

# A Summative Assessment Strategy for a Multi-Institutional, Multi-Task Project: the Case of the Manufacturing Engineering Education Partnership

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## Abstract

*In 1994, a unique partnership of universities - Penn State, University of Washington and University of Puerto Rico at Mayagüez - in collaboration with Sandia National Laboratories, received funding from the ARPA Technology Reinvestment Program (TRP) to develop a new, practice-based curriculum and physical facilities for product realization and manufacturing. This initiative is named the **Manufacturing Engineering Education Partnership** and its overall outcome is the development at each participating institution of what we call **The Learning Factory**. This paper describes the project's summative assessment strategy being implemented project-wide that will allow interested parties to evaluate the project's performance and achievement of goals and objectives. It describes the project's four major tasks and deliverables, the assessment plan and its principal elements. It also presents the assessment schedule and the tools used for qualitative evaluation. The assessment scheme depicted in this paper could be used as a model for similar multi-institutional, multi-task projects.*

## Introduction

The **Learning Factory** is a new practice-based curriculum and physical facilities for product realization. Its goal is to provide an improved educational experience that emphasizes the interdependency of manufacturing and design in a business environment. The overall outcome of this initiative is to graduate better engineering professionals with the knowledge and skills needed to

succeed in the highly competitive world of today and tomorrow. The key element in this approach is *active learning* - the combination of curriculum revitalization coordinated with hands-on experiences, thus, reducing the gap between traditional lecture and laboratory, academia and industrial experience. This project is the product of the *Manufacturing Engineering Education Partnership (MEEP)*, a unique collaboration between three major universities with strong engineering programs (Penn State, University of Puerto Rico at Mayagüez and University of Washington), a premier high-technology government laboratory (Sandia National Laboratories), and more than 100 corporate partners covering a wide spectrum of U.S. industries, and the federal government that has provided seed funding for this project. Nineteen faculty members are engaged in this effort.

MEEP's goals are being achieved through four major tasks, namely:

1. Curriculum Development: develop a practice-based undergraduate engineering curriculum which balances analytical and theoretical knowledge with manufacturing, design, business realities, and professional skills;
2. Integrated Learning Factory: develop "learning factories" at each partner institution, integrated with the curriculum, for hands-on experience in design, manufacturing, and product realization;
3. Industrial Partners: develop strong collaboration with industry; and
4. Outreach: share with other academic institutions, government and industry.

*Presented at the Frontiers in Education Conference  
Salt-Lake City, Utah  
November, 1996*

Assessment of the project's outcomes and performance is a multi-institutional, multi-task job. This paper will describe the assessment strategy being implemented project-wide.

## Assessment Strategy

Assessment plays a vital role in projects such as the Manufacturing Engineering Education Partnership. In 1993, the NSF Engineering Education Coalitions met for the first time to discuss the important and critical aspects of project-wide evaluations. Assessment was concluded to be an important in providing the information necessary for continuous improvement in all aspects of a coalition: in preparing students, developing and disseminating curricular innovations, and managing organizational and cultural changes within the schools of engineering. Therefore, NSF requires all coalition projects to perform formative (performed during process) and summative (upon conclusion of the project) assessment of their processes and deliverables.

The summative assessment strategy designed for MEEP has the following goals and objectives:

- To design and implement a project-wide assessment scheme for the project outcomes and deliverables; and
- To disseminate the outcomes and achievements of the project.

## Methodology

*Quantitative Assessment:* Metrics for each of the four tasks were identified and outlined in the project Strategic Plan. Data is being gathered at the three institutions and includes the following:

<b>Curriculum Development</b>
<ul style="list-style-type: none"> <li>• number of new courses developed</li> <li>• number of existing courses modified to use the Learning Factory</li> <li>• number of students choosing to take new courses</li> <li>• number of faculty and staff involved in the project</li> <li>• job placement statistics</li> <li>• number of industrial projects integrated into the capstone design course</li> <li>• number of "engineers in the classroom", seminars and lectures by visiting professionals</li> <li>• number of courses or modules transferred internally</li> <li>• number of requests for information or course modules by other institutions</li> </ul>

<b>Integrated Learning Factory (ILF)</b>
<ul style="list-style-type: none"> <li>• resource acquisition /donations</li> <li>• student usage</li> <li>• project or process activities</li> <li>• shared use within the institution</li> <li>• training activities</li> </ul>

