Work in Progress - A Problem-Based Learning Approach for Systems Understanding in the MSU AES Program

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Abstract - **Applied Engineering Sciences is a long-standing engineering undergraduate degree program in the College of Engineering, Michigan State University. It is at root an interdisciplinary program integrating core engineering studies, core business/management studies, and a depth-oriented "finishing area." Over the last two years, an evolved program has been designed and implemented that retains the traditional strengths of the program while providing a strong underlying theme of systems thinking. In this WIP report we describe the new AES program, and our plans to leverage problem based learning as the core pedagogy for supporting student introduction and applications of systems thinking.**

Index Terms - Problem-based learning, group work, systems thinking.

Introduction

One key recommendation from the National Academy of Engineering report *The Engineer of 2020* is "engineering education should be revitalized to anticipate changes in technology and society, rather than lagging behind them." One of the strongest responses to the 2020 report is to strengthen our models for engineering education on the dimension of students' ability to understand, analyze, and systematically modify complex systems. Change inevitably brings with it new approaches, new materials… new systems. To the extend our graduates cope with the "Big Picture" of such new systems, the details will fall in place for their understanding.

In the Michigan State University College of Engineering we have recently renovated the Applied Engineering Sciences (AES) undergraduate major, an interdisciplinary engineering major that builds an integrated engineering experience on the foundations of physical and social sciences, business and the humanities. Our design balances between technical depth and breadth. A key programmatic learning outcome is: Students will demonstrate facility in modeling complex systems across a number of situations and domains.

Our core pedagogy utilized to reach the above goal is grounded on the foundation of problem-based learning (PBL). There are two content courses in our curriculum that develop the "systems thinking" thread explicitly. Both are themed courses, one at the sophomore level, and one at the junior level.

The sophomore course is themed as a globalization course. Underneath the surface there are systems viewpoints that are developed and there is student engagement with the target systems. An exemplar is the global hydrological cycle that plays strongly on the environmental dimension of discussions on globalization.

The junior level course is themed as a sustainability course. It explicitly uses domain problems across a number of domains as a springboard to student development of appropriate tools for systems modeling with emphasis on sustainable systems. The core roles of the junior course in our curriculum are to enhance student capability for systems modeling and to develop student skill sets in system analysis tools.

In this report we will (a) describe our program, (b) describe the sophomore and junior courses that are sketched above, and (c) describe our planned use of the PBL methodology to further our programmatic goals. The core research issue we pursue is how to leverage PBL as a methodology in developing and demonstrating student ability to undertake problem solving involving "systems thinking."

AES at Michigan State University

In the College of Engineering, Michigan State University we are extending and updating an agile engineering education program that builds on the foundations of physical and social sciences, business and the humanities. Building on these pillars, a student develops career-oriented knowledge and skills competencies in a student-selected satellite concentration. Our program balances technical depth *and* breadth. Further, it allows rapid evolution of the set of topics for advanced studies to complete the undergraduate degree.

The AES program current enrolls approximately 150 undergraduate engineering students. In 2010, the program graduated approximately 50 students with B.Sc. degrees, with an employment rate before graduation of roughly 80%.

In Figure 1 above, the conceptual architecture of AES is shown. The core program of AES - taken by every AES student consists of (a) standard engineering science, computational, and mathematics studies, (b) basic business studies emphasizing management, (c) foundational engineering studies across mechanical, civil, electrical, and materials engineering, and (d) an "AES Spine" of three (and

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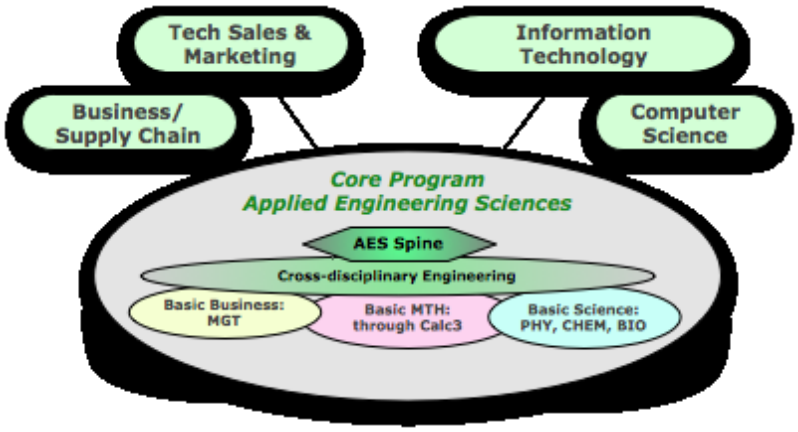

Figure 1: AES Program Architecture

in the future four) courses that are AES specific, themed courses that emphasize systems understanding. The AES Spine courses are strategically placed: sophomore year (a globalization themed course), junior year (a sustainability themed course) and senior year (an integrative capstone projects course). The core program is newly designed and was rolled out in September 2010. We have begun an aggressive and systemic assessment program for AES to drive quality changes in the program.

In contrast to the slow evolution of the AES core program, which makes up 99 of the 120-semester hours total of the program, the four "spokes" from the AES core are program *concentrations*. Each AES student selects one of four concentrations in which to complete her B.Sc. studies. The student-selected concentration provides intellectual depth to the AES student. Two of the concentrations are focused strongly on business students: supply chain management and technical sales. Two are focused on information technology: computer science and information technology management.

The AES concentrations are designed with input from industry and have the aim to meet the primary employment pattern for AES graduates: fast track management path in technology based companies. As market conditions change and new, strong need in technical industry emerges, AES faculty can react quickly to develop and deploy new concentrations that leverage the core mission of the AES program. The AES concentration set will evolve to meet changing conditions rapidly. This provides AES with both stability and definition of purpose (exemplified in the AES core) along with the agility to react quickly and effectively to societal needs (exemplified in the AES concentrations).

AES Spine and PBL

The concentrations provide industry relevant depth in content for AES students. The AES Spine provides course work emphasizing systems thinking competency that is a process-type depth for our students. There are currently three courses in this spine: a sophomore course that is a themed course on the topic of globalization, a junior course that is themed as a sustainability course, and a senior course that is a capstone projects course. The junior course in particular was just rolled out in Spring Term 2011. The first implementation was aimed at developing three case studies in sustainability with concurrent student exploration of the cases. The culminating case study of the course is a study in carbon footprint assessment for sustainability that is large scale.

For each of the three case studies of the term, there are underlying system level modeling tools that are introduced in context to the problem. These range from computer assisted modeling using differential equations to sophisticated tools for carbon footprint analysis.

Based on assessments of the course, to be presented at FIE 2011, we intend in the next iteration of this junior course to incorporate the Aalborg model for problem based learning to go beyond description and use of the case studies and towards the more active learning methods of PBL. Our ultimate goal is to tailor a local variant of the Aalborg PBL approach that is appropriate for our AES project and to utilize is through out AES Spine courses.

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