Assessment of Student Problem Solving Processes

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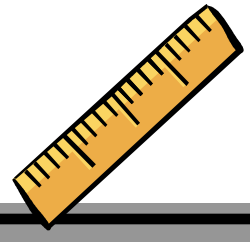
Poster: PST2L-01 & PERC

Problem Solving



- At UMN we have been developing a rubric to assess students' written solutions to physics problems, and obtain evidence for reliability and validity.
  - Useful Description
  - Physics Approach
  - Specific Application of Physics
  - Mathematical Procedures
  - Logical Progression
- Are the written processes assessed by the rubric consistent with students' actual problem-solving processes?
- This talk describes interviews with 8 introductory Physics students.

Problem-Solving Task

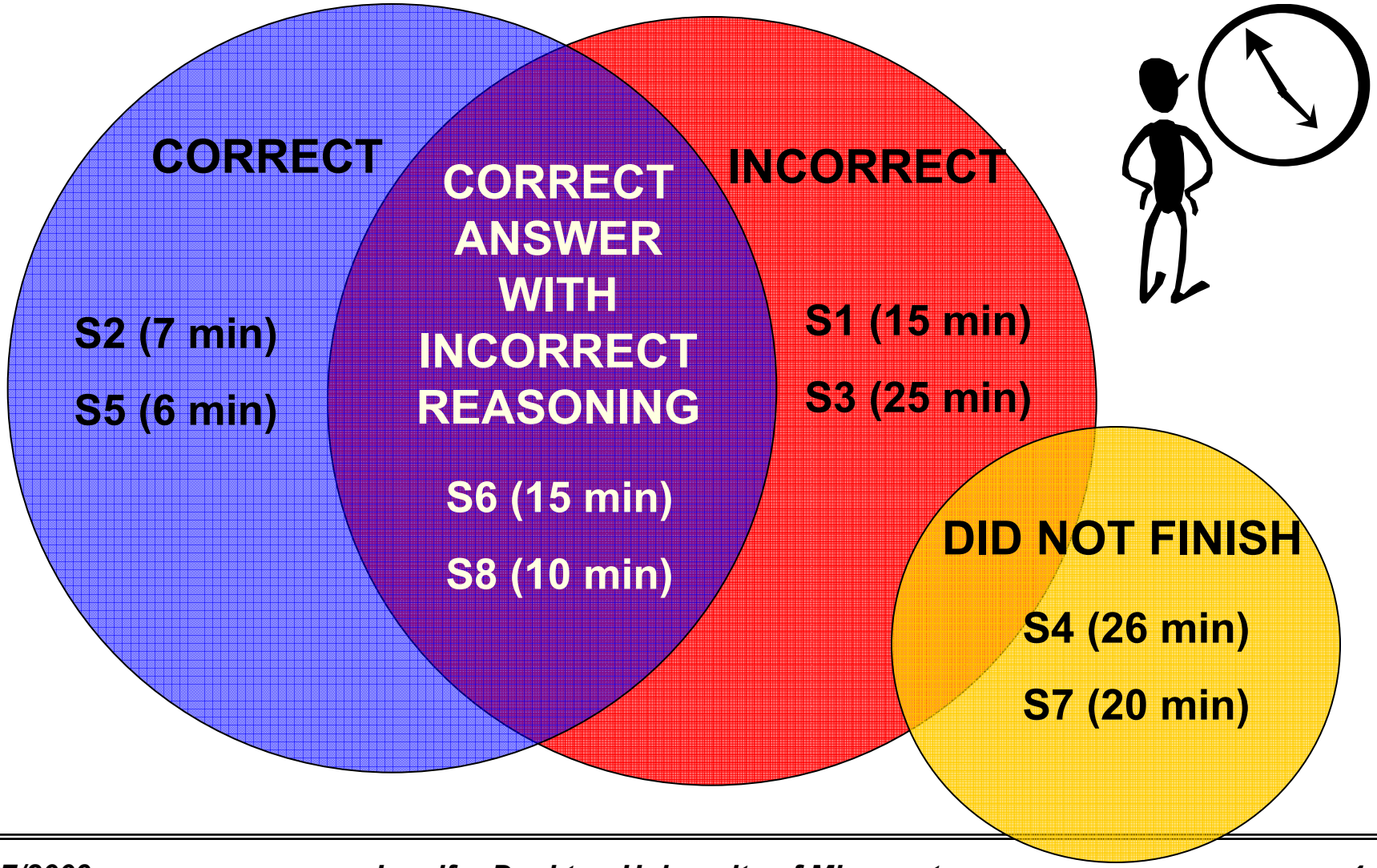
You are working at a construction site and need to get a 14-N bag of nails to your co-worker standing on the top of the building (9 meters from the ground). You don't want to climb all the way back up and then back down again, so you try to throw the bag of nails up. Unfortunately, you're not strong 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.