<b>Industrial Partners</b>
<ul style="list-style-type: none"> <li>• number of industrial partners</li> <li>• number of program graduates recruited by industrial partners</li> <li>• number of courses/hours provided to partners in continuing education</li> <li>• number of hours that industrial partners participate in education programs</li> <li>• number of students enrolled in internship programs</li> <li>• number of industrial projects</li> <li>• number of co-authored papers between faculty and industrial partners</li> </ul>

<b>Outreach</b>
<ul style="list-style-type: none"> <li>• number of courses developed suitable for transfer or distance learning</li> <li>• number of outreach institutions</li> <li>• number of courses utilized by outreached institutions</li> <li>• number of students participating in outreach activities</li> <li>• number of journal papers/presentations</li> <li>• number of participants in annual workshop for academic and industrial partners</li> <li>• ILF outreach activities</li> </ul>

*Qualitative Assessment:* The strategy designed to gather qualitative data about the project's performance is the major subject of this paper. For this purpose, the following methodology is being used:

1. Study the project goals and expected outcomes/deliverables, as per the project's strategic plan.
2. Study the specific tasks goals and expected outcomes/deliverables as per the strategic plan, and the metrics already identified by task leaders.
3. Establish specific criteria, develop **tools** for assessment for each task/deliverable, and establish who/what will be assessed. The assessment plan has the following elements:
  - internal (self-assessments)
  - external (outside the partnership)
  - multiple criteria (variety of modes and viewpoints)
  - holistic (integrated)
  - qualitative and quantitative components
4. Establish the assessment schedule
5. Conduct assessment workshop at a Partnership meeting
6. Conduct assessments and record
7. Report

An assessment team, composed of one representative from each institution (PSU, UW, UPRM), is in charge of the design and implementation of the assessment process. The team has the following responsibilities:

- Leader: coordinate team activities; develop drafts of assessment criteria & tools; conduct assessment workshop; and, record and report assessment findings to project PI, and project task leaders.
- Institutional representatives: review & provide feedback to team leader on assessment criteria & tools; conduct assessment workshop with team leader; conduct assessments at their institution; and report assessment findings to team leader.

An assessment workshop to be offered at the Summer of 96 partnership meeting in Seattle will familiarize participants at each institution with assessment fundamentals (what, why and how to do assessment) and with the elements, requirements and specific strategies of the MEEP assessment plan that will allow successful implementation of the plan at each institution.

The assessment strategy has qualitative as well as quantitative components, which will be associated with the project's general goals and objectives as well as with the individual tasks goals and objectives. Custom assessment tools have been developed and will be distributed to students, MEEP faculty and other parties (industrial partners, employers, and other institutions).

## Assessment Tools<sup>1</sup>

Assessment Design Matrix: The first step in the design of the assessment strategy was the development of an Overall Project Assessment Design Matrix, where each task's goals and objectives - as defined in the strategic plan were outlined. Associated with each goal and objective, the matrix also includes the stockholders or those identified as having a vested interest in the information gathered. Table 1 shows the Overall Project Assessment Design Matrix.

Individual Task Design Matrices: Once the overall project's tasks goals and objectives were summarized in the Design Matrix, four sets of matrices - one for each individual task - were developed, which included the following: general evaluation questions, evaluation instruments and approaches, who the respondents are and the data collection schedule. Table 2 presents the Curriculum Development Matrix.

Surveys: Four surveys to be distributed among the principal stockholders (students, faculty, industrial partners and other institutions) are currently being designed [using the individual task matrices]. Figure 1 contains a draft of the student version. Issues pertaining to courses, skills developed, use and integration of the Learning Factory, industrial partners involvement and outreach are included in these surveys. *Survey Pro Software 2.0 (Apian Software)* is being used to create and manage surveys. These will be administered according to the scenario described henceforth.

External Evaluators: Two external evaluators with experience in manufacturing engineering, similar partnerships and/or learning goals have been identified to conduct an assessment of the projects deliverables. They have already visited one institution and participated in the partnership meetings, visited the Learning Factory, browse course materials and talked with faculty and students. Upon conclusion of the project, these individuals will conduct an overall assessment of the project's deliverables.

