Interdisciplinary Teams Involved in Industry Projects through a Concurrent Engineering Course

Dr. Pedro Resto

Abstract

This paper describes the experiences in a Concurrent Engineering undergraduate course at the Mayagüez Campus of the University of Puerto Rico, which provides students an opportunity for interdisciplinary project activities. The course has involved students from Industrial, Mechanical, Electrical, and Chemical Engineering as well as Business School students from Marketing and Industrial Management. This paper describes the processes that have been developed to promote, execute, and achieve success in the student projects. Two example projects are discussed in detail to provide a flavor of the experience the students are exposed to.

Introduction

Manufacturing in Puerto Rico is responsible for over forty percent of the island's economy. The School of Engineering of the University of Puerto Rico at Mayagüez (UPRM) is by far the main provider of engineers and eventual managers, especially for technology-related businesses. Undergraduate engineering students have been historically active in courses which require projects, within their specialty areas, to be worked in local companies. For example, Industrial Engineering students are required to work on industry projects in at least four courses (Work System Design, Work Measurement, Facility Design and Layout Planning, and the Senior Design Project) [1].

This strong university-industry interaction is made possible by the large number of companies and their proximity to UPRM. Out of 1448 manufacturing companies located in Puerto Rico, 191 (or 13.2 percent) of them are within 30 miles and 177 more (12.2 percent) are within 60 miles from Mayagüez, as shown in Figure 1 (the location of cities and towns within the 30 mile range are identified in magenta while those within the 60 mile range are labeled in bright green).

The next section describes the basic planning activities for every new semester with insight into the team formation strategies. Afterwards, the practices followed as the semester progresses are described. These include team meeting activity and documentation, progress review, and team evaluation tools. The Concurrent Engineering course adds a new dimension to the undergraduate student experience; namely, the opportunity to participate in an interdisciplinary activity in which each specialist shares his tools and skills in dealing with a product and process development challenge following the concurrent engineering model [2,3,4]. The course is also in accord with ABET requirements on interdisciplinary experience [5].

Two example projects from the Fall '02 semester are presented to highlight project contribution, the interdisciplinary effort, and the specific product and process challenges addressed. The paper then ends with a discussion of the project challenges envisioned for the near and some conclusions regarding the interdisciplinary experience.

Figure 1. Puerto Rico's Roadmap and UPRM Location

Planning for a New Semester

Historically, two key ingredients have facilitated the intensive industry project activity: (1) the benefits companies receive from each project at minimal or no cost and (2) the motivation of former UPRM students (working at the plants) to serve as coach to current students. The ongoing interaction with industrial partners simplifies the task of searching for project opportunities for the course. The Concurrent Engineering course is also advertised during professional meetings. For example, in the second half of 2002, the author attended the July meeting of the Puerto Rico Manufacturer's Association (PRMA) western chapter and a two-day Plastics Symposium held in October at Mayagüez to promote the course activities.

The material used to describe the subject (concurrent engineering) starts with a simple definition: a simultaneous approach to product and process design in response to customer needs, and the benefits of concurrent over sequential design in time to market, as illustrated in Figure 2. Critical for project success is the involvement of three key players in the semester activity: the interdisciplinary team, the course instructor, and the industrial partner. Each key player has specific responsibilities, as described in Table 1.