Features:

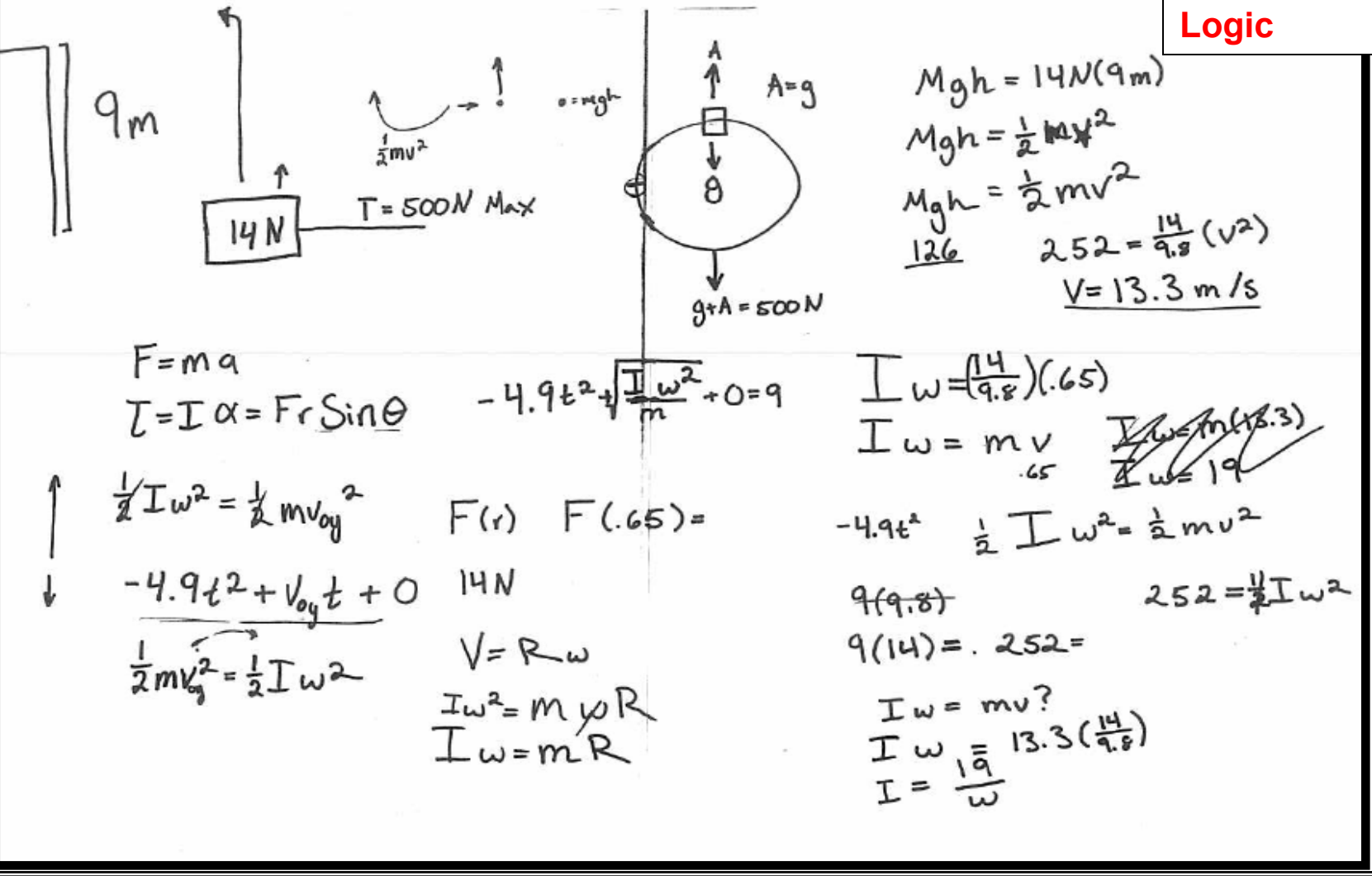
- Context-rich
- No figure provided
- Involves decisions
  - Multiple physics principles
  - What to solve for
  - Representing distances

