PROBLEM SOLVING COACHES IN PHYSICS TUTORING

PART 2: DESIGN AND IMPLEMENTATION

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- Cognitive Apprenticeship (3 types of coaching)
- Problem-solving Framework (Expert v.s. Novices)
- Minimize cognitive load
- Evaluation method (PS rubric)

Pedagogical Principle

- Appropriate problems
- Important Physics approaches
- Useful techniques

Physics Principle

Design

Software Principle

- Simulates office hour coaching
- Allow maximum decision-making (multi-step problems)

--- Branching

- PER input– knowledge on students' problem solving difficulties
- Pragmatic considerations
- minimize students' annoyance

- Naturalistic Visualization (looks similar to written solutions)
- Internet Accessibility
- Reviews available

Implementation

3 Prototypes – flash module

- Action Script source code
- FLA file (contains all the movie clips and pictures)
- XML files (text information about questions & responses)

Duplicate

- Choose problems & write Scripts
- create/modify all the movie clips and pictures in FLA file
- modify text information about questions & responses in XML files

- *Going back and forth within prototype setup*
- *Going back and forth within duplicating*
- *Going back and forth between prototype & duplicating*

WHAT WE HAD

- 8 COE problems in Authorware

WHAT WE WANT

- Physics Principles planned (~ 8 tutors each):
  - Kinematics
  - Dynamics
  - Conservation of Energy
  - Conservation of Momentum
  - Rotational motion

WHERE WE ARE

- 3 COE prototypes built in Flash
- several other COE modules duplicated
- scripts for dynamics and COM

Diagram Topic Subtopic Left Right Note Hyperlink WordGuide Transfer

Sliding Puck

+ Problem data
+ script notes:
+ FOCUS THE PROBLEM
+ DESCRIBE THE PHYSICS
  + Beginning of section
    - Display completed Picture, Question, and appropriate Approach box
  + Diagrams & define quantity(ies)
    - Apply orange highlight to corresponding step in index bar
    - Move in short banner: <• Diagrams & define quantity(ies)>
    + If working on kinematics approach
    + If working on dynamics approach
    + If working on COE approach
    - Picture box is erased.
    - Diagram box moves to Picture box position.
    - Delete short banner
    - Delete orange highlighting in index bar
  + Target quantity(ies)
  + Quantitative relationships
  + End of section
    - Cover workspace (but not index bar with red numbers and green checkmarks) with feedback box.
    - Display
      This is the end of section 2.

      The numbers in red beside each step indicate the number of errors you made in that section. You may want to consult with a TA or the instructor if there is anything you have questions about.

      At any time, you can access any of the diagrams you drew in the section through the **Review** menu.
+ PLAN THE SOLUTION
+ EXECUTE THE PLAN
+ EVALUATE THE ANSWER
+ Display solution summary

+ DESCRIBE THE PHYSICS

  + Beginning of section

    - Display completed Picture, Question, and appropriate Approach box

  + Diagrams & define quantity(ies)

    - Apply orange highlight to corresponding step in index bar

    - Move in short banner: <• Diagrams & define quantity(ies)>

    + If working on kinematics approach

    + If working on dynamics approach

    + If working on COE approach

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Section One: Focus the Problem

Position

What lengths or distances have specifically to do with the solution of this problem?

Check the correct answer(s).

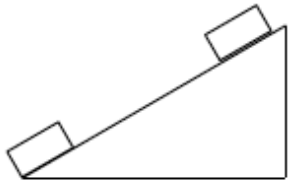
- ☐ Distance traveled by the puck
- ☐ Total length of the ramp
- ☐ Total height of the ramp
- ☐ Length of the puck

Done

Problem

At the State Fair you see people trying to win a prize at a game booth. They are sliding a metal disk shaped like a puck up a wooden ramp so that it gets near the top of the ramp before sliding back down. You estimate that you can slide the 'puck' at 8.0 ft/sec, but would that win the game? The two boundaries of the zone appear to be at 10 and 10.5 feet from the bottom of the ramp where you release the 'puck.' The ramp appears to be inclined at 37° from the horizontal. You happen to remember that between steel and wood, the coefficients of static and kinetic friction are 0.1 and 0.08,

Picture



Problem

Section One: Focus the Problem

- Focus the Problem
  - Draw a Picture
  - Decide on the Question
  - Choose an Approach
- Describe the Physics
- Plan the Solution
- Execute the Plan
- Evaluate the Solution
- Summary

Draw a Picture

I am having trouble deciding how to get started. What should I do first?