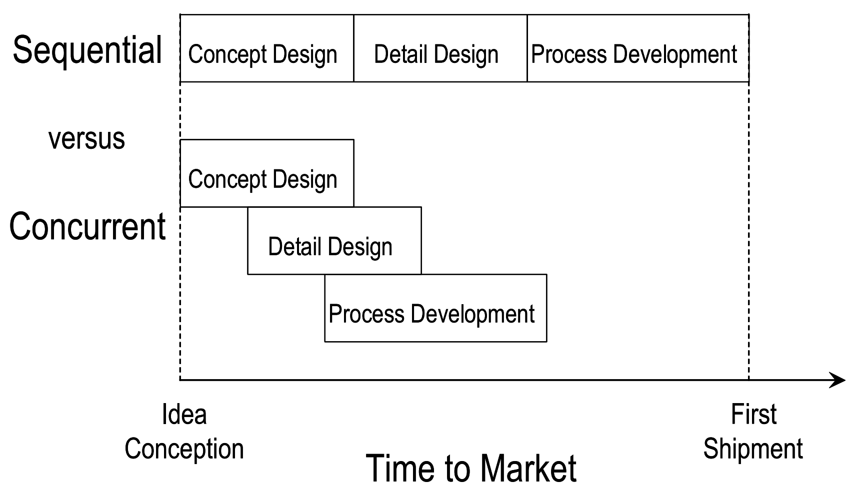


Figure 2. Concurrent Engineering Model Described

Table 1. Key Player Responsibilities for Project Success

Industrial Partner
1. Have a real new product development challenge (i.e. the motivation for the project is not to "help" UPRM)
2. Assign a project lead who will work with the team
3. (The project lead will) maintain good communication with the instructor, especially when unsatisfied with the team execution
4. Provide easy access for team members to the plant (i.e. ID badges)

Course Instructor
1. Form team with needed (interdisciplinary) resources
2. Avoid schedule conflicts so that team members can work together
3. Provide coaching on needed tools to achieve the desired results
4. Monitor progress interacting with the team and the project lead

Interdisciplinary Team
1. Develop product and process
2. Assess customer needs if data/information not available
3. Visit the plant regularly to work close to the project lead
4. Prepare progress and final reports and poster/presentations

Another aspect discussed with interested industrial partners is the contribution expected from the participating students and areas of common activity. Table 2 suggests contributions from the six specialty areas that have participated in the Concurrent Engineering course, connecting with lines those activities in which various specialists can focus on joint efforts.

Table 2. Possible Student Contribution by Specialty Area

Industrial Engineer: 1. Line pace and layout 2. Product cost and profit analysis 3. Process quality/product test strategy	**Mechanical Engineer:** 1. Mechanical design: component selection and measurement 2. Line pace and layout 3. Equipment uptime issues
Electrical Engineer: 1. Electrical design: component selection and measurement 2. Product test strategy	**Marketing:** 1. Customer needs assessment 2. Feasibility analysis
Chemical Engineer: 1. Chemical design: component selection and measurement 2. Product test strategy	**Industrial Management:** 1. Product cost and profit analysis 2. Feasibility analysis

Each Engineering discipline has defined a prerequisite for the Concurrent Engineering course; namely, Heat Transfer Operations for Chemical Engineering, Microprocessors for Electrical Engineering, Work System Design for Industrial Engineering, and Analysis of Machine Elements I for Mechanical Engineering. The course is also available to Business students from Marketing and Industrial Management in their Senior year.

In this initial year developing the interdisciplinary team activity (in support of the concurrent engineering course), the lessons learned at the planning stage are: (1) the instructor's need to invest time recruiting students outside his department (the author is in Industrial Engineering, so he has spent time promoting the course in other Engineering and Business departments); (2) the importance of bringing into the class students close to graduation, who are better prepared for the challenge; and (3) the importance of working with industrial partners only if they have a real product development need and are willing to assign a resource who will serve a project leader.

Project Execution

The instructor needs to have the semester projects defined before the first class meeting to be able to create the interdisciplinary teams as quickly as possible. During the first class meeting the instructor collects the students weekly schedule. The immediate challenge is to form each team with the required expertise for each project and a common free period so that all members can travel to their plant on a regular (e.g. weekly) basis. Team member attendance to the plant can be documented to keep track of team member involvement. Figure 3 shows a one-page format used during the Fall '02 semester.

