Interactive Problem-Solving Tutorials

Computers coaching students

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Acknowledgements: Ken Heller, Kevin Crisp

Teaching problem solving

- Explicit teaching of expert-like strategies
  - Qualitative analysis (drawing pictures and diagrams)
  - Planning of a solution (stating concepts to be used)
  - Assessment of solution (checking final answer)

- Use of strategies modeled by instructor

- Students required to use strategies

One major difficulty

Lack of supervised practice time

Left to their own devices, many students revert to previously learned ineffective problem-solving methods.

Students need a coach!

A possible solution: Computers

Computers can:

- Actively coach students in using a competent problem-solving strategy
- Give students individualized feedback
- Give students immediate feedback
- Be available at students’ need

Existing systems

- WebAssign
- Physics homework service (University of Texas)
- WWWAssign
- CAHP (Computer Assisted Homework for Physics)
- CAPA (Computer-Assisted Personalized Approach)
- Cybertutor

These systems are all answer-driven, with no emphasis on process or problem-solving strategies.

Goal

To design a computer program to coach students in solving physics problems by using a competent problem solving strategy.

The program should:

- Make the problem-solving strategy explicit to students
- Be process-driven, rather than answer-driven
- Keep the student actively engaged in the problem-solving process
- Gradually fade the amount of coaching provided

Other desirable features

- Allow multiple solution paths
- Tailor feedback to both strong and weak students
- Require a minimum of interface instructions
- Allow student coaching of computer (reciprocal teaching)
- Be customizable for individual instructors

