Intelligent coaches for problem-solving in physics

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Motivation

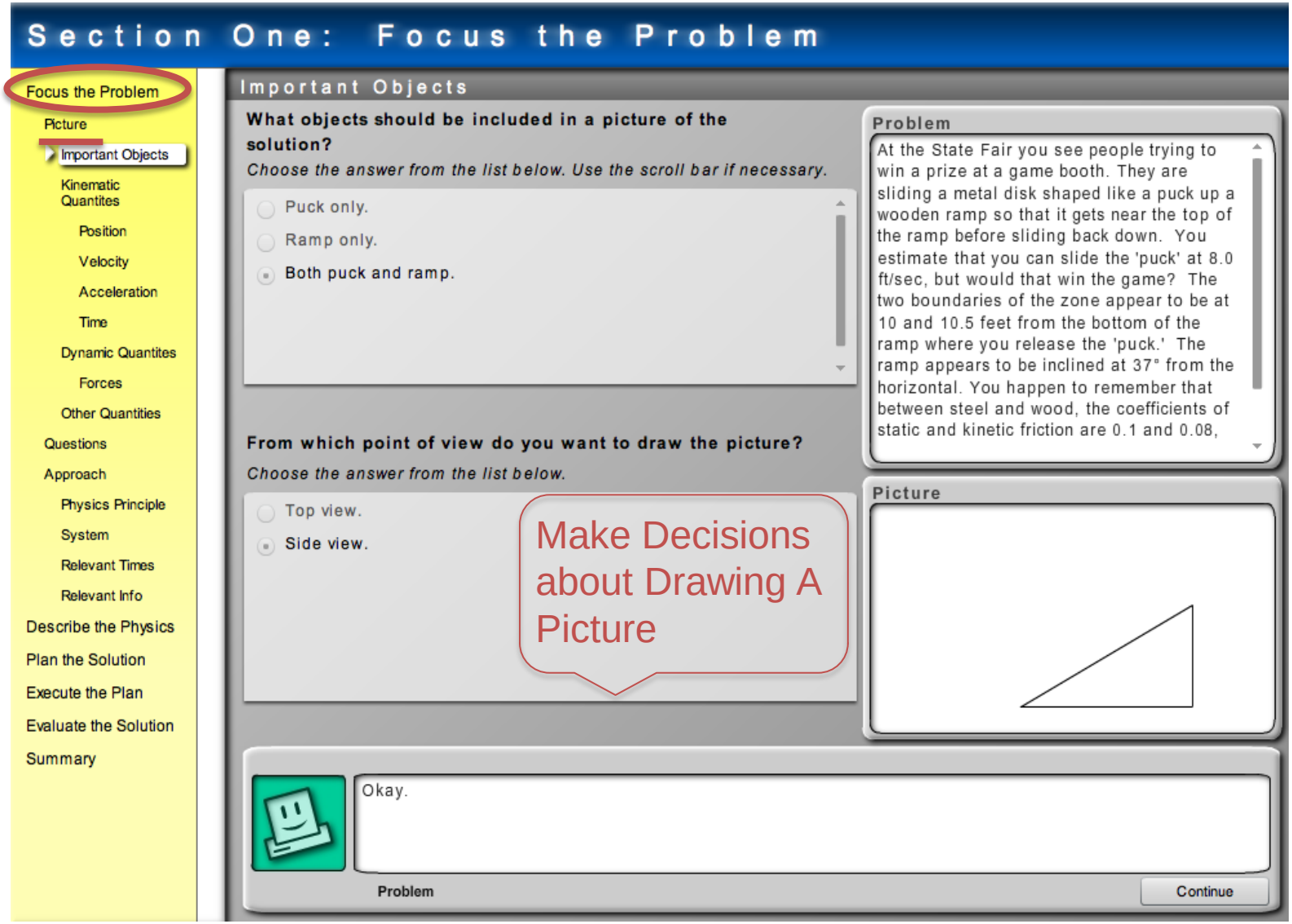
- Problem-solving is important and computers can help students to develop such skills
- Increasing prevalence of online learning emphasizes need for practical and effective online learning tools.
- Computers could provide more effective instruction to a more diverse student audience.