Concurrent E… …ring - Fall '02

DEPT | ID # | NAME | PROJECT | MEETING DATE

Sanz Tropical Manufacturing

DEPT	ID #	NAME	Mon 1:00pm	8/26	8/29	9/5	9/15	9/16	9/30	10/07	10/14	10/21	11/04	11/18	
InIn			Sanz	✓	✓	✓	✓	abs	abs	✓	✓	✓	✓	abs	
InMe			Sanz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Mkt			Sanz	✓	✓	✓	✓	✓	exc	✓	✓	abs	✓	✓	

GE Thermometrics

DEPT	ID #	NAME	Tue 9:30am	8/27	8/30	9/3	9/10	9/26	10/01	10/7-8	10/15	11/14			
InIn			GE Therm	✓	✓	✓	✓	✓	✓	✓	✓	✓			
InMe			GE Therm	✓	✓	✓	✓	✓	✓	✓	✓	exc.			
InMe			GE Therm	✓	✓	✓	✓	✓	✓	exc.	✓	exc.			

Smart Modular Technologies

DEPT	ID #	NAME	Wed 3:30pm	8/28	8/29	9/4	9/11	9/18	9/25	10/02	10/16	10/30	11/06	11/13	
InEl			Smart	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
InIn			Smart	✓	✓	✓	✓	✓		✓	t		✓	✓	
InMa			Smart	✓	✓	✓	✓	✓		✓	✓		✓	✓	
InMe			Smart	✓	✓	✓	✓	✓	✓	✓	t	✓ 4	✓	✓	
InMe			Smart	✓	✓	✓	✓	✓	✓	✓	t	✓	✓	exc	

Advanced Medical Optics

DEPT	ID #	NAME	Thu 8:00am	8/29	9/2	9/3	9/12	9/19	9/26	10/03	10/10	10/17	11/12		
InIn			AMO	✓	✓	✓	✓	✓	✓	exc	✓	✓	✓		
InMa			AMO	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
InMe			AMO	late	abs	✓	✓	abs	abs	✓	abs	✓	abs		
InMe			AMO	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

Horizons International Corp.

DEPT	ID #	NAME	Fri 9:00am	8/30	9/4	9/5	9/6	9/9	9/13	9/26-27	10/11	10/18	12/8		
InEl			Horizons	✓	✓	✓	✓	✓	✓	✓	✓	sick	✓		
InIn			Horizons	✓	✓	✓	✓	✓	✓	✓	sick	✓	✓		
InMe			Horizons	✓	✓	✓	✓	✓	✓	✓	drawing	✓	exc		

Note: waiting for prototype!

Frozen Can / Cooling Suit

DEPT	ID #	NAME	Fri 2:30 pm	8/23	8/29	9/6	9/13	9/17	9/20	9/27	10/11	10/17	10/18	11/01	11/08
InIn			Frozen	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
InMa			Frozen	✓	✓	✓	✓		abs	✓	✓		abs	✓	✓
InMe			Frozen	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
InMe			Frozen	✓	✓	abs	✓	✓	✓	✓	✓	✓	✓	abs	✓

Dr. Suleiman

Dr G. Lopez

Figure 3. Attendance Sheet for Team Meeting Activities

Each team must comply with two documentation requirements: a project timeline (typically developed in MS Project) and a poster presentation (typically developed in PowerPoint) which must include all relevant drawings related to the product and process design. The poster contains eight sections: (1) project intended result, (2) justification for project selection, (3) the use of relevant performance measures that describe the original product or process status (e.g. product cost, production capacity, product or process quality, headcount) (4) product and process analyses performed (including customer needs, possible demand scenarios, and design requirements and constraints), (5) product and process implementations (including relevant drawings and prototypes), (6) the use of the same performance measures used above to describe the improved product and process status, (7) specific tasks or issues pending closure, and (8) future plans as a result of the project experience or required by the market or technology trends.

The poster format must be maintained throughout the project life cycle and should be a source of information in preparation for progress reviews. Progress reviews are excellent for collecting feedback from team members concerning each individual's contribution to the effort. Figure 4 presents a team evaluation form that must be completed by each team member. The form addresses five aspects of the student contribution: (1) results achieved, (2) spirit of collaboration, (3) velocity or speed in performing needed tasks, (4) ability to learn and demonstrate flexibility when the unforeseen happens, and (5) innovation and creativity. The example shown identifies a member that did not contribute his fair share to the effort. When the form is used early in the semester, the instructor has the ability to request more involvement from students with low scores, since this should impact his/her course grade.

