Development of a Multi-Disciplinary Core Engineering Experience for First-Year Students

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Abstract **- The School of Engineering at Rensselaer Polytechnic Institute has initiated a revitalization of its First-Year curriculum for all students. The principal vehicle is a multidisciplinary course entitled "Engineering Discovery," which was offered on a pilot basis during the 04-05 AY. The goal is to establish at an early point in a student's education the link between math and science from the high school years and the ways that engineers think in their approach to problem solving and design. A brief description of the 04-05 pilot and modifications that have been implemented in a pilot for the 05-06 AY, renamed "Foundations of Engineering," are presented. Assessment activities will be discussed during the presentation.**

The 21st-century engineer is that rare individual who has a genuine interest and ability across a wide range of technologies, and who takes delight in working across disciplinary boundaries to identify and use the particular blend of technologies which will provide the most economic, elegant, and appropriate solution to the problem in hand. Furthermore, he/she is a high communicator who has the knack of being able to enthuse others about technologies outside their own, and hence to break down built-in resistance to the use of alternative approaches. To evaluate concepts generated during the design process, without building and testing each one, the modern engineer must be skilled in the modeling and analysis of engineering systems and understand the key issues in experimentation and hardware implementation. This philosophy lies behind the development of a pilot First Year Student engineering course called "Engineering Discovery." The course strives to develop in each student a balance among these and thus lay the foundation for the students to become true 21st-century engineers.

Fall 04 – Spring 05 Pilot Course

The Engineering Discovery pilot course was taken by 90 students over two semesters: 29 students (1 section) in fall 04, and 61 students (2 sections) in spring 05. The focus of the course was the Engineering System Investigation Process with three main elements: investigation of a real engineered product (an electric toaster and room humidifier were used in both semesters), engineering measurement, and engineering computing. The course underwent a revision from one semester to the next, as integration of these three elements presented on a class-to-class basis proved very challenging. The fact that what we were developing for one or two sections eventually had to be delivered to 750 freshman engineers with full participation and shared ownership by the engineering departments was always in our minds. The ability to scale up and sustain whatever we developed were criteria we could never ignore, no matter how promising or successful some approaches were in the delivery of the course. An extensive assessment of this year-long experience was completed and will be discussed during the presentation.

Fall 05 – Spring 06 Pilot Course

As a result of our experience during the 04-05 academic year, we put in place a plan to offer a new version of the Engineering Discovery pilot course in the fall 05 – spring 06 semesters that still captures the essential elements of the original course, with better integration of all the elements and more emphasis on modeling, but also has a greater potential for shared ownership and participation by the engineering departments, and therefore sustainability, and also can be scaled up for delivery to 750 students in sections of approximately 30-40 students each. The course description and learning objectives are given below.

Fall 05 – Spring 06 Course Description and Learning Objectives

The Engineering System Investigation Process is the cornerstone of modern engineering practice and it, and the steps in the process, are the focus for this course. Modern-day design concepts must be evaluated through modeling, analysis, prediction, and experimental verification, not by the old build-and-test approach. The three main elements in this investigation process are studied in this course: <u>modeling</u> mechanical, electrical, electromagnetic, fluid, and thermal systems; <u>predicting</u> behavior by analyzing mathematical models using MatLab / Simulink, Maple, and Excel; <u>measuring</u> engineering systems and analyzing the data using LabView and the National Instruments ELVIS along with C-Programming on a microcontroller for real-time applications. Technical communication in all its forms plays an important role in all aspects of this process. Real devices and products are used to motivate and show the relevance of the engineering system investigation process in the practice of engineering.

Engineers solve problems to benefit mankind. At an introductory level, this course has the following learning objectives:

- Understand and apply the basic problem-solving approach used by engineers.
- Understand the engineering system investigation process and be able to apply it to a variety of elementary engineering physical systems.
- Understand the importance of physical and mathematical modeling (both from first principles and using experimental techniques) in engineering system analysis and design and be able to model and analyze simple mechanical, electrical, electromechanical, fluid, and thermal systems and identify the analogies among the various physical systems.
- Understand the hierarchy of physical models for an engineering system, from a truth model to a design model, and understand the appropriate use of this hierarchy of models.
- Become proficient in the use of MatLab/Simulink, Maple, and Excel to analyze engineering systems and be able to select the right tool to use for the particular problem being solved.
- Understand the key elements of an engineering measurement system and the basic performance specifications and models of a variety of analog and digital sensors.

- Understand the importance of data analysis, including both data from experimental measurements and the results from computer simulations.
- Understand basic analog and digital circuits and components and semiconductor electronics as they apply to modern measurement and engineering systems.
- Understand elementary computer programming and flowcharting.
- Understand C Programming for real-time applications and be able to write an elementary C program for a microcontroller as part of an engineering system.
- Understand and apply the various ways engineers communicate technical information, e.g., reports, problem solutions, block diagrams, electrical schematics, and computer-program flowcharts.

Figure 1 shows the three aspects of the Engineering System Investigation Process emphasized in the course and their appropriate place in the investigation process, i.e., physical and mathematical modeling using basic building blocks and laws of nature, prediction of system behavior through the use of engineering analysis and computational software (e.g., MatLab, Excel, Maple), and experimental verification of predictions using measurement hardware and software tools from National Instruments. These are all emphasized throughout the course and repeatedly applied to various basic engineering systems: a RC low pass filter, a first-order thermal system, a LRC electrical circuit, a brushed dc motor, a spring-mass-damper system. Throughout the course, a real product or device is discussed as a context for applying the material that has been covered. During the Spring, 2006 semester, this context is provided through a fuel cell powered Segway™ self-balancing scooter. The presentation will describe some of the demonstration experiments coupled with modeling and appropriate analysis that we hope will establish the future of this important educational experience for our students. In addition, the challenges of meeting important educational objectives for our program through this new course, in light of curriculum constraints, will also be discussed.

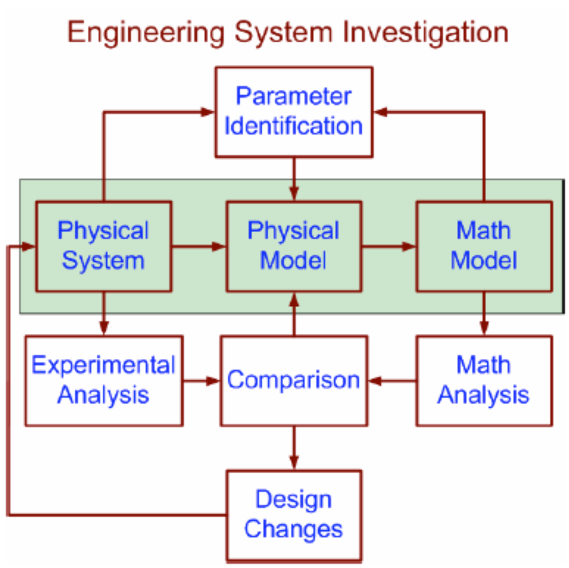

Figure 1. Relationship among physical system, physical model and math model as the foundation for engineering analysis and design

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