ED03
Why Solve Problems? - Part 1: Designing an Interview for Instructors*

Edit Yerushalmi

Ken Heller, Patricia Heller, Charles Henderson, Vince Kuo

University of Minnesota

http://www.physics.umn.edu/groups/physed/

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Rationale for Study

Wide agreement:

- Traditionally physics is taught by solving problems
- Many students cannot solve traditional problems
- Many of those who can do not understand the underlying physics concepts [McDermott, 1984, Halloun & Hestenes, 1985]

Research based curricular efforts:

- Directly building students' conceptual knowledge
  [Mazur et al - Peer Instruction, McDermott et al - Tutorials]
- Developing student problem solving skills
  [Heller et al - CGPS, Mestre et al - MOP, Reif et al - PALs, Van Heuvlen - OCS]

Instructors' practice: Reflect some aspects of research based curricula. Yet, seldom are they fully implemented

Reflects tension between those who shape the learning environment

Curriculum developers

Learning vision

Control artifacts

Complain about instruction

Instructors

Teaching realities

Control schedules, roles

Complain about curriculum

$$\chi$$

Instructor independent curricula

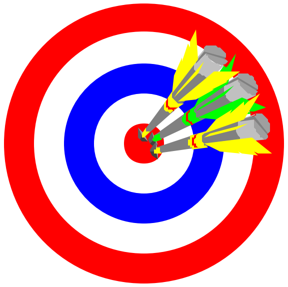
No instructor or instructor proof

Instructor dependent curricula

Need for communication, is there a common language?

E.g. What is a “problem”?

Research defined terms ??



Focus of study:

Faculty beliefs about learning and teaching of **problem solving**

1st stage: Elicit parameters for instructional choices

⇒ Interview sample (Minnesota sample)

2nd stage: Map parameters into the community

⇒ Directed survey (National sample)

Goal: Use results to

- Clarify language and promote instructors' discussion
- Match curricular design to instructors concerns
- Determine possible professional development

Research method

Caution!! Schoenfeld: Different instructor beliefs are activated by different events in actual practice.

⇒ **Beware of general setting!**

Capture instructors' rationale for their choices by inducing reflection on practice through comparisons between variety of curricular artifacts

Interview artifacts: More from less

"Universal": Range of common instructional practices

Range of problem solving processes (research based)

- 5 **problems** (same physics situation)
- 3 **instructors' solutions** (to 1st problem)
- 5 **students' solutions** (to 1st problem)

Note similarities to preconceptions research

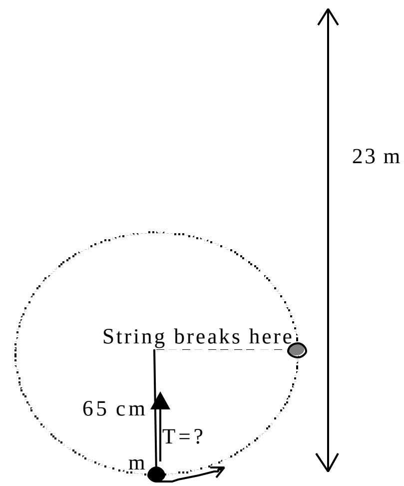
Problems

Verbal

You are **whirling a stone tied to the end of a string** around in a **vertical circle** having a **radius** of 65 cm. You wish to whirl the stone fast enough so that when it is **released at the point where the stone is moving directly upward,** it will **rise to a maximum height of 23 meters above the lowest point in the circle**. In order to do this, **what force will you have to exert on the string when the stone passes through its lowest point** one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the **end of the string at a fixed position**. Assume also that air resistance can be neglected. **The stone weighs** 18 N.

Schematic + Stepped

A 1.8 kg mass is attached to a frictionless pivot point…



A) What velocity, v_1, must the stone have when released in order to rise to 23 meters above the lowest point in the circle?

