Teaching Mathematical Modeling using Innovative Technology Applications

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Abstract

We seek to show that through incorporation of a self-guided practice and examination tool, students are able to improve their performance with respect to mathematical formulation and optimization problems in Industrial & Operations Engineering.

Background

The Industrial & Operations Engineering Department offers several courses in mathematical modeling and system optimization techniques, one of which is geared towards undergraduate students. In this course students learn about not only the algorithms and software tools that exist to solve optimization problems, but also how to formulate mathematical programs, that is, turning a problem description into a set of parameters, decisions variables, objective and constraints.

Mathematical modeling is often referred to as an "art" rather than a science. That is, one cannot simply teach a set of steps that allow a student to turn a problem description into a mathematical model. While there are problem types (assignment problem, resource allocation problems) which share a general structure, from past experience, students tend to learn mathematical modeling concepts best when they are required to perform repetitive modeling tasks.

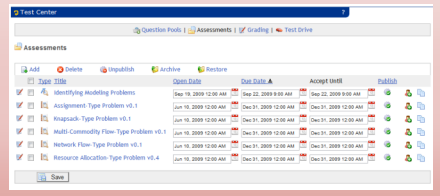
In our project, we explore the use of an electronic system that allows students to download problem descriptions, submit their responses and subsequently provide the instructor solutions. That is, a student is allowed to view the answer only once she has submitted a response of her own. In addition, the student is not only presented with the correct solution, but also incorrect solutions.

Research Question

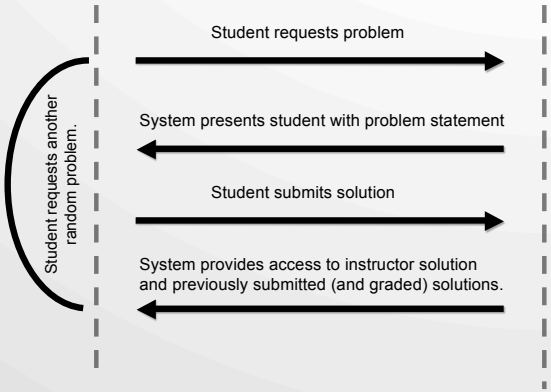
In this research project, we explore the effects of such a system on the students ability to understand a difficult subject. It is our anticipation to show a positive correlation between students who use the system and their ability to create mathematical models.

Student ←→ System Interface – CTools.

Students can access the problem database via the CTools Test Center. A sample screen-shot of the various problem types is shown below.



How It Works



Test System Features

Optimization Problem Types

- Assignment Problem (ASN)
- Resource Allocation Problem (RAP)
- Knapsack Problems (KNP)
- Multi-Commodity Flow Problems (MCF)
- Network Flow Problems (NWK)

Student solution entered in database

Teaching staff periodically checks student submissions and updates the database. Additional responses, correct and incorrect are added to each respective problem.

Key Performance Indicators

- System Utilization (Number of Problems Completed)
- Midterm Exam Performance
- Quality of Student Submission

Step by Step Overview

The following is a guide for the "How It Works" diagram shown above.

- **Student Downloads Problem**
  The system contains roughly 100 question/answer pairs when students were provided access. When the student downloads a problem, he/she specifies which particular category the problem will come from (Assignment Problem, Resource Allocation, etc.)
- **Student Responds to Problem**
  After the student has downloaded a problem, he/she can save/print this problem. The student is given unlimited time to work and complete the problem and upload a solution. This solution may be submitted as a Word document or PDF.
- **Solution Presentation**
  Once the student has uploaded his/her answer to the presented problem, he/she may view the instructor solution. In addition to the instructor solution, the student will also see other student's responses (with names removed) which have been flagged as "correct" or "incorrect" by the instructor.
- **System Upkeep / Extension**
  As students submit more and more answers, the system is continuously updated. That is, the course instructors grade the solution solutions and add the results for the database. This insures that students are able to see other correct as well as incorrect responses.

Outcome Analysis

The effectiveness of our approach will be evaluated using several metrics. These metrics include:

- **Analysis of usage data**
  Students are encouraged to use the system on their own to practice mathematical model problems. We conjecture a correlation between the number problems a student has completed and their performance on modeling, in-class exam.
- **Quality of Submission**
  Students are required to submit a solution prior to receiving the instructor's solution. We anticipate a correlation between the qualify of the solution the student submits vs. the student's performance on the mathematical, in-class exam.
- **Results**
  Our implementation and data collection phase has been completed and we are now in the process of analyzing the results.

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