ASSESSING THE IMPACT OF CONTINUING ENGINEERING EDUCATION

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I. INTRODUCTION

Continuing education is critical for engineers and the organizations that employ them (Gomes, Houche-Mong, Houche-Mong and Wakelin, 199 1; Wolff, 1993). However, findings on the impact of continuing engineering education are mixed. Social Research Inc. (1969)4 examined characteristics of engineers laid off by a major corporation. The common denominator was that none had taken part in continuing education during the preceding six years. Klus and Jones (1975)4 found a direct statistical relationship between individual engineers' salaries and their participation in continuing education. Dalton and Thompson (1971) however, found no relationship between performance ratings of engineers and participation in continuing education. The limited research on the impact of continuing education contributes to the confusion.

Current trends in continuing education are encouraging more attention to this area of inquiry. Potential participants and sponsoring employers are asking for proof of value for their time and monetary investment. The National Alliance for Photonics Education in Manufacturing's (NAPEM) mission is to enhance the national training effort by providing regionally-based educational programs focused on applying photonics to commercial applications. Only by assessing the impact of its educational programs can NAPEM determine if and how its continuing education offerings enable engineers to be more effective. Table 1 identifies NAPEM members.

Table 1: Alliance Members and Manufacturing Areas Served

Alliance Members	**Manufacturing Area**
University of Central Florida	Dual-use & End-to-end System Testing
Industrial Technology Institute (Michigan)	Optical Metrology and Durable Goods
University of Connecticut	Laser Materials Processing
The University of Texas at Austin	Semiconductor
The International Society for Optical Engineering (SPIE)	

(NAPEM is partially funded through a federal Technology Reinvestment Project grant.)

Additionally, each regional program recruits a Curriculum Advisory Board. NAPEM unites the strengths of a professional society, educators, engineering managers, engineers, and human resource personnel in designing, implementing, and evaluating experimental continuing education programs. This paper focuses on assessing the impact of NAPEM's regional pilot programs for the semiconductor, and dual-use and end-to-end systems testing industries. (These programs piloted before the other regional NAPEM.)

II. NEEDS ASSESSMENT

-- A 1992 IEEE survey (Wolff, 1993) revealed that engineers perceived the number two challenge to the profession to be finding effective ways to keep up-to-date. The number one challenge was automation along with the technology and new products needed for managing information. Photonics influences these challenges. In semiconductor manufacturing photonics is prevalent in diagnostics, yield and reliability analysis; device and process technology; and microlithography and patterning. In dual-use manufacturing, photonics enables machines to perform at higher "reasoning" levels. In system testing, photonics enhances imaging and measurement.

NAPEM's regional suborganizations involve SPIE, the university partner, and a Curriculum Advisory Board (CAB). Each CAB offers specific advice on local needs. Table 2 identifies organizations represented on the regional CABS. During regional company visits, NAPEM members facilitated focus group sessions to gain additional information about educational needs. This data was shared with the CABS.

Table 2: Organizations Participating in CABS

Semiconductor (Southwest Region -- The University of Texas at Austin's Microelectronic Research Center)			
Advanced Micro Devices	E-Systems	IBM	MCC
Private Industry Council	Sematech	Tracer	Texas Instruments
Dual-use Manufacturing & End-to-End System Testing (Southeast Region -- University of Central Florida)			
Lightening Optics	Litton Laser Systems	Lockheed Martin	Westinghouse
Schwatz Electro-Optics			

III. EVALUATION STRATEGIES

A count of attendees and cumulative classroom hours are common continuing education measures. However, these numbers do@ help NAPEM or its industry partners assess if NAPEM is moving toward its vision. NAPEM chose a two-tiered evaluation strategy: end-of-course evaluations and follow up with participants four months after the courses. The first tier utilized the International Association for Continuing Education and Training's end-of-course evaluation instrument. It was anticipated that the evaluation item "The content of this presentation will be useful in my work." would help assess if participants anticipated applying the course information back on the job. To facilitate participants' thinking of transfer, the following item was added; "On the job, one way in which I plan to apply the information discussed during this short course is: _____." The second tier involved a follow up survey four months after the courses. Follow up phone calls were made to those who did not responded to the survey within three weeks.

IV. ASSESSING POTENTIAL IMPACT DURING THE PILOT PROGRAMS

A. Pilot Semiconductor Manufacturing Continuing Education Program

Thirteen courses were piloted. Two were half day courses and the other eleven were fill day. Enrollment ranged from a high of 40 to a low of three. Two hundred and twenty-seven incidence of short course attendance occurred. Thirty companies sponsored attendees. The average attendee had been an

engineer for more than five years and held a graduate degree. Three displaced workers participated. Table 3 identifies the courses and displays the averaged respondents' perceived usefulness of the course content.