*Adapted from C. Henderson et al. 2004

Average Time

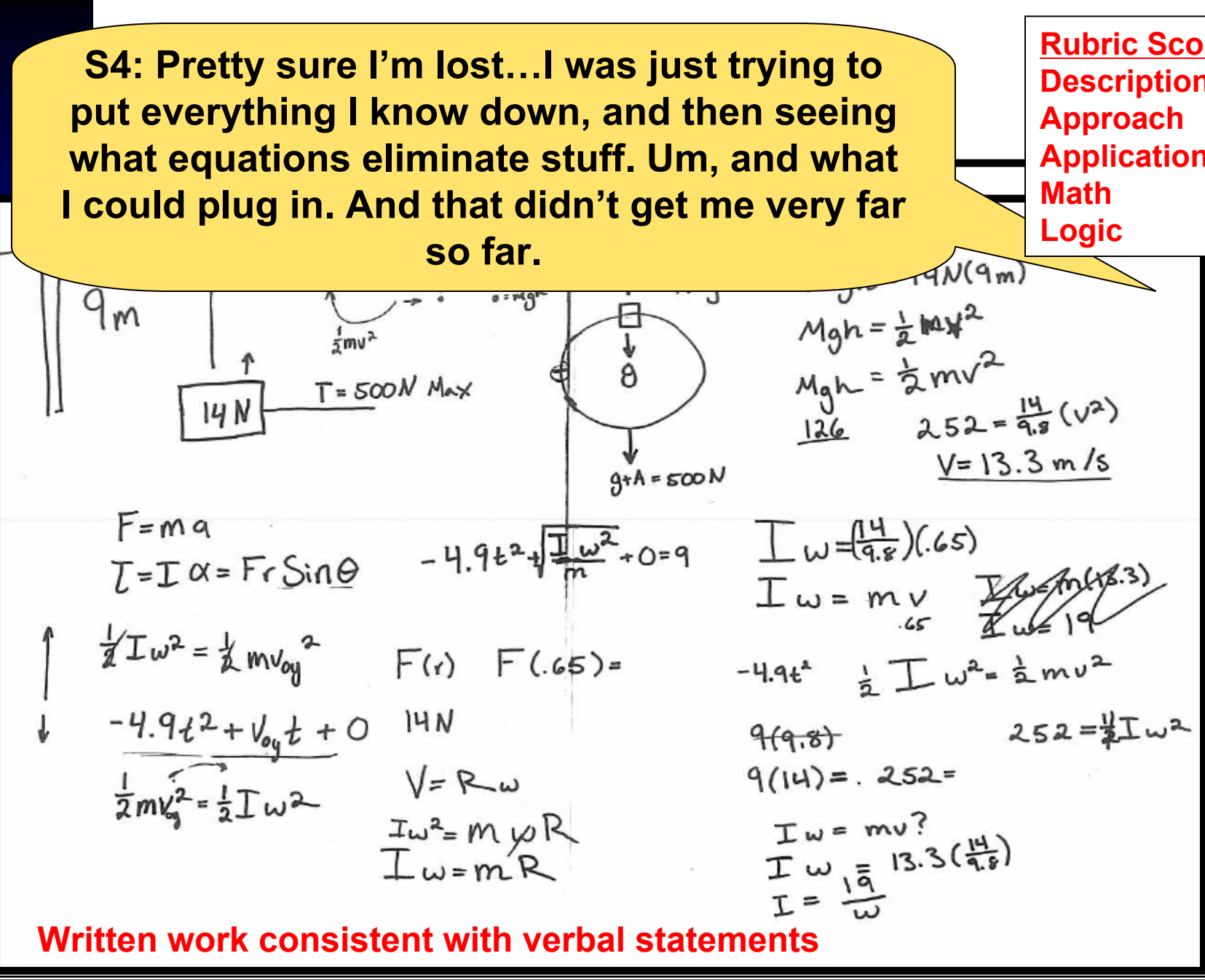


Rubric Scores:	
Description	3
Approach	2
Application	1
Math	2
Logic	1



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.

