INTERNET COACHES FOR PROBLEM-SOLVING IN INTRODUCTORY PHYSICS

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Motivation

- To assess problem solving, a complex cognitive activity, in a classroom situation.

Study

- In Fall 2011, 35 computer coaches were used in one section (219 students) of an introductory calculus-based mechanics class at the University of Minnesota.
- Students could complete their homework either by working through the computer coaches for a given topic or by submitting a correct answer to the same problems through WebAssign within 3 attempts.
- 4 quiz problems and 2 final exam problems were analyzed using a problem-solving rubric.[1]
- Results from the final exam problems were compared with another section of the same class (196 students).

	Useful Description (UD)	Physics Approach (PA)	Specific Application of Physics (SAP)	Mathematical Procedure (MP)	Logical Progression (LP)
5	Useful, appropriate and complete.				
4	Contains minor omissions and/or errors.				
3	Parts of the description/approach/etc. are missing and/or contain errors.				
2	Most of the description/approach/etc. are missing and/or contain errors.				
1	Not useful, inappropriate and/or inconsistent.				
0	Does not include a description/approach/etc.				
NA(S)/NA(P)	Not applicable to the solver/problem.				

Table1: Problem solving rubric [1]

Analysis

- 159 students with a complete set of data were used in the analysis.
- Two experienced raters each scored half of the solutions using the rubric.
- The raters trained by first scoring a common set of 10 student solutions, comparing and discussing their ratings, then repeating the process until their agreement was at least 90% before discussion.

Quiz 1 Problem 1

As the stunt coordinator on a movie set, it is your job to arrange a scene in which a stunt double steps off a bridge and lands onto some mattresses in the back of a large truck that is driving under the bridge. You find that the bridge is 50 feet above the ground. The mattresses in the bed of the truck are about 4 feet above the ground. The truck will be driving toward the bridge at a steady speed of 20 miles per hour. To carry out the stunt safely, you decide to calculate where to place a traffic cone by the side of the road so that when the truck passes the cone, the stunt double will step off the bridge and land safely in the back of the truck.

Quiz 4 Problem 1

You are helping to design a display at a toy store and decide to build a suspended track on which a toy train will run. The track will be a horizontal circle hung from three thin wires attached to a pivot on the ceiling so that it can rotate freely. The train is started from rest and accelerates without slipping to a final speed of 1.0 m/s relative to the track. Because the store owner is worried about the possibility of an accident where the train jumps off the track and falls on a customer, you are asked to find its final speed relative to the floor. The mass of the train is 400 g and the mass of the track is 2 kg. The radius of the circular track is 1.5 m.

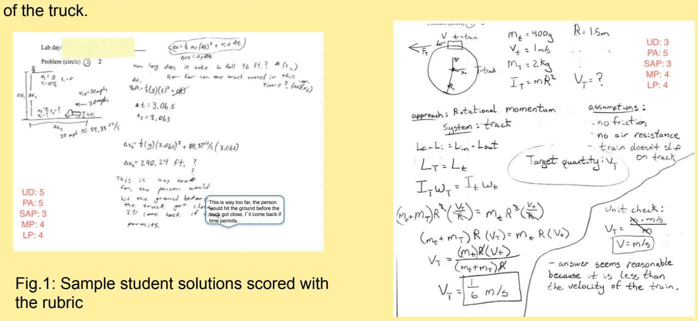

Fig.1: Sample student solutions scored with the rubric

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Results

Characteristics of within class comparison groups

	Entire class (M, F) breakdown	Frequent completers	Less frequent completers
Gender	113 M, 46 F	24 M, 23 F	41 M, 6 F
FCI pre	56% (63, 41)	47% (58, 36)	67% (70, 40)
FCI post	79% (83, 68)	72% (80, 63)	85% (87, 72)
Math pre	64% (65, 61)	61% (65, 57)	68% (69, 60)
Math post	74% (74, 72)	72% (74, 71)	79% (81, 69)
CLASS pre	64% (65, 62)	61% (62, 59)	67% (68, 61)
CLASS post	61% (62, 57)	56% (59, 52)	68% (68, 66)
avg. # coaches completed	22.9 (21.5, 26.5)	32.7 (30-35)	12.1 (5-16)
avg. # coaches attempted	28.3 (27.3, 30.9)	34.2 (30-35)	20.9 (7-33)

Table 2: Differences in background variables between frequent (FC) and less-frequent (LC) completer groups.

Only 9 out of 159 students completed less than 10 coaches. Median number of coaches attempted (completed) is : 31 (24)

Within Class Comparisons : samples matched on pre tests

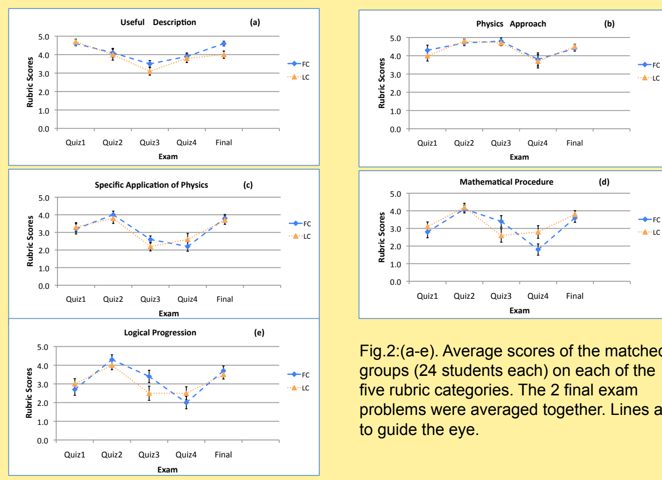

Fig.2:(a-e). Average scores of the matched groups (24 students each) on each of the five rubric categories. The 2 final exam problems were averaged together. Lines are to guide the eye.

Between Class Comparisons: matched samples

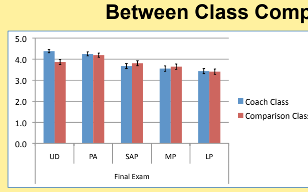

Fig.3. Average scores of the matched Coach class and Comparison class (99 students each) on each of the five rubric categories for 2 final exam problems.

Discussion

- Students frequently chose to use the coaches.
- Students with lower pre-test scores tended to complete coaches more frequently.
- Frequent completers included a much larger fraction of females.
- After quiz 1, the FC group scored higher on a majority of the problems in each category except for Mathematical Procedure, which was not a skill addressed by the coaches. This pattern, while suggestive, is not statistically significant.
- The coach class has a larger FCI gain (g=0.55) than the comparison class (g=0.41) .
- The computer coaches were in addition to the cooperative group problem solving pedagogy. Combined use of individually effective pedagogies may not result in a cumulative gain.[2]
- A longer timescale may be needed to observe the development of problem solving skills. [3]
- It is also be possible that the coaches have no effect on problem solving.

References

1. J. Docktor, Ph.D. Thesis, University of Minnesota, Twin Cities, 2009; Docktor & Heller, AIP Conference Proceedings 1179, 2009, pp. 133-136.
2. K. Cummings, J. Marx, R. Thornton and D. Kuhl, Am. J. Phys. **67**, S38-S44 (1999).
3. P. Heller, R. Keith, and S. Anderson, Am. J. Phys **60**, 627-636 (1992).