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)