Students' Perceptions of Case-Reuse Problem Solving in Algebra-Based Physics

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BACKGROUND

- Problem solving important in Physics[1].
- Programs combining interrelated strategies are more effective than single-strategy programs[2].
- We combined Concept Mapping[3] & Questioning[4] with Case-Reuse[5].
- Objectives:
  - Gauge students' perceptions of strategies -- purpose, ease-of-use and value.
  - How these compare with traditional strategies that they may already use.

QUESTIONS

- To what extent do students find these strategies useful in problem solving?
- How well are these strategies aligned with students' existing techniques?
- To what extent do students understand the purpose of these strategies?
- To what extent do students find these strategies difficult to implement?

THEORY

- Case Based Reasoning (CBR): Using analogies to solve real-world problems.
- Case-reuse promotes CBR using problem pairs sharing deep similarities.
- Case-reuse used with two strategies:
  - '*Questioning*': Answer questions requiring different levels of knowledge. (Fig. 1)
  - '*Structure Mapping*': Use a visual representation showing functional connections of quantities. (Fig. 2)
- Strategies used with problem pairing.

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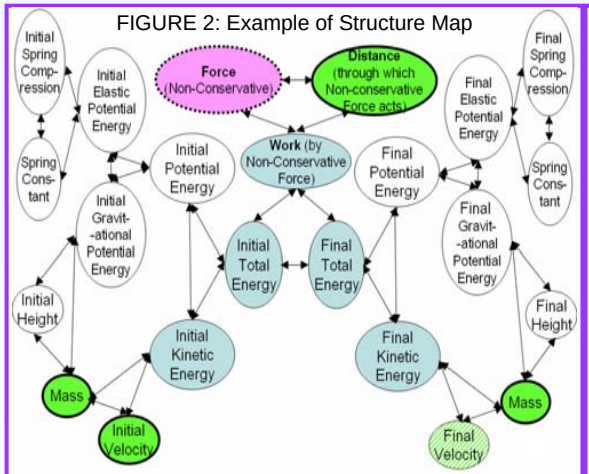
Problem 1 (*Giancoli* 6-29) **A 1200-kg car rolling on a horizontal surface has a speed of 18m/s when it strikes a horizontal coiled spring and is brought to rest in a distance of 2.2m. Neglecting friction, what is the stiffness constant of the spring?**	**Problem 2** (*Giancoli* 6-32) **A spring of stiffness constant 53N/m hangs vertically so that the lower end of the spring is 0.15m above the ground. A 2.5-kg mass is now attached to the spring. Neglecting air resistance, how far above the ground is the lower end of the spring?**
Q1-2: Which of the following are directly given in the Problem 1? Select all that apply. a) Initial speed of the car. b) Final speed of the car c) Mass of the car. d) Stiffness constant of spring. e) Compression in spring. f) None of above. Correct answer is: _____	**Q2-2:** Which of the following are directly given in the Problem 2? Select all that apply. a) Initial velocity of the mass. b) Final velocity of the mass. c) Value of the mass. d) Stiffness constant of spring. e) Extension of spring. f) None of above. Correct answer is: _____
Q1-3: Which of the following quantities change in Problem 1? Select all that apply. a) Kinetic Energy of the car. b) Elastic Potential Energy of the car. c) Gravitational Potential Energy of the car. d) None of above. Correct answer is: ____	**Q2-3:** Which of the following quantities change in Problem 2? Select all that apply. a) Kinetic Energy of the mass. b) Elastic Potential Energy of the mass. c) Gravitational Potential Energy of the mass. d) None of above. Correct answer is: ____
Q1-5: Which info. given in Problem 1 is *not* required to solve it? Select all that apply. a) Mass of the car. b) Initial speed of the car. c) Spring compression. d) All information given is required. e) None of above. Correct answer is: _____	**Q2-5:** Which info. given in Problem 2 is *not* required to solve it? Select all that apply. a) Value of the mass. b) Stiffness constant of spring. c) Initial position of lower end of spring. d) All information given is required. e) None of above. Correct answer is:_____
Q1-6: Problem 1 is changed such that rather than roll on a horizontal surface the car rolls downhill before striking the spring. What minimum *additional* information is needed to find the height of hill? Select all that apply. a) The stiffness constant of the spring. b) Angle of the incline of the hill c) Speed of the car at the top of the hill. d) Speed of the car at the bottom of the hill. e) You already have sufficient information. f) None of above. Correct answer is: _____	**Q2-6:** Problem 2 is changed such that when the mass is attached the spring extends into a beaker of fluid. What minimum *additional* information is needed to find force of resistance of fluid? Select all that apply. a) Distance end of spring extends in fluid. b) Distance end of spring extends before fluid. c) Work done by the fluid on the mass. d) You already have sufficient information. e) None of the above. Correct answer is: ____
Q1-7: You have already solved Problem 1 and are asked to add an additional part (ii) to Problem 1 so that it is similar to Problem 2. Write your own part (ii) and explain why it resembles Problem 2.	**Q2-7:** You have already solved problem 2 and are asked to add an additional part (ii) to Problem 2 so that it is similar to Problem 1. Write your own part (ii) and explain why it resembles Problem 1.

