"Development and Delivery of an Industry Course in Electronics and Electronics Manufacturing"

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Abstract:

The Electrical Engineering Technology Department at Indiana University Purdue University Indianapolis has developed and presented “Fundamentals of Electronics Manufacturing” for a local electronics manufacturing firm. The course was developed to be presented either on-site or on campus, where it would be offered as a "learning communities" introductory course. The course is being offered for its second year at the company’s site, and has targeted a wide variety of employees with little or no previous technical training, including sales and marketing personnel, account managers, and assembly group leaders. Topics include basic electronics, PCB layout and fabrication, and electronics assembly. Each lesson is accompanied by a hands-on laboratory experience in the classroom or on the production floor. The laboratory sessions cover topics such as basic electrical measurement techniques, printed circuit board design, and hands-on manufacture and assembly of a functional, mixed technology circuit board.

The course allows faculty to interact with the design and manufacturing engineers, allowing faculty to keep abreast of state-of-the-art developments in electronics manufacturing and printed circuit board fabrication. The relationship between the local manufacturer and the faculty also leads to increased opportunities for students to tour the facility, and increased employment opportunities.

Funding for development and delivery will be addressed, as well as methods to determine local demand for industry training, and the necessity of a team to cover the breadth of topics. The contrast between college lecture preparation and the development of an industry specific course and differences in facilities and students will also be covered.

The Electrical Engineering Technology department at Indiana University Purdue University Indianapolis worked together with Diversified Systems, Inc., an Indianapolis electronics manufacturing firm, to develop and present a course entitled “Fundamentals of Electronics Manufacturing”.

I. Course Content

The course is structured to be offered as a nine week course at the manufacturer's site or as an on-campus course. The class consists of lecture with hands-on laboratories. The syllabus is as follows:

week	*topic*	*lab*
1	Introduction, components, basic electricity	using multimeters
2	Basic electricity, DC circuits	measure V, I, R, Ohm's law
3	AC circuits	using o-scopes, measuring AC voltage
4	Digital circuits	digital I/O, troubleshooting
5	PCB Layout software	PCB layout (Microsim)
6	PCB fabrication	tour of PCB fab plant
7	SMT and Through-Hole assembly	
8		build a functional assembly
9	Test, Inspection, other issues	tour: test, inspection areas

As the syllabus shows, approximately half of the course deals with electrical fundamentals, touching briefly on components and their properties. The other half of the course deals with all aspects of electronics manufacturing, from printed circuit board (PCB) layout and fabrication through building the final product. Each week begins with a quiz over the previous lesson material.

The first part of the course covers material normally covered over the course of a two year degree, so most of the material is covered at a very broad level. The first four weeks consist of two hours of lecture and one hour of laboratory. The lecture notes are handed out to the students, who gradually build a course notebook. The strength of this part of the course is in the hands-on laboratory experiments. Students that have typically never used a meter are initially introduced to the multimeter, using it to measure the voltage from a power supply and resistance of a handful of resistors. Other labs involve measuring voltages and currents on two circuit boards that were designed by IUPUI and manufactured by Diversified. The first board has combinations of resistors in series and parallel with switches controlling the configuration of the resistors. The board layout is such that the resistors appear in series and parallel to help the students see the relationship. This board also has jumpers that can be removed to let the students measure current. A second circuit has an operational amplifier and potentiometers that are used to measure AC voltages and the gain of the op-amp circuit. The second circuit board is a digital board with three inputs and ten outputs that are different combinations of the inputs. The board has AND and OR gates to build the different combinations. This laboratory experiment leads students through predicting the output of different input combinations and some basic troubleshooting techniques. Diversified has established a training room for the course with computers, power supplies, and multimeters at each station, and a combination of

full size and hand held oscilloscopes.

Starting in week 4, the course changes from electricity and electronics to electronics manufacturing principles. Two weeks are spent on PCB layout and manufacturing. Students use the evaluation version of Microsim layout software to modify a circuit board layout, then tour Diversified's PCB manufacturing facility. The PCB manufacturing facility is one of the benefits to conducting this training on-site, specifically at Diversified. Most electronics manufacturing facilities are involved in electronics assembly manufacturing rather than circuit board manufacturing, but Diversified has both capabilities.