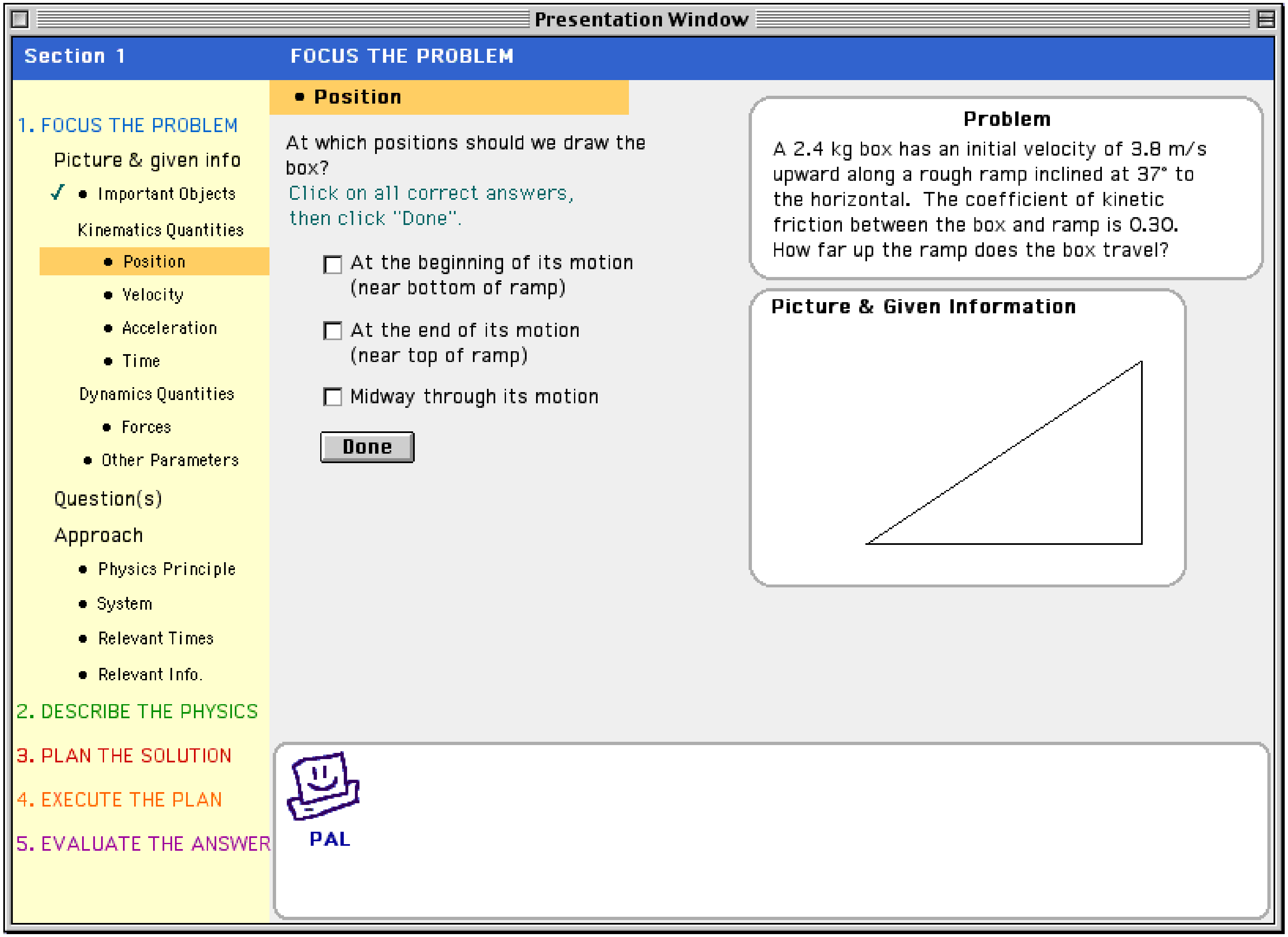
Prototype

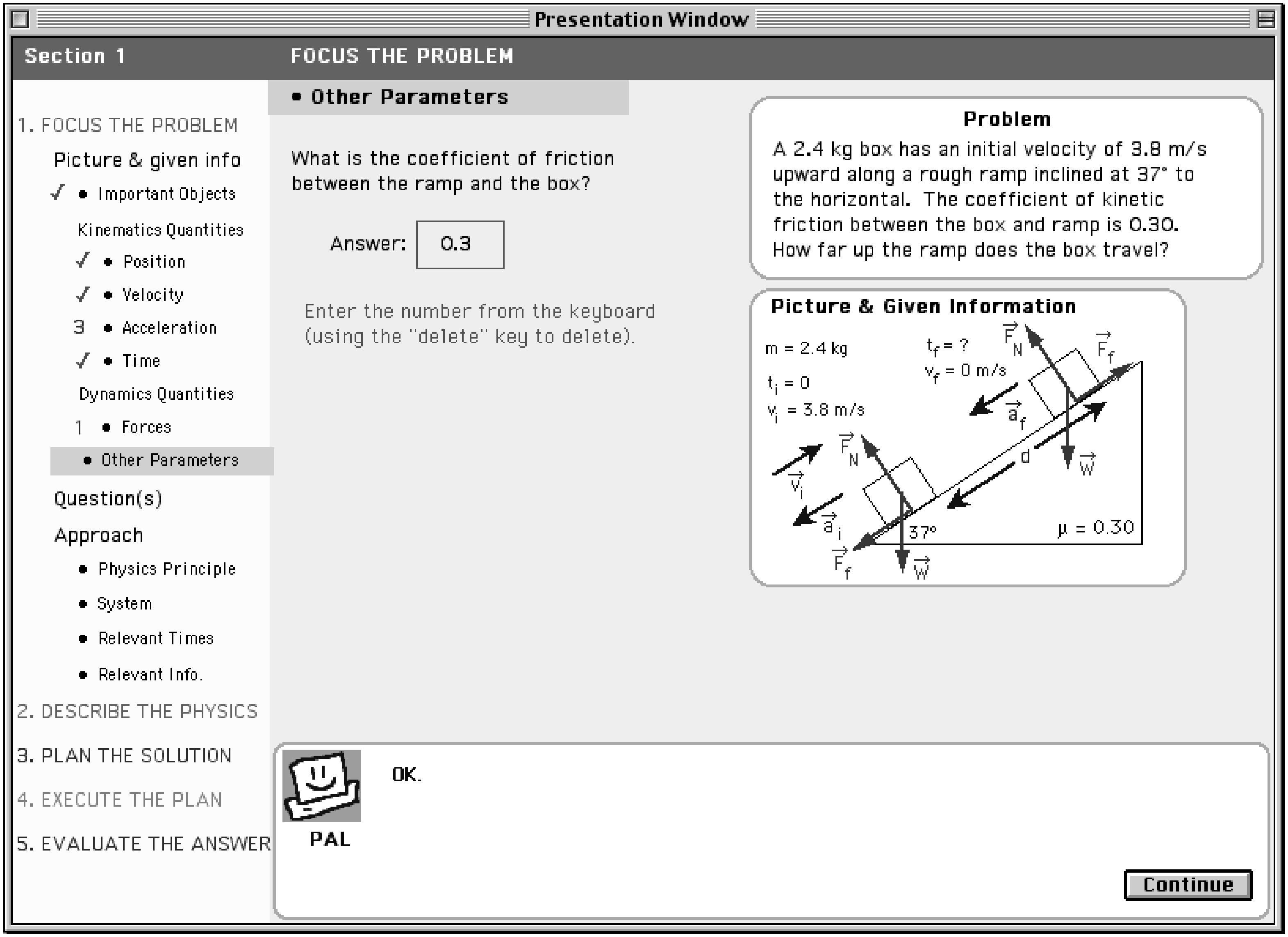
- Based on Fred Reif's PALs (Personal Assistants for Learning)

