Students' Performance on Problem-Solving Tasks in Teaching/Learning Interviews

Dong-Hai Nguyen & N. Sanjay Rebello

Department of Physics, Kansas State University

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1. BACKGROUND

Facilitate students' problem solving skills across problems of different contexts and representations

➢Conducted individual teaching/learning interviews to get insights into students' problem solving process.

➢Sought emergent themes of students' difficulties and the scaffolding that might help them overcome those difficulties.

2. QUESTIONS

- What kinds of difficulties do students have when solving problems different in contexts and/or representations?
- How does the sequence in which problems of different contexts and/or representations are presented to students affect their performance?
- What kinds of scaffolding may help students overcome those difficulties?

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 students 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. V. Engelhardt, E. G. Corpuz, D. J. Ozimek et al., presented at the Physics Education Research Conference, 2003, Madison, WI, 2003.

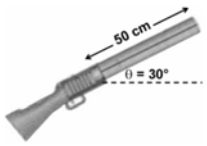
4. EXAMPLES OF INTERVIEW PROBLEMS

A spring of spring constant 3.0 kN/m is compressed a distance of 1.5 cm and a small ball is placed in front of it. The spring is then released and the small ball, mass 0.1 kg, is fired along the slope and launched into the air at point A which is 10 cm above the spring. The angle θ of velocity at launch is 30°. Friction is negligible.

What is the speed of the ball at the launch point (point A)?

Figure 1. Original problem in interview 2

A 0.1 kg bullet is loaded into a gun (muzzle length 0.5 m) compressing a spring to a maximum of 0.2 m as shown. The gun is then tilted at an angle of 30° and fired.

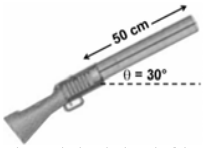


The only information you are given about the gun is that the barrel of the gun is frictionless and that the gun contains a non-linear spring such that when the held horizontal, the net force, F (N) exerted on a bullet by the spring as it leaves the fully compressed position varies as a function of the spring compression, x (m) as given by: $F = 1000x + 3000x^2$

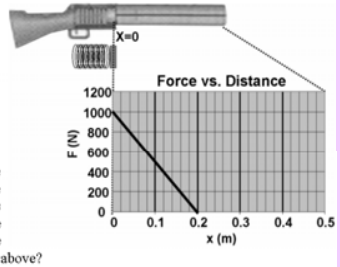
What is the muzzle velocity of the bullet as it leaves the gun, when the gun is fired at the 30° angle as shown above?

Figure 2. Functional problem in interview 2

A 0.1 kg bullet is loaded into a gun (muzzle length 0.5 m) compressing a spring as shown. The gun is then tilted at an angle of 30° and fired.



The only information you are given about the gun is that the barrel of the gun is frictionless and when the gun is held horizontal, the net force F (N) exerted on a bullet by the spring as it leaves the fully compressed position varies as a function of its position x (m) in the barrel as shown in the graph below.



What is the muzzle velocity of the bullet as it leaves the gun, when the gun is fired at the 30° angle as shown above?

Figure 3. Graphical problem in interview 2

5. RESULTS

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

Categories of Difficulties

- PRINCIPLE: inappropriate use of physical principles.
- QUANTITY: incorrect use, calculations, and units of physical quantities.
- FORMULA: incorrectly recalls a formula or interprets 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.
- GRAPH: enables students to read off and process information from the graph provided.
- MATH: corrects students errors with mathematical concepts and processes.
- CALCULATION: helps students recognize and correct simple calculation errors.

Sequencing Effect

On the representational aspect:

- 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.

On the contextual aspect:

- Contextual change occurs in the first transfer.
- Contextual competence is mainly the ability to determine appropriate principle and physical quantities used to describe the problem scenario.
- In G-F sequence: minor difficulties with principle and quantities.
- In F-G sequence: some difficulties with principle and significant difficulties with quantities.

5. RESULTS Cont'd

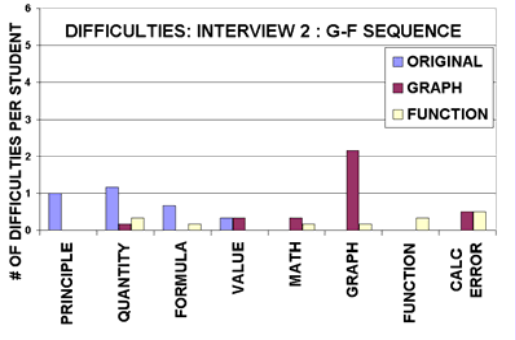


Figure 4. Average number of difficulties in the G-F sequence in interview 2

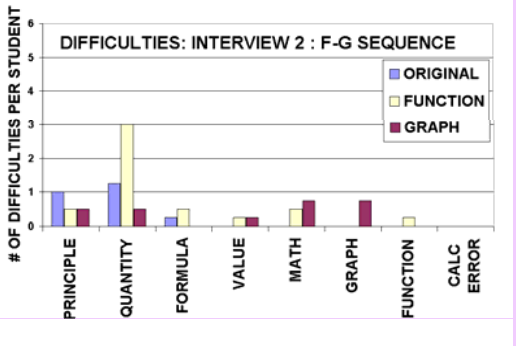


Figure 5. Average number of difficulties in the F-G sequence in interview 2

6. CONCLUSIONS

- Students were unable to interpret physical meaning of mathematical operators and processes, therefore had difficulties with graphical and functional representations.
- Students focused on facial differences rather than physical similarities between problems, therefore encountered difficulties when context of the problem changed.
- The sequence of problems presented to students affected their performance: the difference in context seemed to distract students more significantly in the F-G sequence while transfer across representations occurred more easily in this sequence.