The final four weeks involve electronics assembly, cleaning, test, and inspection. Again, on-site courses offer the opportunity to use actual manufacturing facilities to conduct training. Two of the weeks dedicated to assembly are structured such that one entire week is dedicated to lecture, while one week is a laboratory session. In this laboratory session, students actually build functional assemblies, using state-of-the-art through hole and surface mount assembly equipment. Each student will run this equipment, as well as place and solder individual components. The circuit boards and components are supplied by Diversified.

II Offering the Course:

The course was developed in the Spring of 1997, and was offered for the first time in June of 1997. At the time of writing this paper, the fifth presentation of this course has just finished at Diversified. Typical class size is 18 students. All new hires at Diversified are encouraged or required to take the course, including those in sales and purchasing who typically have little or no technical training, but deal with customers with technical concerns. Employees who work in one very focused area will also take the course to give them a broad exposure to all aspects of electronics manufacturing.

This course is offered for two credits when on-site at Diversified, and is structured such that it could be offered on campus by combining it with a "learning community" course (an introduction course for some Freshman students) for three credits. The course has not been offered on campus at this time. Offering the course for credit may have the added benefit of introducing potential students to the EET program. There were 18 students that successfully completed the course the last time, and of these, one was currently enrolled within the University and two additional students applied for admission and enrolled for courses the following semester.

There are a number of private training facilities that can customize training, but there are many advantages of the current arrangement. Advantages for the University include not only the extra revenue, but also the opportunity for faculty to gain experience and keep up to date on the latest in electronics manufacturing technology by interacting with the employees at the manufacturing facility. The University could also see additional students and gain additional exposure within the community. The EET department at IUPUI and Diversified Systems are both members of industry groups such as the Indiana Electronics Manufacturers Association (IEMA), where word can be spread about the program.

Local industry not only benefits by the less expensive training costs, but also by the fact that students are taking the class for University credit. They also have the benefit of having qualified instructors teaching the first half of the class, an area where a private training company may or may not choose to concentrate on when developing a course.

The main drawback to offering a course like this is that the tremendous demand, and the resources currently do not exist for the EET department to offer the course at other sites or with the frequency that Diversified would prefer. Two concurrent classes have been offered, but were very difficult to successfully accomplish. Current plans are to offer the class once per semester. Of course, the main drawback to offering such a course on campus would be the difficulty in scheduling tours and demonstrations at a manufacturing site. To help alleviate this concern, the EET department, the Manufacturing Technology Department, and other cooperating industry partners are in the process of establishing an electronics manufacturing laboratory. There are no such plans to implement the PCB manufacturing operation on campus due to the expense and the concerns in dealing with the chemicals necessary to manufacture these boards.

Other sites have expressed interest in offering this course on site for their employees, however, this has not been done at this point. Most manufacturing firms do not have the PCB manufacturing capability that Diversified offers, and the department does not have the resources available to offer this course many times per semester.

II Recommendations for starting a cooperative training program:

The secret for departments wishing to start developing and presenting industry specific training is the same as starting any new project - sufficient planning. Once the need for specific training has been established and one industrial partner has been identified, the department should establish a pricing policy, which includes necessary support for personnel involved, as well as supplies, duplicating, components, etc. The initial cost of the course may have an additional component for development time.

Curriculum development should include a team of involved faculty with input from the industrial partner. Allow sufficient time for development, and search for other Universities that may be involved in your area of training.

After adequate preparation, offer the course one time with the understanding that this is a prototype and may need to be modified during the course. Again, allow sufficient time before offering the course again to refine the curriculum. The course described here went through approximately one semester of development time; however, a good deal of material had been developed for a current course in Electronics Manufacturing and through different summer programs.

The instructors must be sensitive to the diverse group of students that will take the course. The students ranged from those with technical degrees to those without high school diplomas. Some students will feel that their job evaluation will depend on their performance in the class, and are quite apprehensive about taking the class. The course instructors or qualified employees at the

site should offer additional help outside of the class if at all possible. This helped students feel more confident about the class.

