AC 2003-1042: BUILDING A SEAMLESS LABORATORY CURRICULUM FOR UNIVERSITY AND COMMUNITY COLLEGE STUDENTS

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Building A Seamless Laboratory Curriculum for University and Community Colleges

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Abstract

The Arizona State University and community colleges across the State of Arizona have a history of collaboration that is acclaimed as a national model. However, Arizona State University East and its community college partners are working diligently to elevate their educational partnership to a new level beyond traditional articulation and the transfer of coursework. This paper describes a model curriculum development project designed to create a seamless microelectronics laboratory curriculum between local community colleges and Arizona State University East (ASUE).

INTRODUCTION

ASU East and Central Arizona College, Chandler Gilbert Community College, Maricopa Advanced Technology Education Center and Mesa Community College have been awarded a grant from the National Science Foundation * to develop a series of curriculum modules that will lead toward a seamless laboratory curriculum for lower division courses. The instructional materials developed will utilize the Microelectronics Teaching Factory (MTF) as the laboratory of choice, located on the ASUE campus. Community college instructors supported by industry mentors and university faculty instruct the community college students on tool operation/and maintenance, semiconductor process, and workplace effectiveness. The curriculum is modular in design, competency based and industry validated with the goal of producing work ready graduates. Six laboratory modules will be integrated into existing Semiconductor Manufacturing Technology (SMT) Degree offerings at the partner community colleges. Associate degree-seeking students enrolled at the community college travel to the MTF for a scheduled laboratory period and co-share the Microelectronics Teaching Factory with baccalaureate and masters degree-seeking students enrolled at ASU.

BACKGROUND

ASU East is a new campus of Arizona State University located in the city of Mesa, Arizona. It is at the former Williams Air Force Base in the southeast part of the Phoenix Metropolitan area; now known as the Williams Campus.

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The Williams Air Force Base conversion to a college campus has opened numerous opportunities to develop a unique partnership between two-year and four-year institutions. ASU and Maricopa Community Colleges both received substantial portions of the Williams facilities because of base closure. The wide range of high quality facilities that were made available made it possible to create a peerless coterie. [1]

ASU relocated the College of Technology and Applied Sciences and its programs, laboratories, faculty, and students to the new site and has rapidly evolved as the cornerstone of ASU East. Several new laboratories, including the Microelectronics Teaching Factory, have been constructed to accommodate the technology degree programs offered within the College of Technology and Applies Sciences.

Microelectronics Teaching Factory: Background, Rationale, and Benefits

Arizona continues to rank as one of the leading states in the number of workers employed in the semiconductor manufacturing industry. To meet these demands, semiconductor companies nationally and locally have launched an aggressive campaign to attract students into programs that prepare them for the future workforce. As a result, local semiconductor companies have sought to collaborate with the higher education institutions, such as their neighboring universities and community colleges, to implement this workforce initiative. The College of Technology and Applied Sciences (CTAS) at ASU East is leading the way by developing a state-of-the-art teaching factory in response to this high technology workforce need locally and nationally. A one-of-a-kind Microelectronics Teaching Factory has been developed in partnership with Intel, Motorola and other local partners in semiconductor industry. [2] The facility will provide a unique learning environment for the students from ASU East, ASU Main and community colleges statewide who represent the future semiconductor workforce.

A major dilemma facing technology programs is the expense of building and maintaining realistic lab facilities. Even in states with generous education resources, costs are making it ever harder to maintain Semiconductor Manufacturing Technology (SMT) programs and lab capability on multiple campuses. Arizona is typical in this regard. Three of the state's community colleges have well regarded SMT programs, but full-scale demonstration labs have been unaffordable. The absence of realistic lab training opens a steadily widening gap between the basic science and engineering taught in the academic world and the complex, expensive, and interactive technology used in the industry. By collaborating via the Teaching Factory, the partners in this project can begin to transform SMT education in Arizona into a truly integrated regional enterprise, one that takes advantage of the unique resources of each partnering institution.

Curriculum Development Goals

The MTF at ASU East is as a key element in the joint effort to develop a comprehensive and roust laboratory curriculum for both the community colleges and university. Student enrollment in Microelectronics and semiconductor manufacturing programs at the partner community colleges is currently in excess of 200 students. ASUE is in the phase of building the Microelectronics program and current enrollment is less than 75 students.

The curriculum being developed uses a hybrid model, consisting of materials and resources e-delivered via the web with a practical application requirement at the MTF to provide flexible schedules to the working student.