Choose the answer from the list below.

- Choose an approach to use
- Decide on the question to be answered
- Draw a physics diagram
- Draw a picture of the situation
- Write down quantitative relationships

Problem

You work for a company that is designing an apparatus for an ice skating show. An ice skater will start from the rest and glide down an ice-covered ramp. At the bottom of the ramp, the skater will then glide around an ice-covered loop which is the inside of a vertical circle. After going around the vertical circle, the skater emerges at the bottom to glide out onto the skating rink floor. For a spectacular effect, the circular loop will have a diameter of 30 feet. Your task is to determine the minimum height from the rink floor to the top of the ramp for the skater to make it around the loop. To just barely make it around, the skater loses contact with the ice at the top.

Picture

OK.

Reference

Continue

Section One: Enter the Answer

Enter & Evaluate the Answer

Enter & Evaluate the Answer

Enter your expression for the unstretched length of the bungee cord ℓ in terms of the mass m of the jumper and the height h of the jump. Click Done when finished.

Use the interface to build an expression that yields the correct answer.

m	4	+	)	
g	5	-		
h	6	*		
1	7	/		+/-
2	8	^	C	CA
3	9	(	Done	

I got stuck and couldn't get an answer.

Problem

Because of your knowledge of physics, you have a summer job working for a company that arranges bungee jumps. The cords used in the jump are sorted by their unstretched length and their spring constant (when the cords stretch, they exert a force that has the same properties as the force exerted by a spring). Your first task is to develop equations for the company employees to use when picking out a cord for a jump. Given the mass of the jumper and the height of the jump, your equations should allow an employee to calculate the correct unstretched length and spring constant for the bungee cord to be used and you decide to first develop an equation for the correct unstretched length. For the most exciting jump, the person should stop just short of the ground. In order to keep the jumper safe, the company doctor recommends that the maximum acceleration

Answer

Help Section: Focus the Problem

Picture and Question

The first step in the problem-solving framework is to Focus the Problem, drawing a picture and deciding on the question. Do you want help with this? (If you're not sure, choose "No" and I'll check your work for this section.)

Choose the answer from the list below.

- Help
- No help

Problem

Because of your knowledge of physics, you have a summer job working for a company that arranges bungee jumps. The cords used in the jump are sorted by their unstretched length and their spring constant (when the cords stretch, they exert a force that has the same properties as the force exerted by a spring). Your first task is to develop equations for the company

Picture

Question

CONTEXT-RICH PROBLEMS

- Your friend has just been in a traffic accident and is trying to negotiate with the insurance company of the other driver to pay for fixing her car. She believes that the other car was speeding and therefore the accident was the other driver's fault. She knows that you have a knowledge of physics and hopes that you can prove her conjecture. She takes you out to the scene of the crash and describes what happened. She was traveling North when she entered the fateful intersection. There was no stop sign, so she looked in both directions and did not see another car approaching. It was a bright, sunny, clear day. When she reached the center of the intersection, her car was struck by the other car which was traveling East. The two cars remained joined together after the collision and skidded to a stop. The speed limit on both roads entering the intersection is 50 mph. From the skid marks still visible on the street, you determine that after the collision the cars skidded 56 feet at an angle of 30o north of east before stopping. She has a copy of the police report which gives the make and year of each car. At the library you determine that the weight of her car was 2600 lbs and that of the other car was 2200 lbs, where you included the driver's weight in each case. The coefficient of kinetic friction for a rubber tire skidding on dry pavement is 0.80. It is not enough to prove that the other driver was speeding to convince the insurance company. She must also show that she was under the speed limit.