## Implementation Scenario/Schedule

All stockholders or customers will be surveyed: faculty, students, industrial representatives and other institutions that have imported our project's deliverables. The survey forms will be provided personally, mail or by electronic means, e.g., fax or e-mail. Initially, our aim will be to

<sup>1</sup> **Resource**: Stevens, Floraline et al, "User Friendly Handbook for Project Evaluation: Science, Mathematics, Engineering & Technology Education, NSF 93-152.

have at least a sample size of 15 of each at each institution for each group of stockholders (except other institutions). Schedule for the assessment strategy is being currently being developed. The data will be compiled and analyzed qualitatively and statistically using *Survey Pro*. Since the project initiated two years ago, not every participant has had the same degree of participation in each of the tasks, and, obviously, this will induce variability in their ability to respond. For example: a student may have taken two MEEP courses at one institution, whereas another student at another institution may have taken two courses, worked very actively at the ILF, may have already graduated and may be working at an Industrial Partner corporation as a result of his/her participation. These facts will have to be considered during the analysis phase of the assessment data.

Once the initial phase of the analysis is completed and preliminary conclusions drawn, it will be determined whether it is necessary to increase the sample size, in which group, and - if necessary - at which institution. With this second set of responses, the final fine-tuning of the analysis will be completed and the results disseminated across the partnership, final report to NSF, and in the literature.

## **Expected Outcomes**

At the time of the writing of this paper, the surveys were being completed. It is expected that they will be distributed and completed by stockholders at each institution during the Fall of 1996. After data gathering and analysis, a final report will be produced thereafter which will include major results of the outcomes of this project and its success in achieving goals. We also hope to use the findings to support efforts in procuring funds to further support the continuation and expansion of this project's outcomes and deliverables. Finally, we expect to publish and present the details of the assessment strategy and results in engineering education publications and conferences.

Table 1. MEEP's Overall Assessment Design Matrix

Task	Goals & Objectives	Stockholders		
		Student	Faculty	Industrials/ others
Curriculum Development	• Develop a new interdisciplinary, practice-based Curriculum which emphasizes the interdependency of manufacturing and design, in a business environment	X	X	X
	• Develop a new paradigm for coalition-wide course development, sharing and export to the academic community at-large		X	X
	• Integrate these new courses into the permanent academic programs of the respective universities	X	X	X
	• Facilitate and encourage the inclusion of more design/manufacturing content into existing courses	X	X	X
Integrated Learning Factory	• Implement the Integrated Learning Factory (ILF) to support curriculum activities locally and across the partnership	X	X	X
	• Initiate the capstone design project course with industrial support	X	X	X
	• Establish linkages to <ul style="list-style-type: none"> <li>• partnership school facilities and activities</li> <li>• local industry and community colleges</li> <li>• national industry, universities, and research institutions.</li> </ul>	X	X	X
Industrial Partners	• Establish a local Industrial Advisory Board		X	X
	• Create a liaison that will interact with the coalition task leader for Industrial Partnership		X	X
	• Expand the industrial sponsor base	X	X	X
	• Coordinate the development of industrial based projects for undergraduate students , and exchange programs to support the curriculum	X	X	X
	• Identify strategies to amplify the effectiveness of the Learning Factory	X	X	X
Outreach	• Develop a process for the members to fully share instructional, laboratory, and manufacturing facilities.	X	X	X
	• Develop a process for external institutions to participate in the MEEP educational program.	X	X	X

Presented at the *Frontiers in Education Conference*  
Salt-Lake City, Utah  
November, 1996

Table 2. Curriculum Development Matrix

<b>Question 1:</b> Was a new interdisciplinary, practice-based curriculum which emphasizes the interdependency of manufacturing and design, in a business environment developed?			
<i>Subquestions</i>	<i>Data Collection Approach</i>	<i>Respondents<sup>2</sup></i>	<i>Schedule<sup>3</sup></i>
1a. Did the program allow students to practice their engineering science fundamentals in the solution of real problems?	Questionnaire (Q) or Focus Group (FG) Samples	S, F, I	
1b. Are professional communication and team skills emphasized?	Q or FG Samples Interviews	S, F, I	
1c. Are case studies, active learning techniques, and computer technologies extensively used in the classroom?	Q or FG Samples	S, F	
1d. Did the program provide previously unavailable opportunities for hands on engineering experience in the Learning Factory?	Q or FG	S, F	
1e. Did the partner schools exchange information and learn from each other's experiences?	Q or FG	S, F, I	
1f. Did you take courses with students from disciplines other than engineering?	Q or FG	S	
1g. Did you develop or modify courses to accommodate multiple engineering disciplines?	Q or FG	F	
<b>Question 2:</b> Was a new paradigm for coalition-wide courses development, sharing and export to the academic community at-large developed?			
<i>Subquestions</i>	<i>Data Collection Approach</i>	<i>Respondents</i>	<i>Schedule</i>
2a. Were resources and ideas shared, avoiding redundant efforts? Were new technologies for communication utilized, achieving consensus on curriculum content?	Q or FG Samples	S, F, I	
2b. Were jointly developed curriculum materials easily transported among the MEEP partners, and exported to the academic community at large?	Q or FG	S, F	
2c. Were computer technologies, multimedia and electronic communications used?	Q or FG Samples	S, F	
2d. Did you participate with partnership professors to develop course materials? How effective?	Q or FG	F	