C_3PO: Customizable Computer Coaches for Physics Online

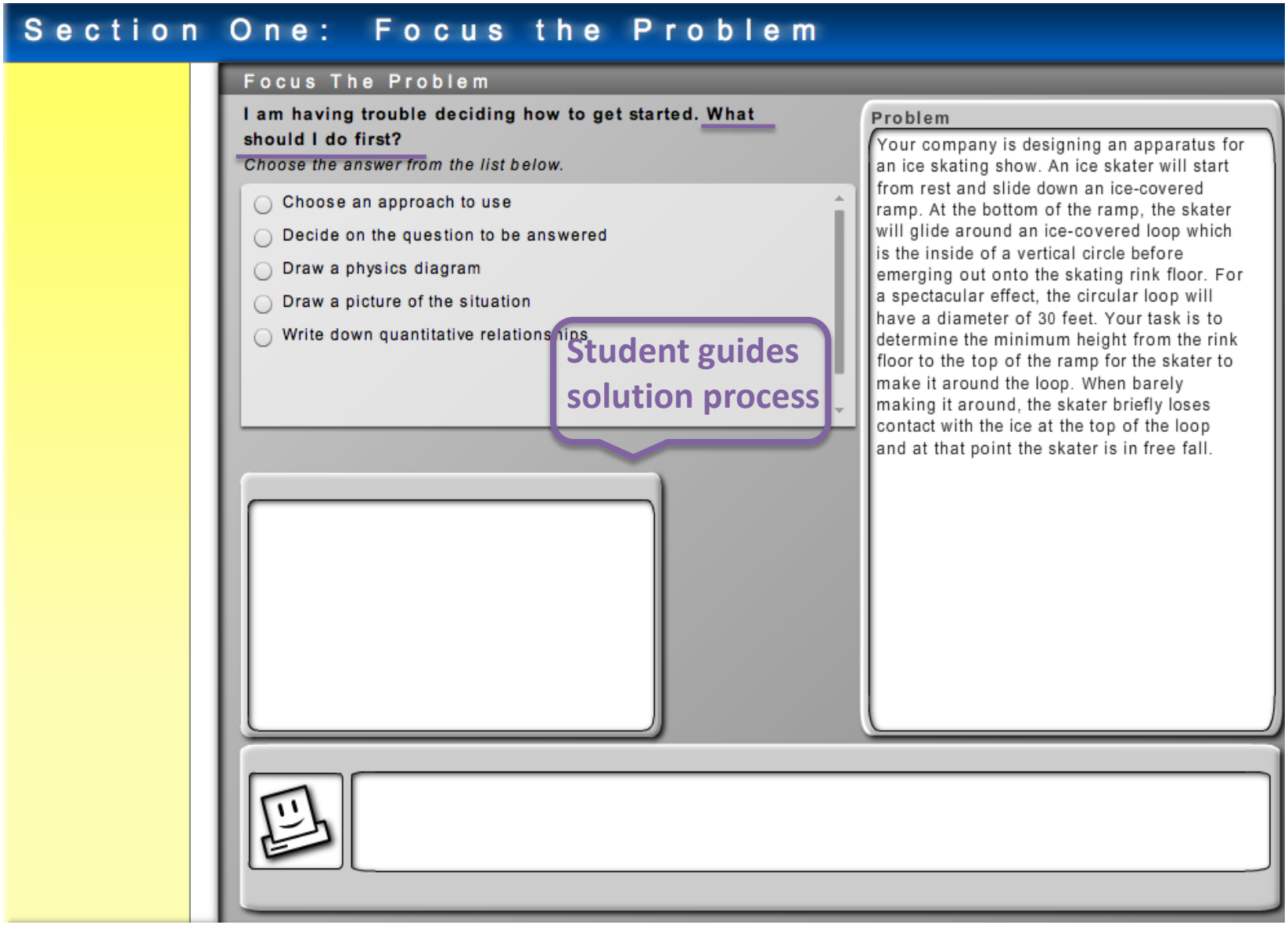
- Coaches students in the use of an expert-like decision-making framework for solving problems
  - Highly interactive
  - Emphasizes the explicit use of a general decision-making framework for all problems
  - Gives students guidance and feedback with flexible grain-sizing according to student preferences
  - Fully customizable by instructors according to their instructional environment and preferences

