"I Like These Problems But I Can't Use Them on My Test"
How Instructors Lower the Bar for Student Performance

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RATIONAL

The structure of problems influence how students approach both the subject matter and the problem solving process.
What problem features do physics instructors see as appropriate for an introductory calculus based physics course?
What are their considerations to use or to give up different problem features in different circumstances?

RESEARCH DESIGN

Part of an artifact based interview with 30 physics faculty (Community College, Primarily Undergraduate Private, Research Oriented State, and Primarily Undergraduate State). Randomly selected from a pool of 107 tenured or tenure-track faculty who had taught an introductory calculus-based physics course within the last five years and could be visited by an interviewer in a single day trip from the University of Minnesota.

Interview question: "Here are several possible ways of asking problems around the same physical situation. Please describe how these problems are similar or different to problems you give to your students. Please explain why you use the problems that you use."
(comparison between series of authentic instructional artifacts allows interviewees to reflect and explicate their thoughts)

Problem A vs. homework Problem:

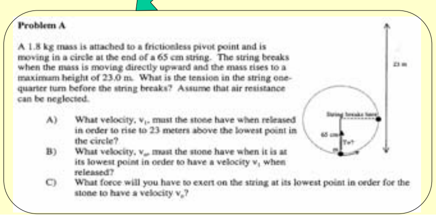
Differences in problem structure:
Does not have real life context / motivation
Broken into parts
Includes a drawing

Differences in solver approach:
Homework problem requires re-describing the problem in physics terms that maybe useful in solving it, and planning (e.g. forming sub-problems), while problem A provides those.

Problem D vs. homework problem:

Difference in problem structure:
"qualitative": Requires to identify change in variables and to draw acceleration and force vectors at certain points along the path described in homework problem.

Differences in solver approach:
Problem D requires an understanding of how the physics entities (velocity, acceleration and force) relate to each other in different parts of the motion, while the homework problem focuses on the computational aspect and can bypass such understanding.

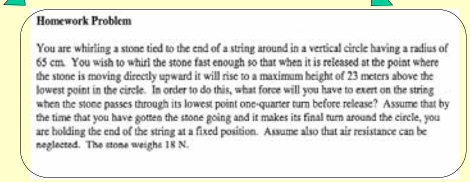

Problem A

A 1.8 kg mass is attached to a frictionless pivot point and is moving in a circle at the end of a 65 cm string. The string breaks when the mass is moving directly upward and the mass rises to a maximum height of 23.0 m. What is the tension in the string one-quarter turn before the string breaks? Assume that air resistance can be neglected.

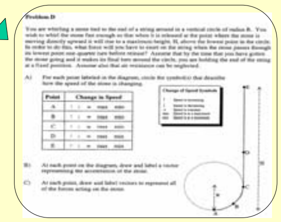
A) What velocity, v_1, must the stone have when released in order to rise to 23 meters above the lowest point in the circle?

B) What velocity, v_o, must the stone have when it is at its lowest point in order to have a velocity v_1 when released?

C) What force will you have to exert on the string at its lowest point in order for the stone to have a velocity v_o?


Homework Problem

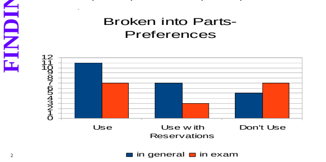
You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in 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.



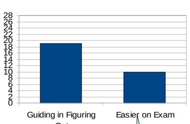
FINDINGS

Broken into parts, 25 mention:

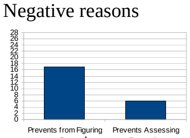
12 (48%) like, 6 (24%) dislike



Positive reasons



Negative reasons



Student's need guiding to figure out: ***"people need much more guidance step-by-step in order to see their way through, see what the steps are that need to be formulated and expressed".***

Exam problems should be easier: ***"If I felt this problem was too hard to do in a single step on an exam, I might break it down like this basically in order to guide the students through the problem.".***

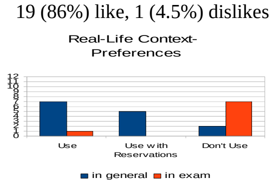
Leading prevents students from figuring out an approach to the problem on their own, which is a course goal: ***"Because I like to see that they know, that they have enough creativity, to devise their own steps"***

Exam problems should allow showing the reasoning: ***"I want to see if they can decide how to break a problem down into parts."***

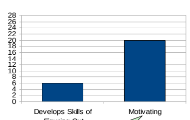
11 instructors are aware of both pros and cons. The resolution of most is to use this feature. Namely, making things easier on the exam weighs more than the wish to see and to develop students' ability to figure out an approach to the problem on their own.

Real-life context, 22 mention:

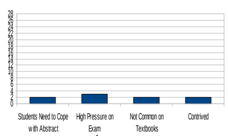
19 (86%) like, 1 (4.5%) dislikes



Positive reasons



Negative reasons



Motivating, conveys a message that physics is relevant: ***"most of them will be the engineer… I always give them… how that's related to our daily life". "an interesting, amusing, context rich problem…"***

Real problems require deeper understanding: ***"…they have to understand the situation…and abstract to figure out what the physics problem is".***

Harder for students on exam: ***" I wouldn't have a problem like this on an exam because it's too easy to misinterpret"***

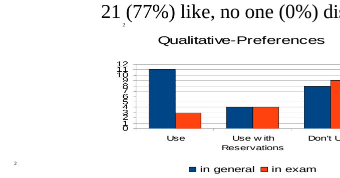
The course goal is to solve abstract problems: ***"Now as far as the engineering students go, they're pretty, I don't know, I think they gotta get used to a little more abstract stuff anyway. "***

Not common in textbooks: ***"…let's say if I had a text book maybe that did a lot of this, I'd probably…"(use this kind of problems)***

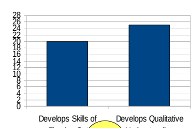
Many are inconsistent: like but don't use.
7 instructors are aware of both pros and cons. The resolution of most is to refrain from using this feature. Namely, standard goals and practices and making things easier on the exam weighs more than motivation.

Qualitative, 27 mention:

21 (77%) like, no one (0%) dislikes



Positive reasons



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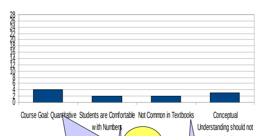

Students need to figure out an approach to the problem on their own: ***"In this case it's actually a bit of thinking process, of course, to formulate the steps"***

Forces conceptual understanding: ***"…it requires the students to think more qualitatively...Without resorting to a formula".***

The course goal is to solve quantitative problems " ***And so just understanding increase, decrease, label them, is not good enough for a calculus-based physics. Because I told them physics is applying mathematics to the real life."***

Not common in textbooks: ***Interviewee:" Well, it depends on if the, most of the homework problems are taken out of the book.***
Interviewer: And they don't have this kind?
Interviewee: Well they have some."

Students are comfortable with numbers: ***" Partially because I think they have a comfort level with coming up with a number."***

Many are inconsistent: like but don't use. 9 instructors are aware of both pros and cons. The resolution of 5 is not to use this feature and 4 use occasionally. Namely, standard goals and practices weighs more than developing students' ability to "figure out" and conceptual understanding

CONCLUSIONS

Instructors who use "non-traditional" problem features exhibited few conflicts.
Instructors who use only traditional problem features frequently exhibited conflicts.
They resolved these conflicts in favor of standard practices and making things easier on the exam rather than in favor of improving problem solving skills and motivating students.
CONFLICT IS AN OPPORTUNITY FOR CHANGE