

Helping Students Approach Simulations Like Experts

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Abstract

The goal of this innovation is to facilitate students' progression from novices to engineers who are able approach advanced simulation like experts. The basis is cognitive research on "expert" vs. "novice" thinking. A process that fosters expert thinking has been developed and implemented in eight ME courses through nineteen web-based software tutorials. The challenge is how to scale up the innovation to impact diverse institutions.

Innovation category: Teaching leading edge knowledge

Introduction

- Physics-based computer simulation is a powerful new modality for solving engineering problems
- Limiting factor in simulation use is often *people* rather than some technical aspect
- Effective integration of simulation into engineering curricula will promote students' problem solving and critical thinking skills

Objectives

- Cognitive research shows that people's understanding lies in a spectrum from "novice" to "expert"
- We seek to facilitate students' progression from novices to experts in applying physics-based simulation

Novice	Expert
Solves problems by matching the pattern of a problem to a memorized recipe	Solves problems by retrieving information from a coherent mental organizational structure
Accepts results at face value	Critically interrogates results

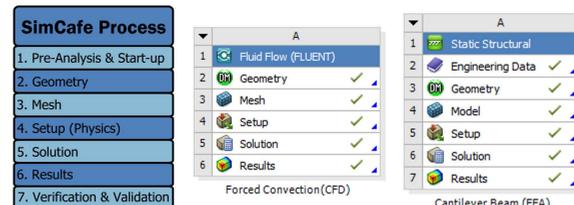
Two Learning Modes

Learning how to apply software

Learning fundamentals using software

Approach

- Nineteen web-based software tutorials have been developed to teach software use in eight undergraduate ME courses
- Diverse courses: solid mechanics, fluid mechanics, heat transfer and dynamics
- Numerical solvers used: ANSYS for FEA and FLUENT for CFD
- A consistent tutorial structure is used across the eight courses



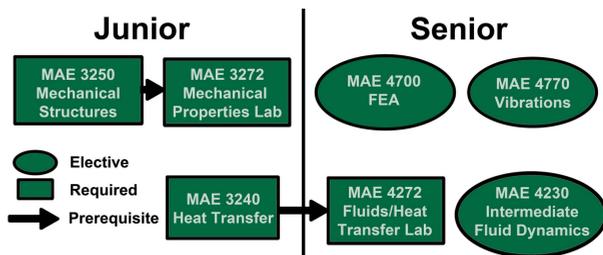
Foregrounding Expert Thinking

- Key aspects of expert thinking are foregrounded in all tutorials through two required steps

- *Pre-Analysis* step at the beginning
- *Verification and Validation* step at the end

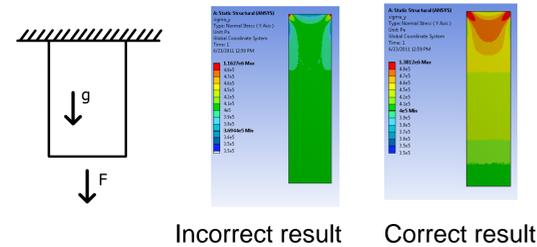
Pre-Analysis step	Verification & Validation step
Summarizes the mathematical model to be solved (boundary value problem etc.)	Checks software results through a formal process
Predicts the likely answer through back-of-the-envelope estimates	Checks results against the predictions in Pre-Analysis step

Courses Impacted



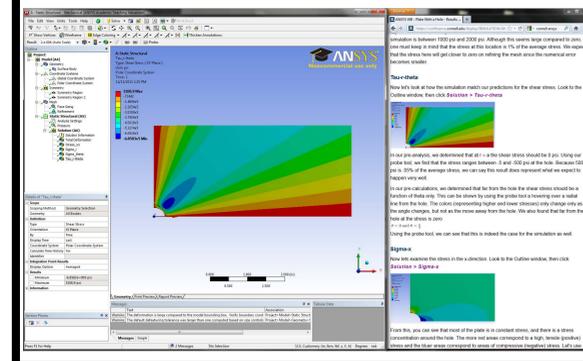
Fostering Results Critique

- Selected exercises provide students with FEA solutions in ANSYS to shift the focus to interpretation of results
- Homework requires students to critique the (incorrect) FEA solutions provided



SimCafe Wiki

- Contains software tutorials and homework problems <http://tinyurl.com/simcafe>
- Others can use content as is, adapt it or create new content
- 50,000 unique visitors from 126 countries in last six months



Major Issues to Resolve

- Assessment of impact on student learning
 - Where to focus efforts?
 - What assessment techniques to use?
- Implementation in courses
 - How to combine simulation with active learning techniques?
 - How to scale up to diverse institutions?
- Long-term sustainability
 - How to sustain efforts beyond the limited terms of grants?

Discussion

- Simulation technology offers exciting opportunities to advance students' problem solving and critical thinking skills
- "Expert vs. novice thinking" is an effective, general way to frame interventions
- Our learning process facilitates the progression of students from novices to engineers who can emulate the behavior of experts

Future work

- Develop *SimCafe* content and user base
- Help other faculty adopt our approach
 - Have developed a mailing list of 150 interested faculty from two workshops in 2008 and 2011
- Apply for TUES Type 2 grant from NSF

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