FIGURE 1: Example of Questioning Strategy

FIGURE 2: Example of Structure Map



METHODOLOGY

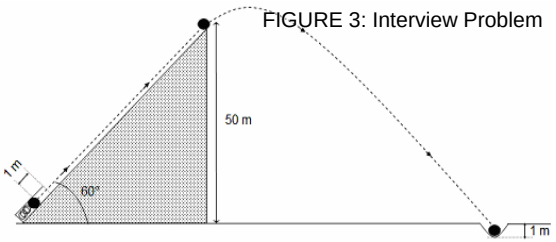
Phase I

- Algebra-based physics (N = 150)
- Worked three types of problem pairs :
  - Work-energy theorem
  - Potential energy
  - Conservation of energy
- Online Extra-Credit: randomly assigned
  - *Questioning Strategy:* Answered questions for each problem in pair. (Fig. 1)
  - *Structure Mapping* group*:* Identified quantities on given map as: directly/indirectly given, asked for, or calculated for each problem in pair. (Fig. 2)
  - *Control* group*:* Solved one problem of each type.
- *Near Transfer* : Three homework problems – one of each type.
- *Far transfer* task: One exam problem.

Phase II

- N=8 : 3-4 weeks after Phase I.
- Two 50-min. semi-structured interviews
  - *Interview 1*: Described how they work through a problem. (Fig. 3)
  - *Interview 2*: Reminded of (or learned) strategy used in Phase I and applied to problem. (Fig. 3)
- Phenomenographic Analysis: Themes emergent from data.

FIGURE 3: Interview Problem



A ball of mass 2kg is held against a spring compressed by 1 m with a spring constant of $k = 3 \times 10^3$N/m, and sits at the bottom of a ramp 50 m high. The ramp is inclined at an angle of 60°. When the ball is released, assuming a frictionless ramp and no wind resistance, the ball will hit a pit of sand. The depth the ball sinks into the sand is 1m.

(a)At what speed will the ball leave the ramp?
(b)What is the average force on the ball by the sand?
(c) Is there any information provided in the problem that you did not need to in (a) and (b)? If so, what information?
(d) If 'k' is reduced, what happens to the depth the ball sinks into the sand?

RESULTS

Phase I

No statistically significant difference between groups on transfer tasks.

Phase II

Questioning Strategy Themes

- *Purpose of strategy*: Help in visualizing and focusing (4 of 4 students)
  "…to help us visualize the problem, to … think of what we should take into account, … of what shouldn't be taken into account…"
- *Comparison with own strategy*: Mimics question asking, similar to own (4 of 4)
- *Using strategy:* Used equations to identify concepts (3 of 4)
  "…I usually try to find the equation I'm using from what I'm given … and .. see if there is something ... I need."
- *Pairing of Problems*:
  - Recognized pairing. (4 of 4)
  - Reasoned: paired because they use same type of equation. (3 of 4)

Structure Mapping Themes

- *Purpose of strategy:* Liked how map…
  - represented problem info. (3 of 4)
  - made relationships apparent. (4 of 4)

  "...it doesn't give you the equation … but.. what you need … to figure out … the answer."
- *Comparison with own strategy*: Not comparable. (4 of 4)
- *Using strategy:* No difficulties. (4 of 4)
- *Pairing of Problems*:
  - Recognized pairing. (1 of 4)

CONCLUSIONS

- Overall: Students find strategies are user-friendly and helpful.
- *Questioning* strategy: Tendency to answer questions using equations.
- *Structure Mapping* strategy: Inability to see value of paired problems.
- Future Work: Adapt, implement & test strategies in algebra-based physics class over long term.