C_3PO Development process: Stage 1

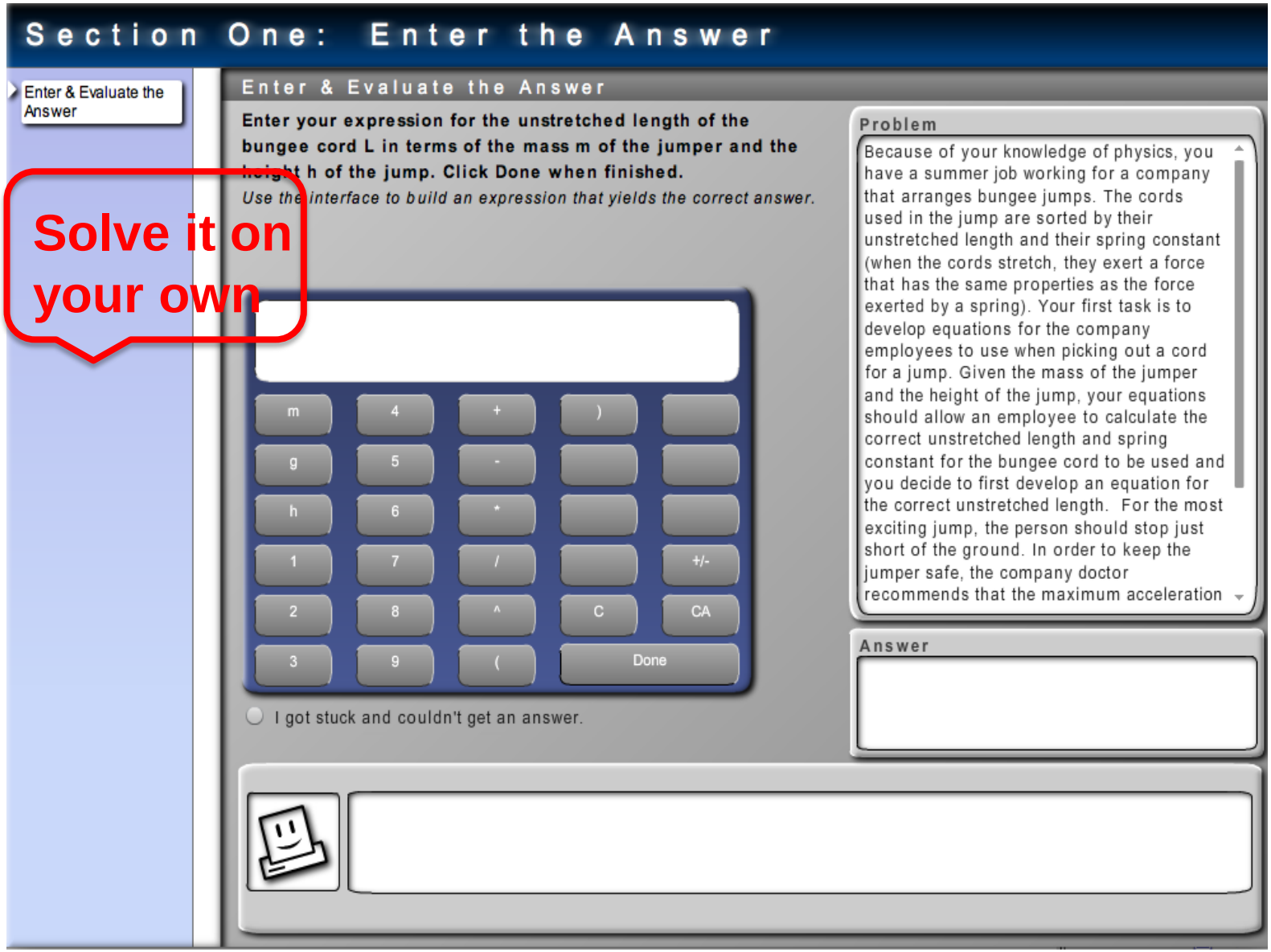
- Version 1.0 (Proof of principle with students)
  - Highly interactive
  - Emphasizes the explicit use of a general decision-making framework for all problems
  - Gives students guidance and feedback with flexible grain-sizing according to student preferences
  - Fully customizable by instructors according to their instructional environment and preferences
- Completed
  - Tested usability and educational impact with students in real classes
  - Achieved positive results (improvement in problem solving skills equivalent to one full letter grade on final exam)



Type 1: Computer (C) guides, student (S) decides, C assesses
Modeling, coaching



Type 2: S guides, C:student decides, S assesses, C:overseer assesses
(Reciprocal teaching, coaching)



Type 3: S works independently, C assesses and provides help as necessary (Fading, coaching as necessary)

C_3PO Development process: Stage 2

- Version 2.0 (Proof of principle with instructors)
  - Highly interactive
  - Emphasizes the explicit use of a general decision-making framework for all problems
  - Gives students guidance and feedback with flexible grain-sizing according to student preferences
  - Fully customizable by instructors according to their instructional environment and preferences **(using a GUI)**

- Currently in alpha version
- Details in next talk

Comparisons

- Web-based homework systems (WHS):
  - WebAssign (www.webassign.com)
  - Mastering Physics (www.masteringphysics.com; Pritchard and Morote, 2002)
  - Interactive Examples (www.smartPhysics.com)

- Strengths of WHS:
  - Large database of problems
  - Well-integrated with course management systems
- Shortcomings of WHS:
  - Do not include detailed coaching on the use of a generalizable decision-making framework
  - Assume that students are competent at creating and translating between various representations (pictures, diagrams, equations)

Comparisons

- Intelligent tutoring systems (ITS):
  - Andes (VanLehn et al., 2005)
  - ViPS (Virtual Physics System) (Myneni et al., 2013)
  - MATHEMA (Papadimitriou et al., 2009)

- Strengths of ITS:
  - Can interpret a wide variety of student responses
  - Use student responses to provide individualized guidance and feedback
- Shortcomings of ITS:
  - Do not include detailed coaching on the use of a general decision-making framework.
  - Difficult/impossible for an instructor to customize.

Summary

- The University of Minnesota Physics Education Research Group has been developing the C_3PO system (Customizable Computer Coaches for Physics Online)
  - Critical features are (1) coaching the use of a generalizable, expert-like, decision-making framework and (2) customizability by typical instructors.
  - The system aims to achieve effectiveness through careful instructional design, rather than sophisticated AI.
- Version 1.0 completed and tested
  - groups.physics.umn.edu/physed/prototypes.html
- Version 2.0 in development
  - Details in the next talk