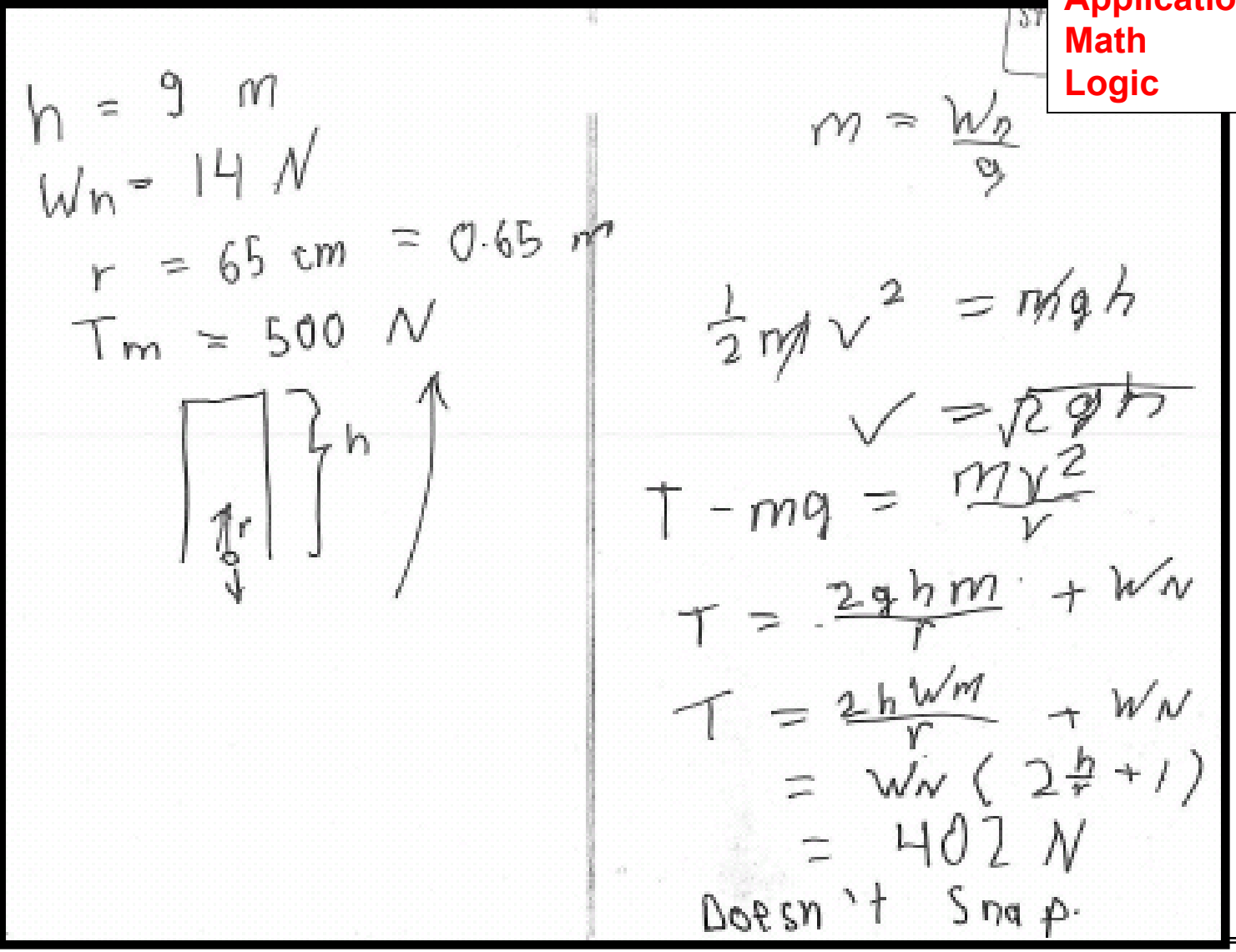
Rubric Scores:	
Description	3
Approach	2
Application	1
Math	2
Logic	1