- Minor superficial changes

Your friend has just been in a traffic accident and hopes that you can show the accident was the other driver's fault. Your friend's car was traveling North when it entered the intersection. When it reached the center of the intersection, the car was struck by the other driver's car which was traveling East. The two cars remained joined together after the collision and skidded to a stop. The speed limit on both roads is 50 mph. From the skid marks still visible on the street, you determine that after the collision the cars skidded 56 feet at an angle of 30° North of East before stopping. The police report gives the make and year of each car. The weight of your friend's car is 2600 lbs and that of the other car is 2200 lbs, including the driver's weight in each case. The coefficient of kinetic friction for a rubber tire skidding on dry pavement is 0.80. You decide to see if the other driver was speeding and if your friend was under the speed limit.

PLAN FOR PILOT STUDY

Purpose: get to know the procedure of doing the real study; think about all the possible problems one can meet during the real study

Procedure: same procedure as the real study, smaller number of students, no random assignment to control and treatment group.

PLAN FOR FULL STUDY

- Number of students needed (30~50 for each group)
- Random assignment
  - Pair match
  - Random assignment within groups
- Treatment and Control
  - Treatment—PhysicsTutor, 2 or 3 problems per week
  - Control– normal class setting
- Data collection
  - Written solutions on quizzes & final exam
  - $2\times4+5=13$ for each student

EVALUATING PROBLEM-SOLVING
(DOCKTOR 2009)

- Objective procedure developed to evaluate student problem solutions
  - Validity measured in several different forms
  - Reliability rating found to be good with a minimal level of training
  - Will use on student solutions during semester of tutor use by students
- Five rubric categories
  - Useful Description
  - Physics Approach
  - Specific Application of Physics
  - Mathematical Procedures
  - Logical Progression

	5	4	3	2	1	0	NA(Problem)	NA(Solver)
USEFUL DESCRIPTION	The description is useful, appropriate, and complete.	The description is useful but contains minor omissions or errors.	Parts of the description are not useful, missing, and/or contain errors.	Most of the description is not useful, missing, and/or contains errors.	The entire description is not useful and/or contains errors.	The solution does not include a description and it is necessary for this problem /solver.	A description is not necessary for this problem. (i.e., it is given in the problem statement)	A description is not necessary for this solver.
PHYSICS APPROACH	The physics approach is appropriate and complete.	The physics approach contains minor omissions or errors.	Some concepts and principles of the physics approach are missing and/or inappropriate.	Most of the physics approach is missing and/or inappropriate.	All of the chosen concepts and principles are inappropriate.	The solution does not indicate an approach, and it is necessary for this problem/ solver.	An explicit physics approach is not necessary for this problem. (i.e., it is given in the problem)	An explicit physics approach is not necessary for this solver.
SPECIFIC APPLICATION OF PHYSICS	The specific application of physics is appropriate and complete.	The specific application of physics contains minor omissions or errors.	Parts of the specific application of physics are missing and/or contain errors.	Most of the specific application of physics is missing and/or contains errors.	The entire specific application is inappropriate and/or contains errors.	The solution does not indicate an application of physics and it is necessary.	Specific application of physics is not necessary for this problem.	Specific application of physics is not necessary for this solver.
MATHE-MATICAL PROCEDURES	The mathematical procedures are appropriate and complete.	Appropriate mathematical procedures are used with minor omissions or errors.	Parts of the mathematical procedures are missing and/or contain errors.	Most of the mathematical procedures are missing and/or contain errors.	All mathematical procedures are inappropriate and/or contain errors.	There is no evidence of mathematical procedures, and they are necessary.	Mathematical procedures are not necessary for this problem or are very simple.	Mathematical procedures are not necessary for this solver.
LOGICAL PROGRESSIO N	The entire problem solution is clear, focused, and logically connected.	The solution is clear and focused with minor inconsistencies	Parts of the solution are unclear, unfocused, and/or inconsistent.	Most of the solution parts are unclear, unfocused, and/or inconsistent.	The entire solution is unclear, unfocused, and/or inconsistent.	There is no evidence of logical progression, and it is necessary.	Logical progression is not necessary for this problem. (i.e., one-step)	Logical progression is not necessary for this solver.

EVALUATION & FUTURE DIRECTIONS

- Will students use them?
- Do they improve students' problem solving skills?

- Are they easily adaptable to be used in teaching other physics courses?
- Can this software be easily modified by faculty to fit their teaching style?

- Special thanks:
  - Erik Hoover (main Flash programmer)
  - all other programmers

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THANK YOU!