

InTEL: Interactive Toolkit for Engineering Learning

NSF Program: Engineering Education and Centers
Project: **EEC 0647915**
Dates: **2007-2010**

Project Summary

Statics, a foundational engineering course, introduces a unique approach to problem solving, which is characterized by model-based reasoning. The major intended course outcome is for students to develop the ability to create and utilize free body diagrams as a mechanism for describing and constraining a problem. This ability to abstract and define an idealized problem from complex objects in the world or textual descriptions ratchets the engineer's ability to solve the problem. Sadly, however, students routinely leave this course having learned to "plug and chug" or jump to a mathematical equation without first defining the problem in a diagrammatic form that articulates the underlying principles. This can lead to serious problems in future courses as the fundamental approach to engineering problem solving has not been understood or embraced. As a foundational course, difficulties here can impact student academic confidence resulting in a diminished sense of self-efficacy that is particularly problematic when amplified by gender and under-represented (URM) minorities issues. And such faltering so early in the major can cause a student to leave engineering.

While difficulties in the course arise for several reasons, our project seeks to address the problem of context. Our hypothesis is that women and minorities particularly, and students generally, are more likely to do well in statics when the problems are placed in the context of real world usefulness. An approach to teaching that effectively scaffolds students' efforts at model building and connects abstract principles/concepts to real world, every day applications will benefit all students while promoting diversity in engineering.

Towards that end, we are developing InTEL (Interactive Toolkit for Engineering Education), a computer-based manipulable environment that supports teaching and learning in statics by mapping images from real-world environments to abstract diagrams for 2D and 3D equilibrium problems. With such digital technology, statics professors will be able to offer students important scaffolding for developing model-based reasoning by contextualizing abstract concepts and principles in lifelike models. Interacting with and manipulating these models will help students develop the kind of intuition that characterizes engineering reasoning and problem solving.

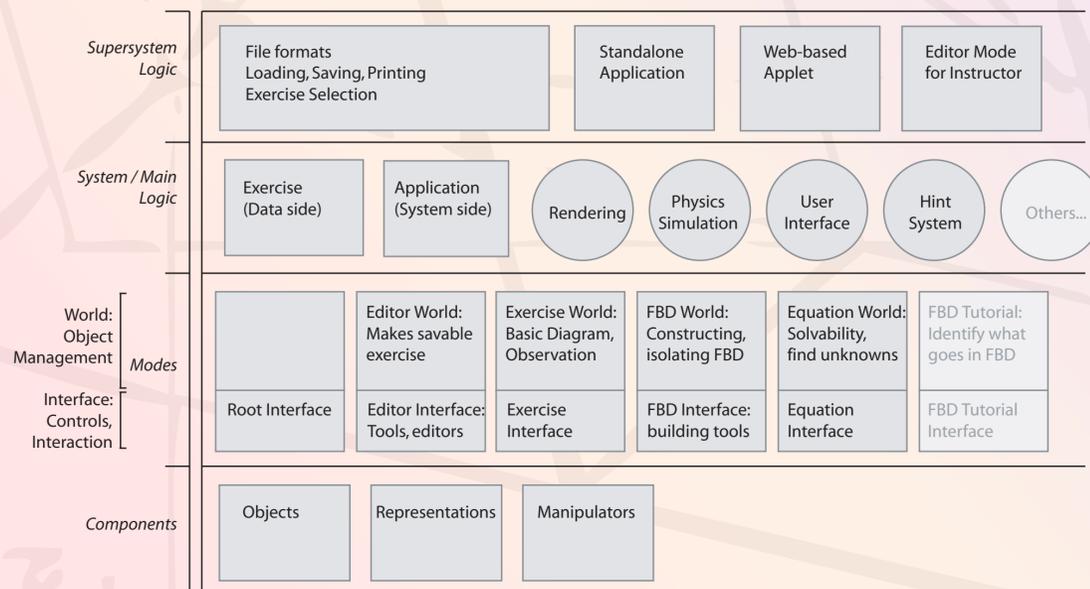
Preliminary Assessment Framework

Our assessment will focus on how well the system supports 1) the development of conceptual understanding in statics 2) the ability to use concepts in problem solving and 3) student perception of self-efficacy and confidence regarding the course material. Initially we will develop comprehensive construct maps of course material guided by the extensive work of Wilson (2005) in chemistry. These constructs will then guide the development of measures and items that reflect developing sophistication in statics understanding. Development of these constructs and measures will go hand in hand with the development of the InTEL system itself in a reflexive interplay of assessment design and system design.

5. Integrating
4. Predicting
3. Relating
2. Representing
1. Describing

Wilson, M. (2005). *Constructing measures: An item response modeling approach*. Mahwah, NJ: Erlbaum: 8.