Fall '02
Team Evaluation

Team: AMO
Date: 12/13/02

Score: 0 = Did not contribute
1 = Below average
2 = Average
3 = Above average

	1.	2.	3.	4.	5.
1. RESULTS					
a) Team member contributed to the team result.	3	3	1	3	
b) Team member allowed others to contribute to the team result.	3	3	3	3	
2. COLLABORATION					
a) Team member fulfilled his/her commitments to the team.	3	3	1	3	
b) Team member went beyond his duty when team needed the extra effort.	2	3	0	3	
3. VELOCITY					
a) Team member worked quickly to achieve team results.	3	3	1	3	
4. LEARNING & FLEXIBILITY					
a) Team member learned new tasks and responsibilities quickly.	3	3	2	3	
b) Team member performed different roles within the team.	3	3	1	3	
5. INNOVATION & CREATIVITY					
a) Team member came up with new approaches and tools to tackle team challenges.	2	2	1	3	

08/20/01 Rev. A

Figure 4. Within-Team Evaluation Form Example

At the end of the project, a customer satisfaction form is completed by the project lead assigned by the industrial partner. Figure 5 presents an example from the Fall '02 semester. In addition to some team aspects, the customer evaluation form also checks on the perceived design completeness, the team's ability to interact with plant personnel, and the efficiency in capturing needed data and information. The third and last evaluation form used belongs to the instructor and is presented in Figure 6. It addresses the results achieved (based on the degree of customer satisfaction), the discipline exhibited by the team for meetings and poster upkeep, and the team's ability to review progress (with emphasis on presentation content and delivery).

The lessons learned concerning the execution stage are: (1) projects should start swiftly, defining from the outset with the project lead the deliverables and developing a Gantt chart; (2) the instructor should define a (weekly) meeting schedule that allows him/her to attend all team meetings; and (3) some projects could require more than one semester; it is critical to collect all relevant documentation (especially CAD files) to assure a steep learning curve for a project in its second semester.

Fall '02: Customer Evaluation Form

TEAM NAME / PROJECT: Sanz Tropical Mfg

05/20/02 Rev. A

0. PROJECT DELIVERABLE Date: 12/20/2002 — Identify design opportunities and improve product flow for the security window.

CUSTOMER EVALUATION AREAS	LEVEL OF SATISFACTION (5=HIGH 3=AVERAGE 1=LOW)	COMMENTS
1. RESULTS	5	n/a
2. INNOVATION & CREATIVITY	4	–
3. RESOURCEFULNESS	5	–
4. VELOCITY	4	–
5. INTERACTION WITH PLANT PERSONNEL	5	–
6.DATA/ INFORMATION COLLECTION	5	–
7. DESIGN COMPLETENESS	4	-
8. TEAMWORK	5	—
9. FUTURE NEEDS WITH REPECT TO THIS PROJECT	Desing a working process, handling racks or storage. Do the same process for the others areas in the plant.	

Figure 5. Customer Evaluation Form Example

Fall '02: Instructor Evaluation Form

TEAM NAME / PROJECT: Sanz Tropical Manufacturing

05/20/02 Rev. A

0. PROJECT DELIVERABLE Date: 12/21/02 — Identify design opportunities and improve product flow for the security window

CUSTOMER EVALUATION AREAS	LEVEL OF SATISFACTION (5=HIGH 3=AVERAGE 1=LOW)	COMMENTS
1. RESULTS	5	
2. DEDICATION	4	
3. MEETING ATTENDANCE	4	
4. CLASSROOM ATTENDANCE	4	
5. POSTER PREPARATION	2	The team was the slowest in having the poster ready
6. PRESENTATION CONTENT	4	
7. PRESENTATION DELIVERY	5	Presentation aided by simulation model

Figure 6. Instructor Evaluation Form Example

Case Study 1: Sanz Tropical Manufacturing

This project involved three students: Industrial Engineering, Mechanical Engineering, and Marketing (project poster presented in Figure 7). This company is a family-owned business and the plant manager (former IE student) served as project lead. The challenges in the project related to the security window, a fairly new product with high margin and sales growth potential. Because of the initial low volumes, the floor space assigned for building the window was not well thought and the product flow had significant improvement opportunities.

