Engaging Higher Order Thinking Skills with a Personalized Physics Tutoring System

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Research Goals
- Identify student weaknesses
- Offer individualized help
- Increase student confidence, engagement and performance in Physics, specifically Kirchhoff’s Rules

Pedagogical Design
- Four modes design based on Bloom’s Taxonomy
- Advanced modes designed to elicit higher order thinking skills
- Each mode involves exercises with three levels of difficulty
- Users placed into most appropriate mode, but has control to opt out

System Architecture
- Designed with 3 modules:
  - Domain – Physics content, solution graphs
  - Student – User knowledge and attitude, behavioural observations
  - Tutor – Expected utility calculations for best action

Student Module
- Formalized as a dynamic Bayesian network
- Models student mastery as well as attitudes
- Applies clique inference to estimate Pr(Knowledge,) and Pr(Neediness,)

Domain Module
- Encodes Physics problems as solution graphs
- Checks student answers to identify types of mistakes present

Tutor Module
- Uses information from other modules to find how to help
- Chooses from 3 possible actions:
  - Offer context-sensitive hint
  - Offer full explanation
  - Do nothing
- Uses maximum expected utility to make decisions

Pilot Study
- Tested with students enrolled in summer offering of PHYS 122
- Showed increase in student interest and confidence
- Knowledge gains: more practice leads to fewer mistakes

Simulation
- Tested ability to support different student types

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