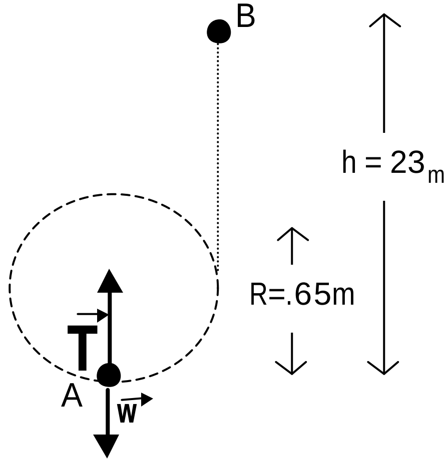
B) ...

C) ...

+ Multiple-choice, "Real-world" context, & Qualitative

Instructor solutions

Bare bones



The tension does no work

Conservation of energy between point A and B

$Mv_A^2/2 = mgh$

$V_A^2 = 2gh$

At point A, Newton's 2nd Law gives us:

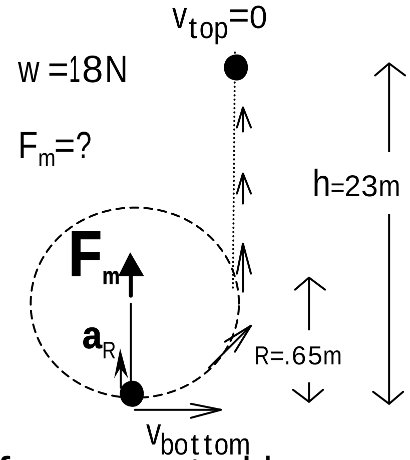
T- w = ma

$T - w = mv_A^2/R$

$T = 18_N + 2 \cdot 18_N \cdot 23_m / .65_m =$ 1292N

+ Detailed presentation

Decision making process



Approach:

I need to find F_m, force exerted by me

A)...

B) I can relate v_b to v_t using either

i) energy, ii) Dynamics and kinematics

ii) Messy since forces/accelerations change through the circular path.

i) I can apply work-energy theorm for stone. Path has 2 parts: ...

Execution:

A) Relate T_b to v_b: $\sum F_R = ma_R$

...

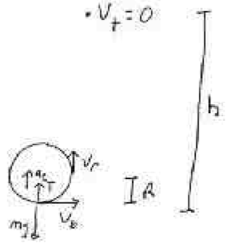
1292N

Large compared to weight

Check limits: $T_b \uparrow$ as R $\downarrow$

Student solutions

Reasoned, wrong



$V_t = 0$
$V_r = ?$
$V_b = ?$
$T = ?$
$mg = 18N$
$h = 23m$
$R = 0.65m$

Find velocity to reach height (Free Fall)

$$v^2 - v_0^2 = 2a(y - y_0)$$

~~$0 - v_t^2 = 2(-g)(h)$~~

$$0 - v_r^2 = 2(-g)(h-R)$$

$$v_r = \sqrt{2g(h-R)}$$

$$= \sqrt{2 \cdot 9.8\,m/s^2 \cdot (23-0.65)m} \qquad \sqrt{m/s^2 \cdot m} = m/s$$

$$= 20.9\,m/s$$

It can't be that $V_r = V_b$ but I don't know how to relate them. If $v_r = v_b$, then:

Find Force

$$\Sigma \vec{F} = m\vec{a}$$

$$T - mg = ma_c$$

uses $V_{release}$ instead of V_{bottom}

$$N + \frac{N}{m/s^2} \cdot \frac{m^2/s^2}{m} = N$$

$$T = mg + \frac{mv_r^2}{R} = 18N + \frac{\frac{18N}{9.8\,m/s^2}(20.9\,m/s)^2}{0.65m}$$

Force exerted by me $= 1256N$

Looks large, but stone needs to go up far

Short, correct?