The team, led by the Marketing student, developed a questionnaire to capture the "voice" of six lumber yards, who are the main security window distributors for the company. The team recommended expanding the market to two big cities in southwestern Puerto Rico where there are no distributors yet. Led by the Industrial Engineering student, the team designed a focused factory for the security window. The transportation activity was reduced drastically by laying out the machines at close proximity following a U-shaped arrangement. The Mechanical Engineering student focused on an old machine that had to be replicated to allow the cell to run with an independent equipment set. He developed Autocad drawings that were needed by a local machine shop to build the new equipment. More details are available in Figure 7.

Case Study 2: Smart Modular Technologies and UPRM's SMT Line

Early in 2002, the Industrial Engineering department received a donation of a printed circuit board (PBC) assembly line based on surface mount technology (SMT). The equipment was donated by Hewlett Packard and Solectron Corporation, both located about 30 minutes north of Mayaguez. The production line is getting ready to provide support to the island's electronics industry. A new SMT course is being offered to junior-level students (from industrial, electrical, mechanical and chemical engineering). These students will be able to work on a part-time basis running the production line.

Since the line will be used to assemble PCB's for local customers, a team was formed in the Fall '02 semester as part of the Concurrent Engineering class. The team included five students: two from Mechanical Engineering and one from Industrial Engineering, Industrial Management, and Electrical Engineering. A senior manager in charge of new products and new technology at Smart Modular Technologies, subsidiary of Solectron Corporation, served as project lead. The team had two charters: (1) define a process for introducing new products into our manufacturing line and (2) contribute to the line preparation activities.

The team leveraged from Hewlett Packard and Smart Modular Technologies in defining the new product introduction (NPI) process. The critical inputs to the process are the details of the product which defines the tooling required (in paste dispensing and component pick and place), the temperatures needed for solder paste reflow, and the desired test strategies. The five students formed sub-teams of two to focus on five line preparation challenges: (1) utilities and lab readiness, (2) waste management and permits, (3) process quality and line capability, (4) product quality and test strategy, and (5) quality system.

The team activities were supported by three other teams from other Industrial Engineering courses. Two students on their Senior Design Project (IE's capstone course) developed a business plan which recommends an organizational structure and demonstrates the profitability of the activity. A three student team attending an advanced Total Quality Management (TQM) course provided support on defining a quality system structure aligned with ISO 9000-2000. A two student team attending a graduate course on Simulation Modeling developed an animated capacity tool to be used for line capacity assessments. Most of these details are presented in the team poster (Figure 8).

Concurrent Engineering Project

Figure 7. Redesign of the Security Window at Sanz Tropical Mfg., Cabo Rojo

Fall Semester 2002 | Date: 12/20/02 | Version A

ISSUE STATEMENT

✓Identify design opportunities and improve product flow for the security window.

WHY SELECTED

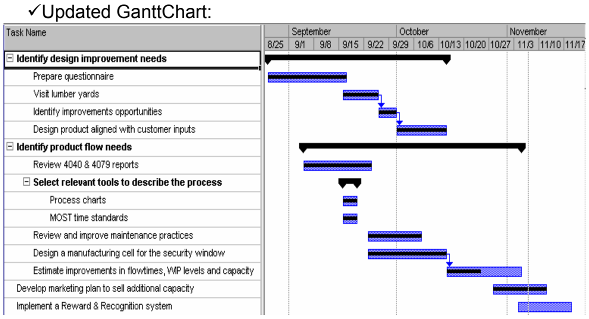
✓Product with market growth possibilities.
✓Obvious opportunities in WIP levels and overall costs.

ORIGINAL STATUS

✓Inefficient product flow due to excessive distances between processes.
✓Inventory controls are not effective.
✓Equipment breakdown concerns.