Written work consistent with verbal statements

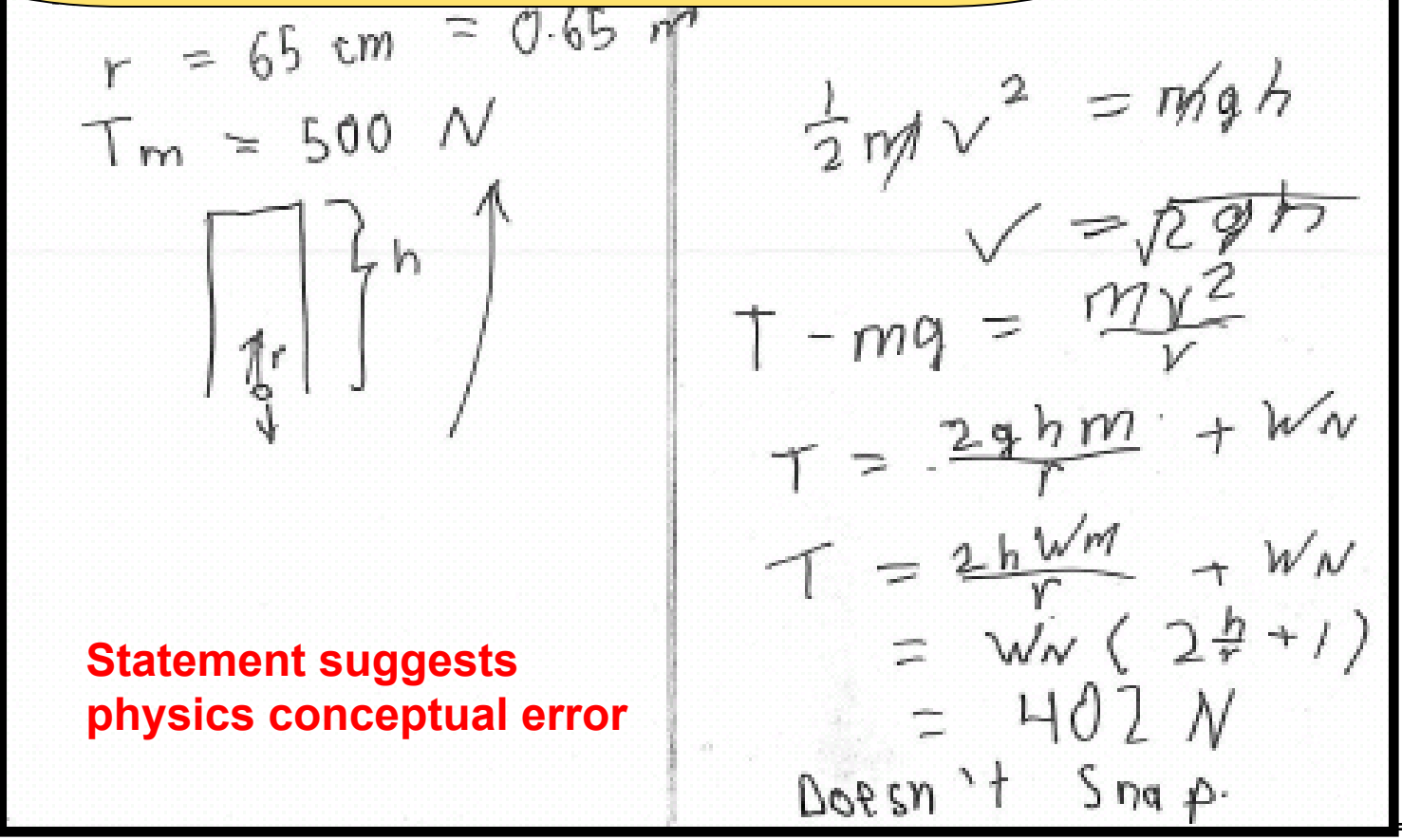
Rubric Scores:

Description	4
Approach	NA(S)
Application	5
Math	NA(S)
Logic	5



Int: What is "v" in your equations?
S8: That's the um, the total velocity in the whirling bag of nails.
Int: Okay, so the bag of nails…
S8: Is like going in a circle so um, there's a tangential velocity to its trajectory.

