Re-developing Upper-level Electrodynamics using Physics Education Research

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University of Windsor
thinking forward

Learning activities & assessment linked to learning goals

Interactive demonstrations of how to translate a physical description of a problem to a mathematical equation

Students generate a midterm and final exam "formula sheet" to help them organize the knowledge from each unit.

Concept Diary: students explain the physical meaning of the formal and/or mathematical formulation of the solution. Peer reviewed double blind.

Homework opportunities to explore concepts and make connections across subject boundaries.

Problem solving scaffolds v1:
- A typical exam problem is given to the students who are asked to think about it and discuss in pre-assigned teams.
- Then they are given a hint sheet with the steps needed to take in order to complete the problem.
- The instructor circulates to ensure that the discussions stay focussed and to redirect the discussion if they are approaching the problem in a wrong or inefficient way.
- As the course progresses, the hints get fewer and less specific.

Problem solving scaffolds v2:
- Engage an 'expert' - a student who has taken the course in the past- to solve a problem similar to the one posed in the worksheet.
- The expert deconstructs the solution into steps, and this deconstructed sample will be given to the students via the course site.
- Gradually, the scaffold will be brought down, i.e., the steps will get fewer and less detailed.

Assessment of strategies:
- see if the students still require solutions of the homework problems
- reduction in time taken to complete a typical problem-solving activity
- normative feedback

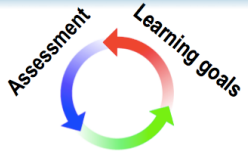
Motivation: The view from the top

Reinforce (explicitly) the applications of a concept to real-world devices/phenomena

Re-develop Lesson Plans with Engagement Strategies (Inspired by Dr. Don Woods)

- 20 minute lecture modules
- Active learning activities: group problem solving, think-pair-share, 'clicker' questions, kinesthetic activities, Applets/animations
- Periodic informal feedback (ombudsmen)
- Positive value reinforcement
- Course and class learning goals
- Synchronization of laboratory activities to "lecture" activities

Strategy



Learning activity/ Teaching method

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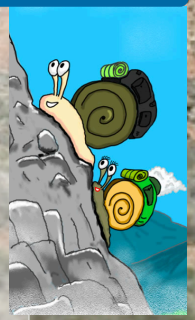
Engagement strategies

"[Electrodynamics] is like Severus Snape…" - Prof. S. Sigurdsson, Penn State Univ.

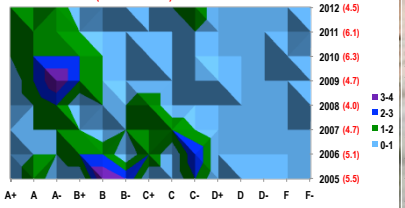
Challenging learning goals:

Students must…
- Acquire diverse mathematical knowledge set (vectors, differential equations, complex variables, special functions, tensors)
- Apply these mathematical techniques for solving problems
- Translate a physical problem to a mathematical model
- Evaluate mathematical methods and select the best technique to solve the problem.
- Critically interpret the mathematical results
- Organize this body of knowledge
- Make connections across subject boundaries



Outcomes

Grade Distribution (& SET scores) as a function of time and interventions



The course was taught with the traditional "chalk and talk" method plus homework problems from 2005-2008. Interventions were started in 2009 (scaffolding v.1) and modified in 2010 (scaffolding v.2). In 2012, the instructor slipped back into old "easy" habits due to increased administrative duties. Instructor SET scores, in red next to the year, clearly indicate the popularity of the teaching methods.

Instructor Reflection:

Students demonstrated improvement in both conceptual reasoning and in problem solving.

Instructor SET scores correlate well with student confidence (not asking for homework solutions), which in turn correlates well with the adopting of these engaging teaching methods.

Providing "example" problems with the scaffold alone is not useful – one has to assign similar problems for homework as well. This is difficult at this level since setting good problems is quite challenging.

A survey in 2010 indicated that students liked the "clicker" questions and think-pair-share the most among all the teaching methods.

Along with the "technical" teaching methods that are designed to improve understanding and retention, it is equally or more important to incorporate the "soft" teaching methods of student engagement, frequent feedback, motivation, etc.

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