Computer coaches for introductory physics problem solving: Research background

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Outline

- Part 1: Research background

- Part 2: Minnesota computer coaches

- Part 3: Upcoming research study

- Poster and demo of working coaches
  PST2 B17: Tonight 9:20 – 10:50 Exhibit Hall

Motivation and Problem

- What is problem solving?
  - "Problem solving is the process of moving toward a goal when the path to that goal is uncertain." (Martinez, 1998, p. 605)
- Problem solving skills are highly valued:
  - By employers (National Academies Press 2007) and educators (Carney 2006).
  - By other disciplines that require their students to take physics (Foster et al. 1998).
- However, many students emerge introductory physics courses not appreciably better at solving problems than when they entered.

Problem Solving Research

- Expert behavior v. novice behavior
- Cognition (use of representations, knowledge structures, cognitive load)
- Transfer of mathematics skills to physics contexts
- Curricular interventions (teaching methods, problem types)
- Computer modeling and tutorial systems

Expert-novice studies

- Experts:
  - Problem solving is a process of making a series of judicious decisions
  - Framework:
    - Create useful description
    - Plan solution based on general principles
    - Carry out plan
    - Evaluate solution (also intermediate steps)

- Novices:
  - Plunge directly into mathematical calculations
  - Do not evaluate progress or final answer

How to make novices more expert-like?

Cognitive Apprenticeship

- A model based on a traditional apprenticeship, but with elements of schooling (Collins, Brown, and Newman, 1989).
  - Modeling: teacher demonstrates the skill
  - Coaching: student practices while receiving guidance and feedback from teacher
  - Fading: teacher withdraws support, student works independently

- In an introductory physics class, the time available for students to practice solving problems while receiving guidance and feedback is severely limited!

Computer coaches

- When integrated into a cognitive apprenticeship framework, computer coaches can:
  - Make explicit an expert-like framework
  - Help with all three stages, modeling, coaching, and fading.
  - Provide students with individualized guidance and feedback
  - Be available to students at their convenience
  - Deliver reproducible instruction that can be improved systematically and used to investigate factors influencing students' learning of problem solving

Existing systems

- Computer homework systems (WebAssign, CAPA, etc.): Correct/incorrect feedback and hints

- Andes (VanLehn et al., 2005): Intensive feedback and guide through problems while allowing the student to work independently as much as possible

- Tycho (Stelzer and Gladding, 2001): Step-by-step heuristics

- Mastering Physics (Pritchard and Morote, 2002): Tutorial problems

Personal Assistants for Learning

- Designed within a cognitive apprenticeship framework (Reif and Scott, 1999)
- Based on a cognitive analysis (and prior investigations) of the thought processes required for applying physics principles to solving problems
- Used the instructional strategies of reciprocal teaching (Palincsar and Brown, 1984) and learning from well-studied examples (Zhu and Simon, 1987)