

Assessment of Student Problem Solving Processes

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INTRODUCTION

Problem solving skills are a primary tool used in most physics instruction and physics education research. Despite this importance, a reliable, valid, and easy to use quantitative measure of physics problem solving does not exist.

The **goal** of the project is to develop a robust, easy to use instrument to assess students' written solutions to physics problems and obtain evidence for reliability and validity. An important test of the instrument is to check whether its categories correspond to processes students engage in during problem solving.

This poster describes interviews with introductory physics students:

- How well does a written problem solution represent a student's thought processes?
- To what extent are the rubric category processes represented during a problem-solving interview?



STUDENT INTERVIEWS



- Eight student volunteers
- Calculus-based Physics for Science & Engineering course (mechanics)
- One-hour interview
- Video and audio taped while solving physics problems
- Near the end of the semester

Transcripts were coded using NVivo for statements pertaining to the rubric categories and responses to particular questions.

PROBLEM-SOLVING TASK

You are working at a construction site and need to get a 14-N bag of nails to your co-worker standing on the top of the building (9 meters from the ground). You don't want to climb all the way back up and then back down again, so you try to throw the bag of nails up. Unfortunately, you're not strong enough to throw the bag of nails all the way up so you try another method. You tie the bag of nails to the end of a 65-cm string and whirl the string around in a vertical circle. You try this, and after a little while of moving your hand back and forth to get the bag going in a circle you notice that you no longer have to move your hand to keep the bag moving in a circle. You think that if you release the bag of nails when the string is horizontal to the ground that the bag will go up to your co-worker. As you whirl the bag of nails around, however, you begin to worry that the string might break, so you stop and attempt to decide before continuing. According to the string manufacturer, the string is designed to hold up to 500 N. You know from experience that the string is most likely to break when the bag of nails is at its lowest point.

Problem-solving task adapted from previous research [7]

RUBRIC CATEGORIES

USEFUL DESCRIPTION: summarize essential problem information visually, symbolically, and/or in writing

PHYSICS APPROACH: select appropriate physics concepts & principles to use

SPECIFIC APPLICATION OF PHYSICS: apply physics to the specific conditions in the problem

MATHEMATICAL PROCEDURES: follow appropriate mathematical rules and procedures during the solution execution

LOGICAL PROGRESSION: (overall) the solution progresses logically; it is coherent, focused toward a goal, and consistent

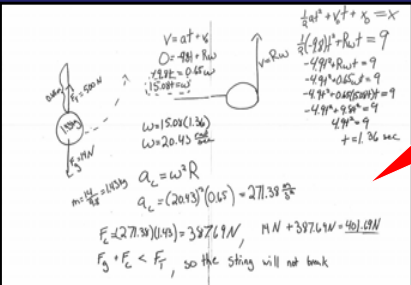
*Categories are based on problem solving research [1-3] and past research at UMN [4-6].

SAMPLE RESPONSES

WRITTEN

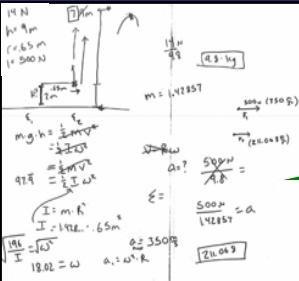
VERBAL

STUDENT 6



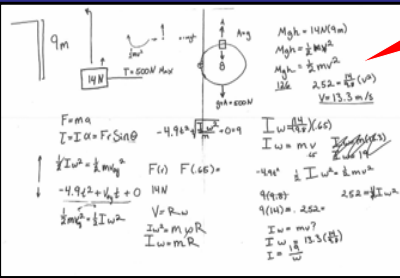
S6: The first thing I thought about was just that it mentioned that the string was most likely to break when the um, bag was at it's lowest point. So I...just kinda drew that even though that didn't prove to be, the most helpful diagram, um. Just something to get started...Then I was thinking about, um, equations for circular motion.

STUDENT 1



S8: I just like, visualized it. Maybe the height had to be from the center of the, center of the thing. I wasn't quite sure exactly what it was but when I drew a picture it made more sense to me.

STUDENT 4



S4: Pretty sure I'm lost...I was just trying to put everything I know down, and then seeing what equations eliminate stuff. Um, and what I could plug in. And that didn't get me very far so far.

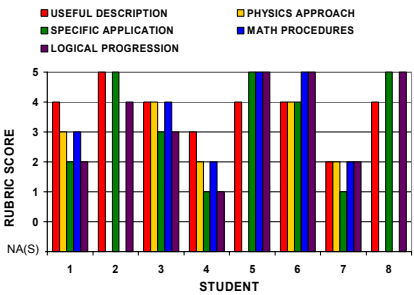
S5: Um, first uh, I find out what I want to know. And I find out what I already know. And I need to build a relationship between them...in this problem I want to know the height so I need to know the velocity. And in order to find the velocity I need to know the, use Newton's second law I can find the, the relationship between force and the velocity.

RUBRIC SCORES

IF YOU CONSIDER STUDENTS' VERBAL STATEMENTS:

- Student 2's rubric score for Logical Progression would change from a 4 to a 5.
- Student 8's rubric score for Specific Application of Physics would change from a 5 to a 4 (incorrect reasoning for velocity term).
- The Not Applicable (NA – Solver) scores for Math and Physics Approach would change to a 5.

RUBRIC SCORES FOR WRITTEN PROBLEM SOLUTIONS



AVERAGE TIME

CORRECT

INCORRECT

CORRECT ANSWER
INCORRECT REASONING

S2 (7min)
S5 (6 min)

S1 (15 min)
S3 (25 min)

DID NOT FINISH

S4 (26 min)
S7 (20 min)

SUMMARY

- Eight introductory physics students each participated in a one-hour interview to compare their written and unwritten problem solving processes.
- The time spent on the first problem ranged from 6 to 26 minutes.
- All students wrote down a description, physics equations, and mathematical operations. Most said they would add more descriptive words on an exam.
- Unwritten decision-making processes included interpreting the question, planning steps, deciding among multiple physics concepts, determining whether they should abandon their approach and try something else, and evaluating the answer.
- In general, rubric scores of students' written solutions were consistent with verbal evidence of those same processes.
- Evidence for Logical Progression and Physics Approach was more prominent in the transcripts than on written papers.
- Students 6 and 8 had incomplete reasoning for some quantities that was not apparent from their papers alone.
- Rating student solutions using a rubric gives an accurate, though course-grained, view of problem-solving processes.

REFERENCES

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