The Design of a Skill-based Course Focused on Student Outcomes: a Partnership Template

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Abstract

The NSF-sponsored partnership, the Manufacturing Engineering Education Partnership (MEEP), has a major goal: the development and implementation of an undergraduate manufacturing engineering option. Four institutions: Penn State, University of Washington, University of Puerto Rico at Mayagüez and Sandia National Laboratories, are working together in this endeavor. The main focus is the design and development of a manufacturing engineering option with emphasis on hands-on and practice-based activities. This goal is being achieved by developing a sequence of undergraduate, interdisciplinary courses that balance traditional scientific and mathematical principles with practical experiences. In addition, the partnership seeks to develop a Learning Factory for experiential learning, which will provide the close interaction between theory and practice for the new courses being developed. Industrial collaboration in this project is of utmost importance. The outreach task of the project will make available course materials and other deliverables to interested parties through publications and electronic means. This paper summarizes the methodology the MEEP curriculum team is following to design these new practice-based courses. The process starts with the definition of the concepts and skills intended to be developed and mastered, the identification of educational activities needed, and the design of assessment criteria and tools to evaluate student performance.

Background

Since the Summer of 1994, NSF has sponsored an agreement under the Technology Reinvestment Program (TRP): the Manufacturing Engineering Education Partnership (MEEP) Three universities, Penn State (leading institution), University of Washington and the University of Puerto Rico, and Sandia National Laboratories, agreed to develop a practiced-based engineering curriculum in recognition of the need to revise and revitalize engineering education. This goal is proposed to be reached, among other activities, by developing a sequence of undergraduate, interdisciplinary courses which balance traditional scientific and mathematical principles with practical experiences, and by the development of a Learning Factory for experiential learning, which will provide the close interaction of theory and practice for the new courses being developed. The Curriculum Development Team (CDT) of the Partnership agreed to follow a basic methodology for course development. Since courses to be revised/created have a strong component of practice and skills, the objectives, content, teaching methodology and assessment of student performance are unique.

The Educational Paradigm

The guidelines/recommendations for course design described herein are based on a specific **educational paradigm**. Basically, education is viewed as a process, which inputs students with certain knowledge, attitudes, values and skills, and outputs students with another set of knowledge, attitudes, values and skills. Education should increase **both knowledge and skills,** and promote new attitudes and values**.** The educational process is designed as to maximize and enhance the students' knowledge base and skills, and develops an individual who is a self-learner and thinks critically.

Table 1 presents the educational paradigm and the types of questions asked during the analysis/design of educational experiences . Our focus was to design these using an **integrative approach**.

Table 1. Educational Paradigm

"Input" Students	Educational Process	"Output" Students
What do we have? Who are our students? What background and skills do they possess and master?	What do we need to teach them in order for them to become the engineers society needs? What experiences should they have to acquire desired outcomes?	What do we want? What kind of engineer we expect to "produce" from this experience? What are they expected to know and do with what they know upon completion of the course? What do stakeholders want?

Course Design

Each institution in the partnership is designing one course to share and institutionalize. Courses are being designed using a **modules** format in a common standard that will eventually facilitate sharing within partnership institutions and other interested parties through available electronics means (e.g., Picturetel, WWW). Each module will be a self-standing unit, containing the basic aspects for teaching content and develop skills, in addition to suggesting educational activities and assessment methods. The **template** designed for course development is shown in Table 2. It contains the module number/name, the general concepts and objectives, the skills (and levels) to be developed, the learning activities to be held and suggested assessment modes. Emphasis is put on non-traditional learning activities (e.g., strong interaction with Learning Factory, cooperative learning) and assessment criteria and modes.

Table 2. Course Syllabus Template

Module	Name	Con-cepts	Objec-tives	Skills	Activi-ties	Assess-ment Modes

The following guidelines were followed in course design:

Step 1:Course Rationale/Objectives/Content

This is the traditional course design/evaluation activity. It entails, for example, listing the topics and concepts that will be delivered to the student, the activities needed to achieve the goals, the credits awarded, level, place in the curriculum, pre-requisites.

Rationale: Describe the course rationale, answering questions like: On what grounds is the existence of this course justified? What are the reasons for existence of this course? What are the needs?

Objectives: The objectives must be real and feasible in terms of abilities of the target population and the available time and resources. The objectives must also be related to the competencies and skills students will need in their subsequent courses and in everyday life outside college. In addition, one can ask what are the expectations students may have for the course.