Six laboratory modules and their corresponding laboratory workbooks (LabEx) are being developed during the duration of the multi-year project funded by NSF. Two modules relating to the cleanroom operations and the oxidation process have been developed to date. These laboratory modules will be beta tested and evaluated in community college and ASUE courses during the fall semester, 2003.

Each module will focus on selected process areas within the Teaching Factory and will correspond with a community college or ASU East courses. The electronic workbooks contain lab preparation materials, learner oriented lab manuals, laboratory exercises, and assessment instruments for both degree levels. Electronic versions of the workbooks will be available to the community college and university faculty and students via the web as downloadable files housed on the ASUE web site.

A curriculum development team consisting of fifteen community college and university faculty utilize a standardized instructional development process template to produce the LabEx workbooks. The instructional design template provides the developers and editors a model for ease and consistency during each development phase.
The template contains:)

- Competency statements.
- Learning objectives.
- Prerequisite objectives.
- Lab setup procedures and materials.
- Lab summary.
- Lab goal and procedures.
- Special safety requirements.
- Performance assessments.

Each development team produces the LabEx manuals utilizing an on-line authoring system located on the ASUE Microelectronics Teaching Factory web site.

Curriculum Development Project Goals:

- ♦ Develop, pilot test, and refine six LabEx1 electronic workbooks for lower division courses for use in the Teaching Factory by associated degree-seeking students.

- ♦ Develop, pilot test and refine an additional six LabEx2 workbooks with emphasis on data analysis and interpretation (expanded from LabEx1) for use in the Teaching Factory by B.S.-degree-seeking students.

- ♦ Validate LabEx curriculum and the related Teaching Factory experience and its impact on early job performance in the semiconductor and microelectronics manufacturing workplace.

The term "electronic workbook" (EW) refers to a package of instructional material that is available to students online and will serve as a vehicle for self-paced learning activities. EWs produced for the Teaching Factory will have summaries and examples that facilitate understanding and retention of technical subject matter; practice on applying new knowledge to technical tasks and problems to promote skill development; and information that students need for reference purposes. There are several advantages of EWs that provide a strong return on investment (ROI) for improved learning and instructional efficiency. Table 1 below identifies "ROI Objectives" that can be achieved using EWs. [3] Table 2 identifies instructional strategies that will be leveraged by Teaching Factory EWs and the associated ROI objectives that each strategy will support.

The hands-on LabEx electronic workbooks are platformed on selected semiconductor manufacturing curriculum modules produced by the Maricopa Advanced Technology Education Center (MATEC). MATEC is a national center of excellence funded by the National Science Foundation (NSF). The MATEC modules were chosen as they represent the critical competencies taught by community colleges offering semiconductor manufacturing oriented degree programs nationally. The electronic workbook format provides a seamless integration of lab exercises between local community colleges and ASU East curriculums.

Table 1: EW ROI Objectives

ID	*ROI Objectives*	*Description*
A	*Learning Acceleration*	*<u>Increase</u>: Rate at which learners acquire new knowledge and skills that are applied to required job tasks*
B	*Training Automation*	*<u>Reduce</u>: Limitations associated with classroom-based activities and printed materials—travel to classroom, scheduled course hours, instructor fees, etc.*
C	*Access to Learning Events*	*<u>Increase</u>: Learners' opportunity to practice and build skills via 24-hour access to instructional exercises, reference materials, and learning vehicles (e.g., Internet)*
D	*Longevity and Breadth of Knowledge/Skills*	*<u>Extend</u>: Learners' retention and breadth of essential knowledge and skills by providing diverse exercises, problems to solve, and distributed team activities*

ID	ROI Objectives	Description
E	*Stability of Learning Designs*	*Expand: Methods for embedding learning facilitation within a single electronic delivery vehicle (EW)—ongoing improvement via emerging IT capabilities*
F	*Transfer of Knowledge/Skills*	*Increase: Readiness and ability of learners to immediately apply new knowledge and skills to operational tasks and job-related goals and objectives*

Table 2: EW Instructional Strategies Tied to ROI Objectives

Instructional Strategy	*IT/Learning Capability*	*ROI Objectives*
Simulation	*Produce robust representations of dynamic tasks and systems to increase understanding of complex technologies and work environments*	*A, B, C, D, F*
Hyperlinking	*Link words, concepts, and graphic objects together to produce a more meaningful and robust information structure*	*A, B, E*
Distributed Learning Events	*Employ networks and software capabilities to distribute learning events and communications with peers and faculty across the learning system*	*B, C, D*
Abstract-Concrete Pairing	*Combine verbal, symbolic, and other abstract representations of to-be-learned content with concrete representations and real-world examples*	*A, B, F*
Multi-Modal Presentation	*Increase volume and speed of learners' information processing by simultaneously presenting information in at least two perceptual modes*	*A, B, E, F*