ANALYSIS

✓Prepared questionnaire; answered by six key customers.
✓Evaluated current product flow; opportunities on traveled distances identified.
✓Possibility for a focus factory studied; need to replicate two machines (jambas saw and top/bottom perforation)
✓Updated GanttChart:



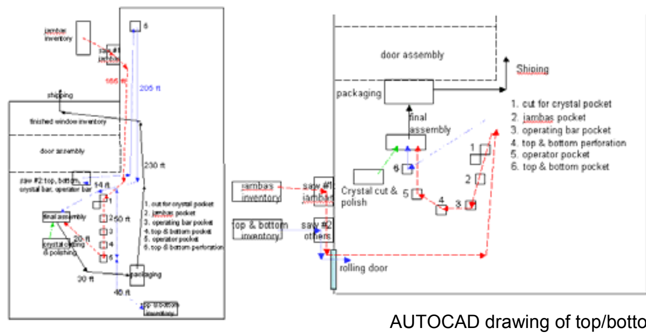
ACTIONS

✓ Lumber yard questionnaire results:

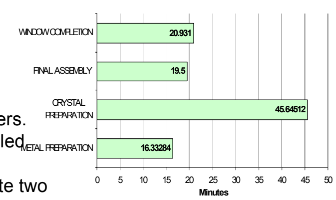
A. Customer satisfaction: 4/6 = 66.7%
B. Lumber yard and client priorities:
1. Price
2. Security
3. Durability
4. Elegance/Style
C. Quality problems
1. Defective operators
2. Frame's paint, possibly related to packaging

✓ Previous student projects were analyzed and taken into consideration for future actions.

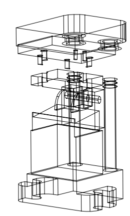
Current versus Proposed Layouts



STANDARD TIMES FOR THE SECURITY WINDOW ULTRA 3000 (12 SHEETS)



AUTOCAD drawing of top/bottom perforation saw. (additional machine needed)



RESULTS

PROPOSED MARKETING PLAN

A. Company strengths
1. Window quality
2. Company stability
3. Large sales margin in the security window
B. Loyalty program
1. Quantity incentives
2. Sanz as a synonym of quality
3. "Open house" for current and future lumber yard customers
C. Distribution
1. New target markets: Mayagüez & Ponce
2. Sales force by consignment
3. Distribution through contract truckers
D. Advertising
1. Security window posters at lumber yards
2. House visits to facilitate sales estimates
3. Joint advertisements between Sanz and lumber yards
4. Webpage for product visibility and inquiries

MANUFACTURIN CELL proposal developed (described above)

MACHINE REDESIGN for increased uptime (described above)

Arena Simulation model used to demonstrate the benefits of the cellular design (IE 6026 project).

PROBLEMS REMAINING

FUTURE PLANS

✓Layout to be implemented in Jan '03.
✓Project lead requesting an additional project focusing on the Miami window line.

Concurrent Engineering Project

Figure 8. New Product Introduction Process from Smart Modular Technologies to the UPRM SMT Line

Spring Semester 2002 | Date: 12/16/02 | Version 1.4

ISSUE STATEMENT

Provide support for the start-up of a Surface Mount Technology (SMT) line at UPRM and develop a product transfer process to facilitate contract manufacturing.

WHY SELECTED

1. Relevant business activities are desired using the recently donated SMT line.
2. Local electronic industry partners would like UPRM to provide hand-on experience on SMT to future graduates.

ORIGINAL STATUS

1. A SMT line was donated in early '02; it was transported into IE's Manufacturing Lab.
2. The line is becoming operational in January '03.

ANALYSIS

Project broken down into five areas:
1. Utilities and lab readiness;
2. Waste and permits;
3. ISO 9000-2000;
4. Process quality and line capability;
5. Product quality and test strategy.

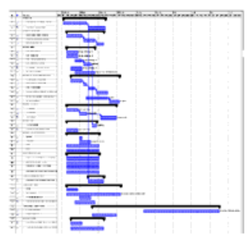
SMART documentation evaluated:
1. NPI/Product Transfer checklist;
2. Process documentation;
3. Equipment maintenance procedures;
4. SMT process mapping;
5. Memory products quality plan;
6. IPC workmanship standards.

