing programs. As a result, educators are pressed to design and implement whole curricula seemingly overnight.

In response to the urgent need for curricula and materials, as well as faculty development opportunities, the Maricopa Advanced Technology Education Center (MATEC) has been established under sponsorship of the National Science Foundation to create and maintain a national resource center for developing, managing, evaluating, and distributing educational materials for SMT programs nationwide. These products are to be characterized by their balance of practical knowledge with mathematical and scientific understanding, relevancy to industry workforce needs, and adaptability under rapid technological change. To meet the challenge, MATEC is creating a curriculum development system that allows individual institutions opportunities to transition successfully from existing programs as well as service local industry partner needs. The key features of this system are: 1) the curriculum is modular in design and based on workplace competencies and, 2) it is delivered to faculty electronically with an accompanying electronic performance support system.

Competency-Based, Modular Curriculum

In 1995, the SEMATECH and SEMI/SEMATECH Technician Training Council outlined a recommended course of study for technical degrees in semiconductor manufacturing processes, and equipment or facilities maintenance. The three-tiered course of study includes a conceptual foundation in mathematics, chemistry and physics, a sound footing in the ability to work and communicate as a productive team member, and a technical core of skills in managing sophisticated manufacturing tools and processes. MATEC has adopted this curriculum and recommends it to its partner schools. However, the educational philosophies, available resources and approaches to pedagogy of our partner institutions vary considerably. MATEC's task is to respond to each of these institutions with appropriate and useable courseware and teaching materials.

To accomplish this task, MATEC has adopted a system to implement the technical core of the SEMATECH curriculum in a format that is modularized and competency based. The focus on competence allows MATEC to provide educational and industrial partners nationwide with an objective, replicable set of skills which learners should master prior to graduation. This skill set can be taught and assessed, despite pedagogical differences among participating institutions or the unique manner in which the SEMATECH curriculum is realized within any individual program.

Competencies are major skills or abilities needed to perform work-related tasks effectively. A competency-based curriculum identifies the competencies that the learner is expected to master, states clearly the criteria and conditions by which performance will be assessed, and defines the learning activities that will lead the learner to mastery. The objective of the learning activities is to provide the learner with the underlying knowledge, skills and attitudes which enable mastery of the competency. It is through the learning activities that foundational knowledge in science and mathematics is developed, and the attitudes and abilities of professional communication are practiced.

Using a standard DACUM process, MATEC has defined 135 technician competencies that cover a range of skills and abilities required of technicians in semiconductor manufacturing, including management of fabrication processes, equipment maintenance and troubleshooting, quality control, safety and contamination control. Each competency defines the content of a curriculum module. The focus on a modular design permits partner institutions access to discrete sets of learning activities in concentrated packets. These packets may be incorporated into existing courses to provide industry-relevant applications of theoretical principles, or clustered into units to create courses leading to a degree in Semiconductor Manufacturing Technology. Each module contains approximately three to five hours of instructional activity.

Electronic Delivery System

A MATEC module consists of background information, learning plans, and support resources to enable successful delivery of the learning activities by the instructor and mastery of the targeted competency by the learner. Because these modules contain the technical core of a rapidly evolving industry, it is critical that MATEC develop an equally nimble system for delivering them to the faculty. Traditional paper-based or conventional electronic delivery systems would prohibit rapid response to industry change. Therefore, MATEC is delivering the modules and their associated teaching materials to the faculty electronically, using a hybrid Internet/CD-ROM combination.

The delivery system is being developed using commercially-available applications (e.g., MacroMedia AuthorWare) and is available to subscriber institutions through the MATEC Internet Home Page (http://matec.org). The system is designed to be accessible by any computer platform using either a Netscape or Internet Explorer browser. Module "templates" contain background information, lesson plans, and resource materials, including laboratory activities, student handouts, a performance assessment task and scoring guide. In addition, the template provides references, a glossary and hyperlinks to related Internet sites. The templates are created

and controlled by MATEC to ensure that new course content materials may be rapidly deployed and existing materials can be revised rapidly in response to developments in the industry. It is anticipated that when the templates are fully functional, changes in the industry could be reflected in the curriculum in less than forty-eight (48) hours.

Although users may not alter the templates or change information contained in the modules, all materials are downloadable by the faculty or accessible from the CD-ROM. At present, the hybrid design of the system allows access to high bandwidth movies and graphics without consuming a great deal of download time. However, use of the CD-ROM format limits the rapid deployment of new materials or changes. As the capacity and speed of the Internet increase and high-speed connectivity to faculty offices becomes the norm, the system will become more reliant on the Internet.

Under advisement of Intel training specialists, MATEC is adopting the model of an Electronic Performance Support System (EPSS) to provide faculty development opportunities within the context of each curriculum module. An EPSS is "a system that provides users with the information, advice and learning experiences they need to get up to speed as quickly as possible, with the minimum of support from other people" (Barry Raybould, Ariel Performance Centered Systems, Inc.). It is designed to provide just-in-time training at the faculty's task site and in response to a need-to-know for task performance (e.g., the chemical properties of photoresist used in the manufacturing process). To ensure maximum benefit from the system, performance support is embedded within the AuthorWare template. Thus embedded within the module content, it is context sensitive to the user's situation.

Faculty have two performance support options. First, experienced faculty who are transitioning from electronics programs, need technical information. The Technical Advisor offers in-depth information from industry on recent developments in the science of semiconductor manufacturing. This information provides the faculty with the background information to successfully integrate new knowledge while preparing for class. The second option is the Teaching Associate. Because many colleges lack faculty for their SMT programs, industry is supplying content experts as adjunct faculty. While knowledgeable of the industry, these experts often lack teaching experience. The Teaching Associate offers advice on how to best teach the module in a college setting from fellow faculty at other colleges. Together the Associate and the Advisor support faculty performance in the classroom.

Evaluation of the MATEC modular curriculum project will be multifaceted. Initially, industry subject matter experts and experienced faculty will review the module content for completeness and accuracy. Teaching faculty will evaluate the module’s success in the classroom. Finally, a comprehensive usability study will provide the foundation for future developments in the electronic interface and delivery system.

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