Above all, be sure that there is an excellent communication flow between the University and industrial partner.

IV Statement from the Industrial partner, Diversified Systems, Inc. (*dsi*)

The training coordinator from Diversified systems describes the benefits of the arrangements as seen by Diversified:

"FUNDAMENTALS OF ELECTRONIC MANUFACTURING"
***A dsi and* I.U.P.U.I. College Accredited Course**

Diversified Systems, Inc. (***dsi***) came to the realization that while not every facet of a job requires an engineering degree, many customers require someone with a basic understanding of electronics to effectively communicate and offer alternatives during the quoting or production assembly process.

Together with Indiana University Purdue University Indianapolis (IUPUI), ***dsi*** has created a college credit course entitled the "*Fundamentals of Electronic Manufacturing* ."
dsi invested in an 18-seat training room complete with computers, schematic capture layout software and various lab equipment such as multimeters, ohmmeters, DC power supplies and oscilloscopes. The goal was to provide a course that described the complete electronic process, from circuit design through manufacturing of a marketable product.

Starting in June of 1997, 9-week sessions were offered to ***dsi*** employees as an on-site college accredited course. ***dsi*** worked closely with Kenneth Reid, Elaine Cooney, (Director of Electronics Manufacturing Associate Degree Program), and Patricia Scott from Electrical Engineering Technology, IUPUI to create together a curriculum that encompassed both textbook electronic information and standard manufacturing practices used at ***dsi.***

To date, 5 course sessions have been held with ***dsi*** employees from all segments of the operation, specifically those with direct customer contact such as outside sales, project and account managers, purchasing, and rapid prototyping personnel. The course is available to all levels of production employees with a desire to learn more and be more effective in their daily activities.

dsi has seen the benefits of sponsoring an accredited college course in many ways. Customers interfacing with sales and project managers are assured of a basic level of understanding of the processes required to produce their products. And internally a team of trained individuals supports the production activities. Many individuals who were knowledgeable of only part of the process are now cross-functionally aware of the processes outside their daily activity.

Employees who can understand and advance the total process allows ***dsi*** to satisfy customer needs and contribute value-added suggestions for cost reductions, design enhancements or assembly alternatives.

V. Conclusion:

Teaming with industry to offer training benefits both the University and industry in a number of ways. The University gains exposure to current technology for its faculty, and potentially gains students and revenue. The industry partner gets excellent training with a smaller investment than expected, and has the additional marketing tool of a staff trained by University professors.

Establishing this relationship can be relatively straightforward, once the partner is identified, but there must be a clear understanding of responsibility of all parties. Finally, for a successful implementation, there must be adequate time allowed for preparation and refinement of the material.

Once a program is established, other areas of training can be explored. The EET department is currently establishing an on campus training facility with Electronic Training Advantage (ETA), another industry partner, for training to industrial manufacturing specifications, and is preparing to offer the Fundamentals of Electronics Manufacturing for a sixth time.

KENNETH J. REID

Kenneth Reid is an Assistant Professor of Electrical Engineering Technology for the Purdue School of Engineering and Technology at Indiana University Purdue University Indianapolis (IUPUI). He has over ten years of experience in electronics manufacturing research, and works with area industry in electronics manufacturing education. He received a B.S. degree in Computer and Electrical Engineering from Purdue University in 1988 and an M.S. degree in Electrical Engineering from Rose-Hulman Institute of Technology in 1994. His concentration is in Electronics Manufacturing and Digital Electronics.

ELAINE M. COONEY

Elaine M. Cooney is an Associate Professor of Electrical Engineering Technology and Director of Electronics Manufacturing Associate Degree Program in the Purdue School of Engineering and Technology at Indiana University Purdue University Indianapolis. She received her undergraduate degree in Electrical Engineering from GMI Engineering and Management Institute in Flint, Michigan and her MSEE from Purdue University in West Lafayette, Indiana. She has worked for Delco Electronics in Kokomo, IN and ICFAR in Indianapolis before her recent internship with UMM Electronics. She has been on the IUPUI faculty the since 1987. She is currently the chair of the Women in Engineering Division of ASEE. Her interests include electronics manufacturing, analog electronics, and electronic communications.