HP documentation reviewed:
1. Prototype deliverables checklist;
2. Brainstormed with C. Sotomayor on prototype deliverables by equipment.

Selected a 512MB memory board to identify critical equipment readiness Issues prior to manufacturing.

Discussed the possibility of implementing four SAP modules:
1. Production planning / shop floor control (PP);
2. Documentation management (DM);
3. Product costing (PC); and
4. Sales and distribution (SD).

Project Gantt chart:



ACTIONS

1. Utilities and Lab Readiness
   a. UV oven power source to be upgraded (Jan '03);
   b. Humidity and temperature monitoring system purchased.
2. Waste and Permits
   a. JCA and HP-EHS contacted; oven emissions are minimal
   b. Need to replace the oven exhaust system for increase CFM (Jan '03);
   c. Lead utilization and disposition; need to consider low-temp lead free solder.
3. ISO 9000-2000
   a. TQM team defined (IE 5505);
   b. Document control and master list definition are the principal targets.
4. Process Quality and Line Capability
   a. Capability was reviewed for product specific components and IP3's are adequate once the specific nozzles and feeders for the smallest parts are purchased;
   b. IE Dept. (Dr. Rullán) subscribed to IPC; training materials should be easy to acquire.
   c. Estimated line capacity in terms of daily placements (completed by D. Claudio and F. Ortiz – IE 4079).
5. Product Quality and Test Strategy
   a. Request HP donation of hp3070 (Jan '03);
   b. Paste pattern inspection (w/ Cyber machine) being tested.

SMT line view:

RESULTS

1. A Control Document under ISO 9002 was initiated.
2. Transfer List for New Product Introduction developed (based on the SMART NPI/Product Transfer checklist)
3. SMT Process Readiness Table developed (based on HP inputs)
4. SMT line was inaugurated with a press conference on 12/12/02.
5. An Arena simulation model was developed to mimic line performance for a desired product mix.

PROBLEMS REMAINING

1. Need to complete the IP3 calibration (in progress)
2. Use of IPC materials
3. Feeders and nozzle acqusition based on component characteristics
4. Identify the needed ISO 9000 documentation:
   a. Manage ISO documentation with SAP's DM module.

FUTURE PLANS

1. SMT Course in Spring '03
2. Full operation to start in Summer '03
3. Define other line uses:
   a. new products and prototype runs;
   b. graduate and undergraduate course projects;
   c. enhanced process/systems approaches.

Final Remarks

The two-semester experience with the Concurrent Engineering course has been very positive. Faculty at UPRM should assertively develop a mix of interdisciplinary course activities. Such activities should relate to the technologies that are relevant to the present and future needs of the island's industrial sector. It is my belief that industry is motivated to provide the tools (equipment and materials) that should allow the student population to become knowledgeable in the technology and its challenges, so that they can contribute more rapidly after graduation. I just started pushing for more similar interdisciplinary activities by visiting the Engineering Dean weekly meeting. I am also pushing for a periodic technical "get together" between Engineering and Science educators and researchers to take interdisciplinary activities to a higher step.

Upcoming Course Experiences

As explained in the second case study, Concurrent Engineering teams can be assigned not only to industrial partner challenges but also to entrepreneurial initiatives internal to the university. Some of the projects for the upcoming semester will be related to defining the product and process and assessing the market for simple ideas that will be sold locally. After product and process are defined, the intent is to expose students to real manufacturing activities (on technologies relevant to our island). Such business activities will provide a steady income to the Manufacturing Lab involved as well as to participating students.

Conclusion

The paper has presented insight into the planning and execution of interdisciplinary efforts in a Concurrent Engineering course. Planning includes contacting industrial partners through personal visits and attendance to professional forums. It also includes attracting students from relevant disciplines to join the course.

Successful execution requires involvement from each student team, the project leads, and the instructor. The first week of the course is crucial for the instructor; he/she must form the teams with the needed expertise and common free time for team visits and meetings. Evaluation forms are used to monitor involvement within each team and to measure customer (i.e. project lead) as well as instructor satisfaction. Two efforts were reviewed by means of their poster, which contain all relevant details of each effort.

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