The Learning Model

The pedagogical model of the Teaching Factory project is ***integrated learning*****,** where the students prepare by learning principles of semiconductor processing and practice those processes on actual tools. In contrast, the classical academic model starts with basic science and may (if there is time) briefly cover a few practical applications. In the Teaching Factory, practical applications are not optional. Our partnership aims to graduate technicians soundly prepared in technology principles, work habits, and tool and process skills that they can contribute to a company's bottom line on the day they are hired.

Challenges

A major challenge confronting the community college faculty as they seek to utilize the MTF is the lack of experience and knowledge of semiconductor manufacturing and related technology. Professional development for the faculty is crucial to the long-term success of the partnership. There is a big difference between teaching classroom courses and performing practical demonstrations with real tools. To help manage the transition, to the community college faculty, a broad range of faculty development activities are provided at ASU East. Faculty development venues such as short courses, web-based information, and mentoring from many sources provided routinely by ASU East faculty and industry personnel.

Conclusions

We at ASU East believe that our successes in partnering with our community colleges statewide can serve as a national model for other universities throughout the country. This project will pave the way for creating a "Seamless Curriculum" resulting in an integrated regional workforce development effort for students majoring in semiconductor technology at the A.A.S. and B.S. degree levels. The multifaceted project comprises curriculum and materials development, faculty development, and technical experiences for students. The goal is to educate more and better-prepared technologists to answer the persistent workforce needs of the region's semiconductor industry. The strategy is to consolidate in a single world-class facility known as the ***Microelectronics Teaching Factory*** the hands-on laboratory instruction for all semiconductor students from multiple campuses throughout the region.

Through this project, the partners will develop curriculum and electronic educational materials for use in the Teaching Factory (six units of ***LabEx1*** for A.A.S. degree level and eight units of ***LabEx2*** for B. S. degree level); develop the content knowledge and technical skills of faculty; and provide state-of-the-art technical experiences and workforce preparation for students.

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Biographical Sketch
Richard L. Newman

Richard L. Newman joined Arizona State University East (ASUE) in August of 2001 and currently serves as Director of Training Operations for the Microelectronics Teaching Factory. In this position Mr. Newman is responsible for the identification, development and delivery of education and training for the semiconductor manufacturing industry. Prior to joining Arizona State University, Richard served twenty years as a faculty member and administrator within the Division of Technology and Applied Sciences at Arizona Western College and the University of Arizona. He most recently held the position of Associate Director at the Maricopa Advanced Technology Education Center (MATEC). MATEC is a national center of excellence funded by the National Science Foundation (NSF) that focuses on workforce development for the semiconductor manufacturing industry. As the associate Director Richard served as the semiconductor industry liaison and assisted in the development of a national workforce development model in collaboration with SEMETECH, Semiconductor Industry Association (SIA) and member companies. Mr. Newman has been actively involved in curriculum and program development for Technology and Applied science programs since 1980.

Lakshmi Munukutla received her Ph.D. degree in Solid State Physics from Ohio University, Athens, Ohio and M.Sc and B.Sc degrees from Andhra University, India. L.V. Munukutla developed an interest in semiconductor device processing technology and characterization while she was working at Motorola Inc. She has been active in research and published several journal articles. She holds an Associate Dean position in the College of Technology and Applied Sciences at Arizona State University East.

John Robertson is a professor in the Department of Electronic and Computer Technology at ASU's East campus in Mesa, Arizona. From 1993 to 2001, he held a number of senior R & D positions in Motorola's Semiconductor Products Sector. His earlier academic experience was as Lothian Professor of Microelectronics in Edinburgh University, UK where he managed a national research center and developed continuing interests in process control and the global economics of semiconductor technology.

Jon Weihmeir is currently a visiting professor at ASU's east campus from Motorola's Semiconductor Products Sector. He joined Motorola in 1984 as a wafer fabrication engineer and worked in R & D as well as production facilities, focusing on diffusion, wafer cleaning, and gate oxide integrity. From 1996 through 2002, he held management positions in process engineering, device engineering, and manufacturing at Motorola in Mesa, Arizona. Jon received the B.S. and M.S. degrees in Electrical Engineering from the University of Illinois and National Technological University respectively.