InTEL System Diagram



Women and URMs in Engineering

Difficulty in model-building can cause a lack of confidence and a diminished sense of self-efficacy that is particularly problematic when amplified by gender and underrepresented minority (URM) issues. Women and minorities are also more likely to do well when problems are placed in a context of real world usefulness. An approach to teaching and learning Statics that effectively scaffolds students' efforts at model building and connects abstract problems with multiple real world applications will benefit all students and particularly help to promote diversity in engineering.

Research Questions

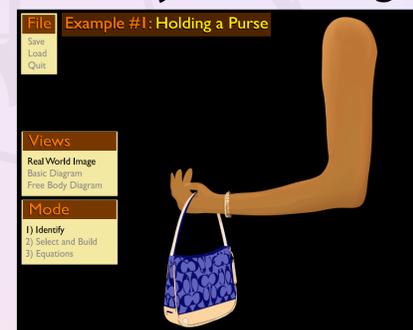
- Can software environments be designed and used to support the development of diagrammatic reasoning in introductory statics courses?
- Can software environments be designed to support the development 2D to 3D reasoning and manipulation?
- Can software environments afford the kinds of contextualization that clarify real world usefulness?

Statics at Georgia Tech

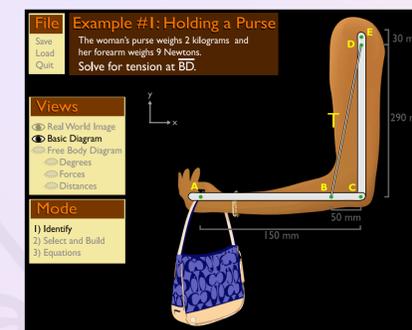
The InTEL system will be tested in the context of Georgia Tech's COE 2001 Statics course, which was instituted by the College of Engineering in the summer semester, 2005 with the aim of unifying the teaching of Statics across the College. COE 2001 is part of the required curriculum for eight engineering majors (Aerospace, Biomedical, Civil, Environmental, Materials, Mechanical, Nuclear and Textiles) and is taken as an elective by a large percentage of the other engineering majors (especially Computer, Electrical and Industrial). In fall semester 2007, there are fifteen sections of COE 2001 being offered with an average class size of fifty students, meeting two hours per week in traditional lecture format, and taught by faculty from across the College of Engineering.

- Can using these environments foster and sustain disciplinary engagement among women and URMs?
- Can integrating interactive learning tools into a foundational statics course increase representation of women and URMs in engineering majors?

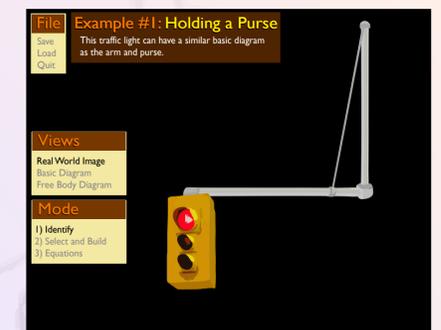
InTEL System Design



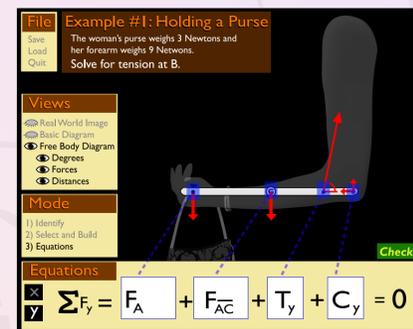
Real World Problems



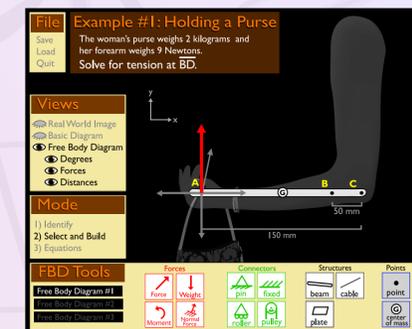
Basic Diagrams



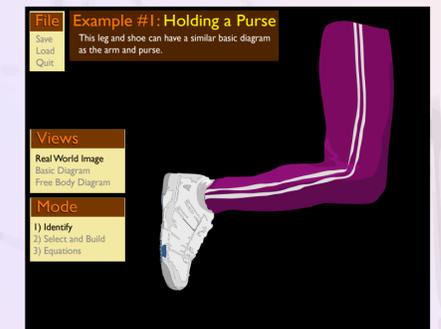
Generalizing Knowledge



Solving Equations



Building Free Body Diagrams



Generalizing Knowledge



Socially Relevant Examples: The Minneapolis Bridge Collapse