# An Active Learning Environment in an Integrated Industrial Engineering Curriculum

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## Abstract

We are developing a new learning environment that supports a suite of interrelated modules based on real-world scenarios. The primary goals of the project are to integrate industrial engineering courses, improve students' information technology skills, and enhance students' problem solving skills. In particular, metacognitive abilities will be strengthened as students apply domain knowledge, data, methods and software tools while monitoring their own solution processes. This paper presents the design of two modules that have been developed.

## Introduction

It is widely accepted that information technology (IT) may be a vehicle to improve engineering education, but doing so will require careful consideration of both technical content and learning objectives so that the technology environment promotes learning that we value. It should also address challenges in the existing curriculum that may be difficult to solve without the enabling technology. One clear potential for IT to improve upon traditional lecture classes is to promote collaborative and active learning [2,3,6].

Other less obvious challenges in the traditional curriculum can also be addressed effectively using IT. For example, the traditional industrial engineering curriculum encompasses what may seem like loosely connected courses that address different elements of manufacturing and service enterprises. A common computer-based environment can be used to integrate these courses. Such an environment can also be used to encourage the development of specific learning skills. For example, when assigning homework and exams it may be difficult to ensure that students plan how to learn a given task, monitor their comprehension of the task, and evaluate the progress that they are making towards completing the task. Such metacognition

has been found to be an important component of learning [1,4].   In a computer-based environment, where each step of a student's progress can be monitored, encouraging reflection and self-evaluation at each step becomes a viable option.

We have designed a new active learning environment where students in each course complete one or more modules that relate to the course content.   These modules are designed with several goals in mind:

- o Each module presents a *realistic engineering problem* that students must solve using the declarative and procedural knowledge acquired during the course.
- o The modules are *interconnected* so that the relationships between previously isolated parts of the curriculum are made apparent.
- o The modules focus on helping students develop both their *cognitive and metacognitive skills.*
- o For each module, students must independently define goals, formulate problems, and develop solution strategies while mastering the course material.

This environment, which encourages cooperation and communication with other students, is thus a fundamental shift from the existing emphasis on the traditional lecture format to *active and collaborative learning*.


## Electronic Learning Portal

To help achieve the goals outlined above, we have developed an electronic learning portal (ELP) which: (1) provides scenario specific information based on student-initiated requests, (2) structures the problem solving process, (3) collects information on cognitive processes, (4) collects work in multiple formats from each student team, and (5) provides feedback to teams on their progress.

Each of the modules developed has the following problem solving stages:

Objective:  Students specify what they are trying to achieve before they begin the solution process.   A justification of the objective is also required.

Plan and Analysis: Teams construct plans for solving a problem consisting of a set of actions based on the module knowledge domain. The team must provide justification for each action in the plan.

Solution:  After completing the plan, the solution is submitted along with a justification.

Students have the opportunity to change their solution at decision points in the scenario timeline based on system performance in a scenario.

Performance: A scenario specific simulation model provides a representation of the system under the solution parameters selected by the team. Performance measures for the system are provided at pre-defined time periods.

Student reflection is encouraged by requiring justification for student responses as well as self-evaluation after each stage (using rubrics that describe the evaluation criteria). These criteria can be viewed prior to completing a stage.

The first module developed was used in our Engineering Economic Analysis course during three consecutive semesters Fall 2002, Spring & Summer 2003. This module and student results are described in a companion paper [5].

## Manufacturing Systems Engineering Module

The second module developed was for the senior level manufacturing systems engineering class. As with the engineering economy module, this module is also based on actual manufacturing system problems of a local manufacturer. This company faced a production bottleneck caused by the limited capacity of its turret punch press operation used to cut the steel parts from the sheet stock. The project description gave an overview of the company, and the production problems it was facing.

Students first wrote a concise objective statement for their work that included quantifiable evaluation measures. During the 'plan and analysis' stage, the students researched a variety of sheet metal cutting processes (e.g., turret punch press, die stamping, laser). While some of these alternatives can be quickly eliminated, others require further analysis. Students need to provide justification of any processes that were eliminated, based on many factors such as, equipment and tooling costs, cutting speed, labor requirements.

During this initial use of the module, students were provided with sample outputs of the actual parts laid out on a sheet using SigmaNest nesting software. Starting in the Fall 2003, students will be required to access a database of CAD files, and run the nesting software themselves to calculate potential yield for the different processes. Students will also gain more IT experience by querying a database for production history, bill of materials, process plans, and quality information

needed for their analysis. At the solution stage, they need to conduct an engineering economic analysis of the potentially viable alternatives identified in the plan and analysis stage, and justify their final recommendation.

This module strongly ties the material from several other industrial engineering courses, such as engineering economy, manufacturing processes, production scheduling and quality control, into the manufacturing systems engineering course.

Initial feedback from the students was similar to that from the engineering economy module. Students recognized the value of the connections between classes and like the engineering problem solving skills developed in the open-ended problem. Some students were initially frustrated by the fact that they did not immediately know how to proceed in solving the problem. Our goal is that this frustration will subside as they are exposed to similar open-ended problems in modules developed for most of their industrial engineering courses.

## Conclusions

Our initial experience with the ELP indicates that IT can be used effectively to create opportunities for students to collaboratively solve realistic engineering problems, thereby promoting deeper learning and higher order thinking. Students benefit from the integration of material from a variety of industrial engineering courses. Methods for formative assessment and understanding the role of metacognition in engineering problem solving require further investigation.

## Acknowledgements

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