Table 3 Semiconductor Pilot Program Short Courses

Course Title	**Participant Rating (5pt scale)***
Lithography for Manufacturing	4.47
Survey of Optoelectronic Devices*	*
Optoelectronic Interconnects & Packaging	*
Optical Diagnostic Techniques for Plasma Processing	4.38
Optical Methods for Passive Monitoring of Bulk& Surface Properties	*
Formation of Scaled Oxides& Junctions for Deep Submicron	4.13
Semiconductor Material & Device Characterization Issues	4.29
Plastic IC Packaging: Assembly& Reliability Issues	4.29
Silicon Defect Engineering Science & Technology	4.33
Advanced Silicon Wafer Cleaning	4.50
New Failure Mechanisms in Submicron Semiconductor Devices	4.07
Process Integration Issues in Microelectronic Manufacturing	3.77
Reliability & Manufacturing Issues of ULSI Devices*	3.82

* No rating listed because less than 5 evaluations were returned.

B. Pilot Dual-use Manufacturing and End-to-End Testing Continuing Education Program

Twelve courses were piloted; eleven were half day courses and one was a full day. Two hundred and twenty six incidence of course attendance occurred. Table 4 identifies the courses and displays the averaged respondents' rating of the perceived usefulness of the course content,

Table 4: Dual-use Manufacturing and End-to-End Testing Pilot Program Short Courses

Course Title	**Participant Rating (5pt scale)**
Basic Optics for Engineers	3.97
Manufacturing Materials for Infared Optical Systems	4.54
Solving Industrial Problems with IR Imaging	4.63
Active Thermography for Manufacturing and Process Control	4.34
Advanced Applications of GPS	3.81
Fundamental Factors Affecting Image Quality	4.20
Testing and Evaluation of E-O Imaging Systems	4.47
Information Display System Testing	4.24
Optical System Testing	4.29
IR Detector and Focal Plane Testing	4.18
Focal Plane Electronics Testing	4.00
Steps Required to Produce High-Quality Embedded Software Systems	3.73

V. ASSESSING IMPACT THROUGH FOLLOW-UP

Four months after the courses, a follow up survey (Figure 2) was sent to participants who lived in the United States. Reminder phone calls were made to attendees who did not responded within a month. Of the 115 Semiconductor Manufacturing participants who were sent surveys, 32 responded (28'%.). Of the 189 Dual-use Manufacturing and End-to-End Testing participants, 51 responded (270/0).

Figure 2: Follow Up Survey

- What have you done differently at work as a result of participating in the short course?
- What additional information have you sought as a result of the short course?
- Did you share what you learned at the short course with others who then applied the knowledge in the workplace?

The follow up surveys provided information on how participants applied what they had learned in the short courses back on their jobs. Figure 3 shows a sample of the data for one course.

Figure 3: Follow Up Data for the Optical Diagnostic Techniques in Plasma Processing Course

- I ordered 25 copies of Gary Selwyn's book. I plan to incorporate some of his ideas into the etch course I teach to maintenance and process engineers. (from a senior engineer)
- I look at particles differently. It helped with the thinking needed for a particle monitoring system project I am working on. Also, I have an endpoint project coming up; I will refer back to the course materials for that project. (from an entry level engineer)
- I will start a job with Intel next week. The courses made a difference during my interview. I could identify the terms being used and explain my transferable skills on a basic level. (from a displaced worker)

Respondents from both groups gave examples of

- modifying equipment
- running experiments based on information from the course
- more effectively interacting with customers
- teaching the information to others.

Additionally, over half the respondents (55?4.) reported sharing course information with others. Eight percent reported that they had not done anything differently at work as a result of participating in the short courses. Their reasons included a lab shut down, a job change, and a course being more of a review than new information. Respondents also used the follow-up survey to provided critical feedback. One requested a more advanced course for the following year. Another expressed frustration with the sparseness of a specific set of course notes -- the notes were difficult to use as reference material. This constructive feedback was valuable for planning subsequent course offerings and providing instructor feedback. Additionally, one engineer highlighted a weakness of NAPEM's approach to assessing the impact of the courses.

Despite the fact that I will not be able to directly apply the information learned in this short course to my current work, I found the-course very informative and worth the time and money invested. I will recommend the course to others in our engineering group as a good forum for addressing future issues that we will ultimately face. Perhaps the most important message carried from the class was the changes in processes and equipment that will be required in the future.

VI. CONCLUSIONS

NAPEM's continuing engineering education offerings were based on a model of partnering with industry, assessing needs, following up with participants, and continuously improve educational offerings. If these activities are effective, then engineers may be more effective on the job. While continuing education alone cannot guarantee improved performance, continuing educators who do not gain post-course feedback miss an opportunity to critically examine and improve upon their course offerings.

Areas for further research includes examining 1) the relationship between individual engineers' salaries and their participation in continuing education, 2) the corporate systems surrounding continuing engineering education and 3) correlations between companies technical ranking, market share, and investment in continuing education of engineers.

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For more information on NAPEM Continuing Education Programs for Manufacturing Engineers, contact Susan Anderson at (800) 483-9034.