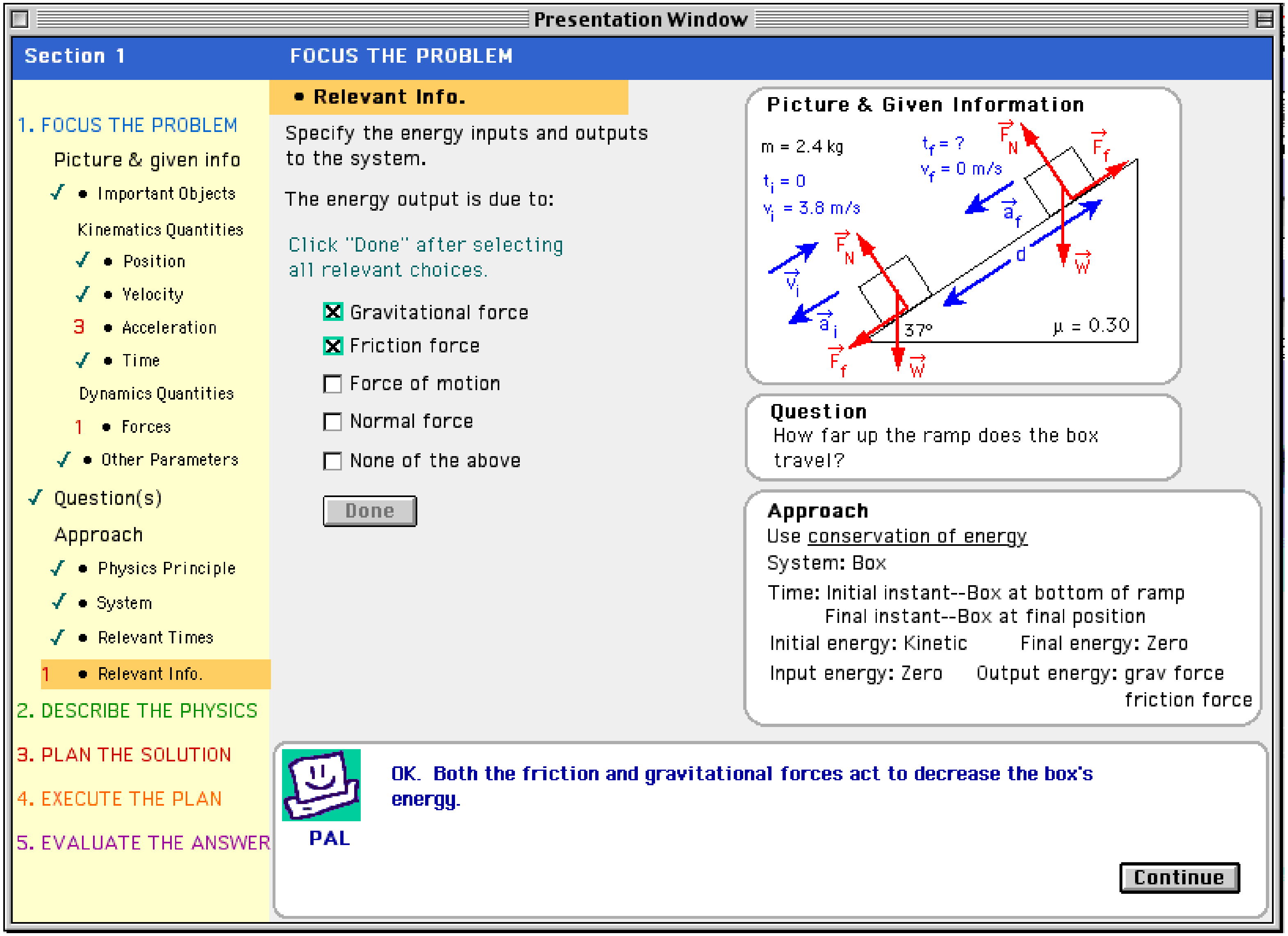
  (F. Reif and L. A. Scott, Am. J. Phys. **67**, 819 (1999).

