Facilitating Students' Transfer of Problem Solving Skills Across Representations in Teaching/Learning Interviews

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1. QUESTIONS

- What kinds of difficulties do students have when transferring their problem solving skills across different representations?
- How do the difficulties depend upon the sequence in which problems are presented?
- How do these difficulties change as students progress through the semester?

2. LITERATURE REVIEW

- Van Heuvelen developed strategies to facilitate students' problem solving across representations [1].
- Meltzer found a dependence of students' performance on representational form [2].
- Kohl and Finkelstein found that students' prefer pictorial representation, but this does not necessarily make them more successful in problem solving [3].

3. METHODOLOGY

Individual Teaching/Learning Interviews

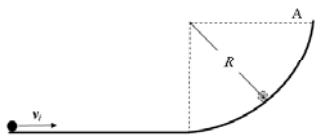
- Calculus-based physics volunteers (N = 20)
- Each participant was interviewed four times during the semester.
- Each interview came after an in-class exam.
- During each interview, the student were:
  - Asked to solve three problems:
    - Original problem: a problem from their most recent exam
    - Graphical problem: part of the information was given as a graph
    - Functional problem: part of the information was given as a function
  - Asked to think aloud while solving problems.
  - Given verbal hints whenever unable to proceed.

REFERENCES

1. A. Van Heuvelen and X. Zou, American Journal of Physics **69** (2), 184 (2001).
2. D. E. Meltzer, American Journal of Physics **73** (5), 463 (2005).
3. P. B. Kohl, D. Rosengrant, and N. D. Finkelstein, presented at the 2006 Physics Education Research Conference, Syracuse, NY, 2006.

4. EXAMPLE OF INTERVIEW PROBLEMS

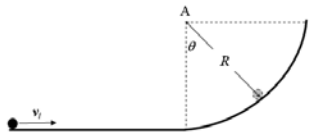
A hoop radius $r = 1$ cm, and mass $m = 2$ kg is rolling at an initial speed v_i of 10 m/s along a track as shown. It hits a curved section (radius $R = 2.0$ m) and is launched vertically at point A. .



What is the launch speed of the hoop as it leaves the slope at point A?

Figure 1. Original problem in interview 4

A sphere radius $r = 1$ cm, and mass $m = 2$ kg is rolling at an initial speed v_i of 5 m/s along a track as shown. It hits a curved section (radius $R = 1.0$ m) and is launched vertically at point A.

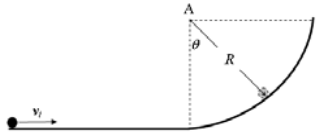


The magnitude of the rolling friction force F_{roll} (N) acting on the sphere varies as angle θ (radians) as per the following function

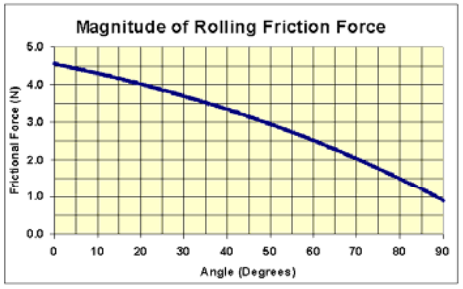
$$F_{roll}(\theta) = -0.7\theta^2 - 1.2\theta + 4.5$$

Figure 2. Functional problem in interview 4

A sphere radius $r = 1$ cm, and mass $m = 2$ kg is rolling at an initial speed v_i of 5 m/s along a track as shown. It hits a curved section (radius $R = 1.0$ m) and is launched vertically at point A.



The magnitude of the rolling friction force acting on the sphere varies as angle θ as per the graph shown below



What is the launch speed of the hoop as it leaves the slope at point A?

Figure 3. Graphical problem in interview 4

5. RESULTS

For this poster, we present data from students in interview 2 and interview 4.

Categories of Difficulties

- PRINCIPLE: inappropriate use of physical principles
- QUANTITY: incorrect use, calculations, and units of physical quantities
- FORMULA: incorrectly recall a formula or interpret meaning of formulae/expressions
- VALUE: uses incorrect value of physical quantities
- MATH: unable to manipulate mathematical processes
- GRAPH: unable to process information from the graph provided
- FUNCTION: inappropriate interpretation or use of the function given
- CALCULATION: simple calculation errors

Categories of Hints

- PRINCIPLE: enables students to determine the appropriate principle to use
- INFO: asks students to take a more careful look at the problem statement to gather necessary data
- QUANTITY: enables students to decide which quantities are applicable in each situation
- FORMULA: helps students understand the meaning of a formula or an equation
- MATH: corrects students errors with mathematical concepts and processes
- GRAPH: enables students to read off and process information from the graph provided
- CALCULATION: helps students recognize and correct simple calculation errors

Sequencing Effect

- In G-F sequence: most difficulties with graph (Fig. 4)
- In F-G sequence: minor difficulty with function (Fig. 5)
- Students' transfer occurs more easily in the F-G sequence than in the G-F sequence.

Trends Across Interviews

As students progressed from interview 2 to interview 4 (Figs. 4 and 6)

- difficulties with graphs and functions decreased dramatically: students had become more capable with graphical and functional representations.
- difficulties with quantities increased significantly due to the increase in complexity of the problems.

5. RESULTS Cont'd

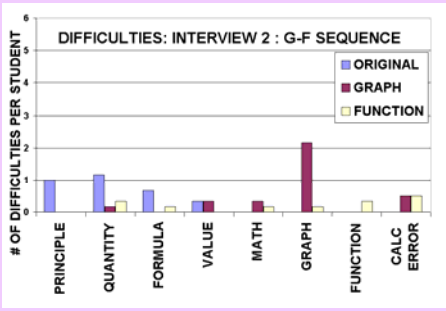


Figure 4. Average number of difficulties in the G-F sequence in interview 2

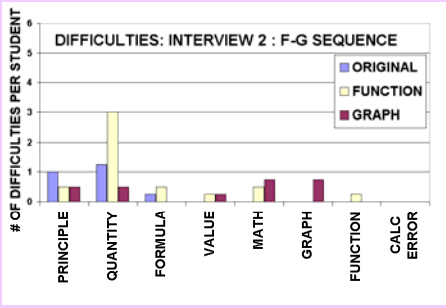


Figure 5. Average number of difficulties in the F-G sequence in interview 2

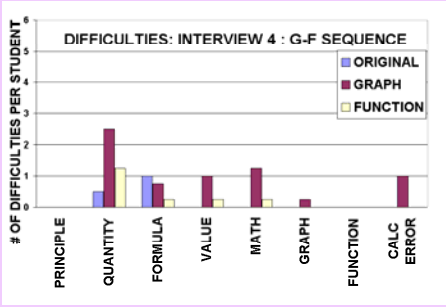


Figure 6. Average number of difficulties in the G-F sequence in interview 4

6. CONCLUSIONS

- Students were unable to interpret physical meaning of mathematical operators and processes, therefore had difficulties with graphical and functional representations.
- The sequence of problems presented to students affected their performance.
- As students progressed through interviews, the difficulties decreased.