$$V^2 = 2gh$$

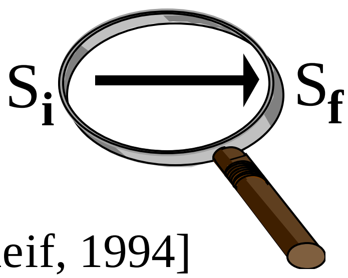
$$F - mg = \frac{m\,2gh}{R}$$

$$F = 18 + \frac{2 \cdot 18 \cdot 23}{.65} = 1292\,N$$

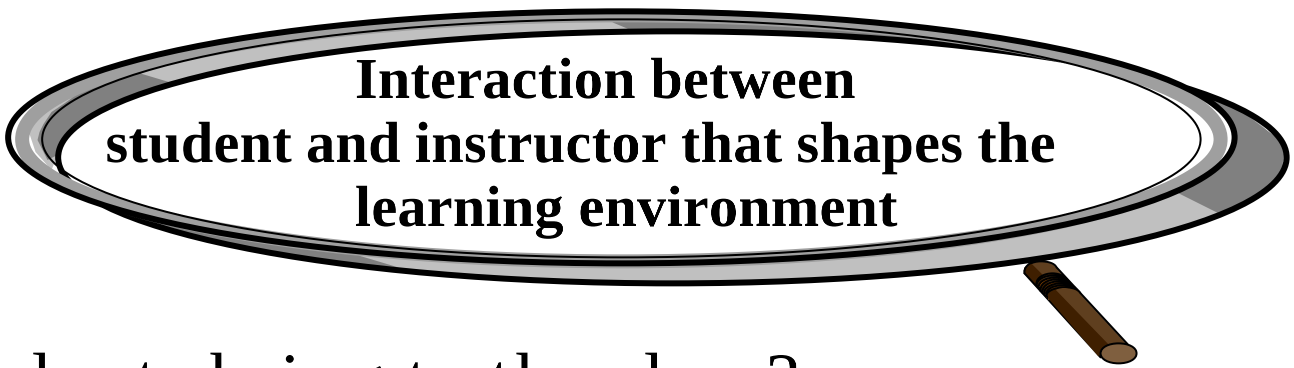
+ 3 others: all 5 are based on actual student solutions from final exam at the University of Minnesota

"Research" → Interview questions

Goal: To find out instructors' teaching models



[Reif, 1994]



S_i What students bring to the class?

→ What instructors do to promote learning?

What students do to learn?

S_f What students take from class?

All in respect to problem solving

Constraints on teaching model

Structure of the interview

Homework problem. 1½ hours, four parts.

1st) **Instructor solutions**: Focus on instructor, correct solution

2nd) **Student solutions**: What students give to instructors

3rd) **Problems**: Expand to different problems

Story line anchored in instructor practice.

In all 3 parts:

How and why artifact is used?

- Abstract
- Concrete

Reflect on students' problem solving based on artifacts

each problem solving feature on separate index card

4th) Instructor sorts index cards into categories of their choice

Questions regarding these categories

Administration of interview

Physics faculty in Minnesota, taught introductory calculus-based physics course in the last 5 years, could be visited and interviewed in a single day, randomly selected (107 possible).

Final sample: 31 faculty members (From 36 contacted 5 declined to be interviewed).

Roughly divided between:
1) Community College
2) Private College
3) Research University
4) State College

Many did not want to quit interview after 1½ hours

Great, we have a lot to say

Oh no!! They are trying to look into on my mind

	Students	**Instructors**
Study	Pre-conceptions	Conceptions
Debate	Theories vs. P-primes	Models vs. Fragments
Agree	**Should be taken into account**	

Lessons from pilot testing

In pilot versions the interview consisted of several parts,
Each consisted of set of questions around type of artifact

Difficulties and refinements:

1) Different teaching models evoked in different interview parts

$\Rightarrow$ **Represent research questions in all interview parts**

2) Problem moderately difficult for students can't be instantaneously solved by instructors

$\Rightarrow$ **sending the problem prior to the interview**

3) Range of artifacts makes it hard to keep the faculty attention

$\Rightarrow$ **Limit # of artifacts and design coherent story line**

Example - Part 1, Instructor solution

Q1: In what situations [during lecture, after test...] are students provided with examples of solved problems in your class. How does this work?

Q2: How would you like your students to use the solved examples you give them in these different situations? Why?

Q3: Scan through each of these instructor solutions. Please describe how these solutions are similar or different to your solutions. Please explain your reasons for writing solutions the way you do.

Q4: Looking at the instructor solutions, what aspects/components that you consider important in problem solving are represented in these instructor solutions, and what aspects are not represented?