- Based on the Minnesota Competent Problem-Solving Strategy

  K. Heller and P. Heller, *The Competent Problem Solver, calculus version, 2ed.* (Minneapolis, MN: McGraw-Hill Primis Custom Publishing, 1997).


Presentation Window
Section 1
FOCUS THE PROBLEM
1. FOCUS THE PROBLEM
Picture & given info
✓ • Important Objects
Kinematics Quantities
• Position
• Velocity
• Acceleration
• Time
Dynamics Quantities
• Forces
• Other Parameters
Question(s)
Approach
• Physics Principle
• System
• Relevant Times
• Relevant Info.
2. DESCRIBE THE PHYSICS
3. PLAN THE SOLUTION
4. EXECUTE THE PLAN
5. EVALUATE THE ANSWER
• Position
At which positions should we draw the box?
Click on all correct answers, then click "Done".
At the beginning of its motion (near bottom of ramp)
At the end of its motion (near top of ramp)
Midway through its motion
Done
Problem
A 2.4 kg box has an initial velocity of 3.8 m/s upward along a rough ramp inclined at 37° to the horizontal. The coefficient of kinetic friction between the box and ramp is 0.30. How far up the ramp does the box travel?
Picture & Given Information
PAL


Presentation Window
Section 1
FOCUS THE PROBLEM
• Other Parameters
1. FOCUS THE PROBLEM
Picture & given info
✓ • Important Objects
Kinematics Quantities
✓ • Position
✓ • Velocity
3 • Acceleration
✓ • Time
Dynamics Quantities
1 • Forces
• Other Parameters
Question(s)
Approach
• Physics Principle
• System
• Relevant Times
• Relevant Info.
2. DESCRIBE THE PHYSICS
3. PLAN THE SOLUTION
4. EXECUTE THE PLAN
5. EVALUATE THE ANSWER
What is the coefficient of friction between the ramp and the box?
Answer: 0.3
Enter the number from the keyboard (using the "delete" key to delete).
Problem
A 2.4 kg box has an initial velocity of 3.8 m/s upward along a rough ramp inclined at 37° to the horizontal. The coefficient of kinetic friction between the box and ramp is 0.30. How far up the ramp does the box travel?
Picture & Given Information
m = 2.4 kg
t_f = ?
v_f = 0 m/s
t_i = 0
v_i = 3.8 m/s
d
37°
μ = 0.30
OK.
PAL
Continue


Presentation Window
Section 1
FOCUS THE PROBLEM
• Relevant Info.
1. FOCUS THE PROBLEM
Picture & given info
✓ • Important Objects
Kinematics Quantities
✓ • Position
✓ • Velocity
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✓ • Time
Dynamics Quantities
1 • Forces
✓ • Other Parameters
✓ Question(s)
Approach
✓ • Physics Principle
✓ • System
✓ • Relevant Times
1 • Relevant Info.
2. DESCRIBE THE PHYSICS
3. PLAN THE SOLUTION
4. EXECUTE THE PLAN
5. EVALUATE THE ANSWER
Specify the energy inputs and outputs to the system.
The energy output is due to:
Click "Done" after selecting all relevant choices.
☒ Gravitational force
☒ Friction force
☐ Force of motion
☐ Normal force
☐ None of the above
Done
Picture & Given Information
m = 2.4 kg
t_f = ?
v_f = 0 m/s
t_i = 0
v_i = 3.8 m/s
F_N
F_f
a_f
W
d
v_i
a_i
37°
μ = 0.30
Question
How far up the ramp does the box travel?
Approach
Use conservation of energy
System: Box
Time: Initial instant--Box at bottom of ramp
Final instant--Box at final position
Initial energy: Kinetic
Final energy: Zero
Input energy: Zero
Output energy: grav force
friction force
OK. Both the friction and gravitational forces act to decrease the box's energy.
PAL
Continue

Development plans

- Complete programming of two tutorials
- Test tutorials with a small number of students (Fall 2002)
- Refine tutorials
- Create larger set of 5 to 7 tutorials
- Test tutorials with a small number of students
- Further refine tutorials
- Test tutorials with an entire introductory physics class

Suggestions welcome!