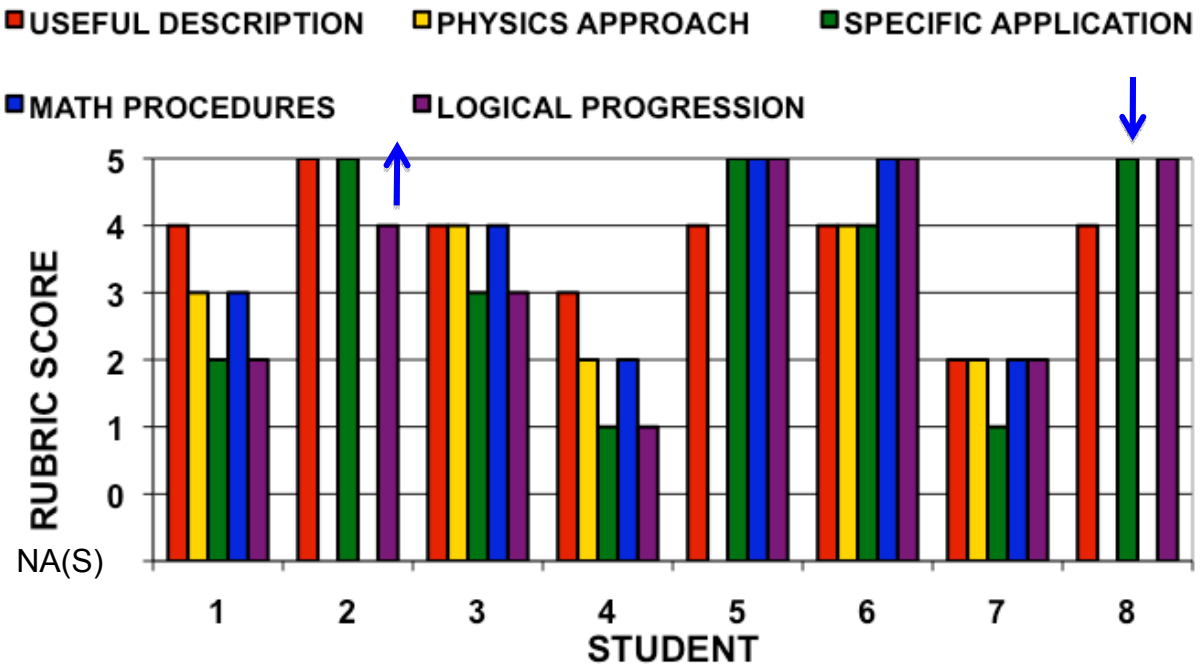
Rubric Scores:	
Description	4
Approach	NA(S)
Application	5
Math	NA(S)
Logic	5



Statement suggests physics conceptual error

Summary

- In general, rubric scores of students' written solutions are consistent with verbal evidence of those same problem-solving processes.



- NA scores have a value after interviews
- All students said they would write more words of explanation for a graded exam problem (but only half did on final exam)

References

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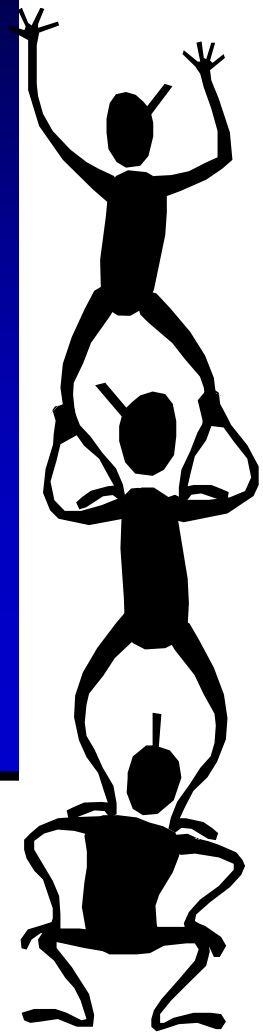

C. Henderson, E. Yerushalmi, V. Kuo, P. Heller, K. Heller, "Grading student problem solutions: The challenge of sending a consistent message" *Am. J. Phys*. 72(2), 164-169 (2004).

OTHER:

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T. Foster, *The development of students' problem-solving skills from instruction emphasizing qualitative problem-solving.* Unpublished doctoral dissertation, University of Minnesota, Twin Cities (2000).

P. Heller, R. Keith, and S. Anderson, "Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving," Am. J. Phys., 60(7), 627-636 (1992).

Additional Slides

	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 PROGRESSION	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.

Rubric Scores (in general)

5	4	3	2	1	0
Complete & appro-priate	Minor omission or errors	Parts missing and/or contain errors	Most missing and/or contain errors	All inappro-priate	No evidence of category

NOT APPLICABLE (NA):

NA - Problem	NA - Solver
Not necessary for this problem *(i.e. visualization or physics principles given)*	Not necessary for this solver *(i.e. able to solve without explicit statement)*