Content: Deciding upon content, questions like these may be answered: What information, processes, concepts constitute the subject-matter or content of this course? How are they related to the objectives? Which should receive more (less) emphasis? How is content sequenced, arranged? Establish the fundamental topics that the student should master (these are handy when preparing assessment tests)!. A list of general **curriculum themes** (including some basic skills) developed by the CDT appears in Table 2.

Skills: Determine the skills (describe them) that should be developed by the students upon completion of the course. Decide which should be "initiated" but not necessarily mastered (overview), those that should be expected to be using (basic), those that should be mastered.

Number of students/class size: Determine the ideal and maximum number of students to enroll in the course. This number may be affected by the activities designed, type of learning/teaching method (e.g., collaborative learning) and the facilities available (e.g., Learning Factory, labs, classroom size).

Activities/Teaching strategies: Establish/design the learning activities and materials to be used. These activities/experiences can include labs, field trips to industrial facilities, demos, oral/written presentations, team experiences, etc. Clearly define the instructor’s role (e.g., lecturer, facilitator, mentor). Identify successful teaching methodologies to develop skills and achieve goals (e.g., collaborative learning, teamwork). Several resources, including Wankat’s and Oreovicz book, **Teaching Engineering** (McGraw-Hill, 1993) are recommended as references for this task.

Faculty/student ratio: Type of course activities and teaching/learning methodology will affect the faculty/student ratio. For example, if course calls for student teams, and multi-faculty lectures, this ratio will vary. If there is more than one instructor, define the duties/responsibilities of each.

Step 2:Criteria/Tools to Assess Student Performance

Once the objectives (in terms of concepts and skills) are established, the **criteria** and the **tools** needed to assess student performance must be designed. These must be as specific as possible because student must know **exactly** how he/she is going to be evaluated, specially, in skill’s development. What instruments and procedures are going to be employed as a means of collecting evidence of the student’s performance? What criteria are going to be used? Will these assessment instruments yield valid and reliable results? Is the amount of assessment realistic?

Step 3: Special Contacts

Start making contact and interacting with faculty members, guest speakers, **Learning Factory Team**, **Industrial Partners, Outreach Team**, that may be used as resources, labs, etc. Be sure to specifically describe task, as to content, criteria and tools for assessment.

Step 4: Course Outcomes Assessment

Design means to evaluate the course, both at midterm and final. It may be by standard forms or custom-designed. Criteria may include: number of student completing, withdrawing and failing the course, attrition rates compared with other courses. At the end of the course, is there evidence of the students achieving goals? For which objectives was the course most/least successful? What effects did the course had upon the students' interest, motivation, values, study habits, interpersonal relationships? Is there evidence the students are better prepared for subsequent courses? Are the teaching methodologies appropriate? What changes must be made?

Table 3. MEEP Curriculum Themes

Engineering science fundamentals
Design/synthesis
Probabilistic methods
Materials
Creativity
Manufacturing processes
Communication skills
Team skills
Problem-solving skills
Total quality
Business concerns
Project Management
Cross-disciplinary industrial projects
Analysis
Self-awareness, awareness of others and the environment

The focus of this course design scheme (and template) is on skills development and student outcomes. This strategy allows course designers to clearly define the desired student outcomes, not only on content, but on skills. It also provides the instructor the means to determine specific criteria and tools to measure student performance and the fulfillment of goals.

This course design scheme has already been used at UPRM in the design of an interdisciplinary course that emphasizes teamwork problem-solving and product design in manufacturing (concurrent engineering). The course was created and offered by faculty members from four engineering programs and Business Administration, and is currently open to students from those disciplines. This course design scheme is also being used by MEEP institutions to create the following partnership courses: Product Design, Entrepreneurship, Concurrent Engineering, and Quality Control.

Conclusion

The MEEP Partnership members are committed to design a practice-based engineering curriculum which will develop students capable of using and applying knowledge in real-life situations, engineers with the competencies and skills needed in the highly competitive manufacturing world of today. This new approach in course design will ensure that this new curriculum achieves its goals successfully.

That the courses being developed also include suggested non-traditional, educational activities that enhance student learning and motivation, together with novel student performance assessment modes make this effort a unique academic endeavor. And finally, that faculty from three engineering schools from such distant places are able, in a focused team effort, develop and share these activities is the best example of true engineering problem-solving: interdisciplinary, multidisciplinary, and challenging. We only hope that the outcomes of this project prove to be a success in terms of student learning.

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