<sup>2</sup> S: students; F: faculty; I: industrial partners; O: others [e.g., other institutions outside the partnership]

<sup>3</sup> Still under consideration

Table 2: Cont. Curriculum Development Matrix

<b>Question 3:</b> Were these new courses integrated into the permanent academic programs of the respective universities.			
<i>Subquestions</i>	<i>Data Collection Approach</i>	<i>Respondents</i>	<i>Schedule</i>
3a. Is the interdisciplinary curriculum available as minor or a degree option at the participating schools?	Q or FG	S, F	
3b. Were the institutional changes approved by the faculty at the departmental, college and university levels?	Q or FG	F	
<b>Question 4:</b> Was the inclusion of more design/manufacturing content into existing courses facilitated and encouraged?			
<i>Subquestions</i>	<i>Data Collection Approach</i>	<i>Respondents</i>	<i>Schedule</i>
4a. Did the partnership develop courses with more, the same or less an industrial focus than other courses at your institution?	Q or FG	S, F, I	
4b. Were real-life problems provided by industry?	Sample of students projects	S, F, I	
4c. What was the impact of MEEP (courses, the LF, Industrial Partnership) on other courses, programs, projects, etc. at your institution?	Q or FG	F, O	

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Figure 1: Student Survey (draft)

**MEEP STUDENT SURVEY**

University \_\_\_\_\_ Major \_\_\_\_\_

Male \_\_\_ Female \_\_\_ Age \_\_\_

Involvement with MEEP

\_\_\_ Taken one course      \_\_\_ Research Assistant  
 \_\_\_ Taken more than one course      \_\_\_ Other (Specify) \_\_\_\_\_

The program courses were offered as:

\_\_\_ a minor      \_\_\_ electives      \_\_\_ a degree option

The courses were:

\_\_\_ interdisciplinary      \_\_\_ engineering students only

Instructions:

The following items reflect some of the ways in which the Manufacturing Engineering Partnership (MEEP) can be described. Please, circle the number which indicates THE DEGREE TO WHICH YOU AGREE that each item is descriptive of the experiences you were exposed to and provided by the program. If you have no information or feel an item does not apply, please circle the N/A.

KEY:	1	2	3	4	5	N/A
	strongly disagree				strongly agree	

The program allowed you to practice engineering science fundamentals in the solution of real problems.	1	2	3	4	5	N/A
Professional communication skills were emphasized.	1	2	3	4	5	N/A
Team work skills were emphasized.	1	2	3	4	5	N/A
Case studies were extensively used in the courses.	1	2	3	4	5	N/A
Active learning activities were extensively used in the courses.	1	2	3	4	5	N/A
Computer technologies were extensively used in the classroom.	1	2	3	4	5	N/A
Hands - on engineering experiences were extensively used in the classroom.	1	2	3	4	5	N/A
The course was set in an industrial like setting.	1	2	3	4	5	N/A

The course you took had more design/manufacturing content than other similar courses at your institution. 1 2 3 4 5 N/A

The Institution Learning Factory provided you with a fully integrated activity center for the creation and implementation of products and processes. 1 2 3 4 5 N/A

The ILF facility was well equipped to give you real life experience in "state of the art" processes. 1 2 3 4 5 N/A

The ILF facility was professionally staffed to allow you to get involved in research activities. 1 2 3 4 5 N/A

Your feel that your participation in the MEEP Program improves your career opportunities. 1 2 3 4 5 N/A

The MEEP courses provided more to your professional development than your typical classes. 1 2 3 4 5 N/A

The MEEP instructors were superior as compared to your typical university instructors. 1 2 3 4 5 N/A

COMMENTS: