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### The intervention

Online computer programs designed to improve students' problemsolving skills by coaching them while they practice solving problems were introduced into an introductory physics class.

### **Computer coaches**

The computer coaches (Hsu& Heller, 2004) were developed in the context of a **cognitive apprenticeship** (Brown, Collins & Newman, 1989) and emphasized the use of a general decisionmaking framework for solving all problems.

Section	ne: Focus the Problem	n
Focus the Problem	celeration	
Picture	hat is the acceleration of the puck at its final position?	Problem
Important Objects	lect the correct answer from the list below. Use the scroll bar if	At the State Fair you see people trying
Motion	cessary.	win a prize at a game booth. They are
Position	) †	wooden ramp so that it stops in a mark
Velocity		zone near the top of the ramp before sl
Acceleration	$\rightarrow$	back down. You estimate that you can
Time		
Interactions	$\rightarrow$ $\downarrow$	Picture
Forces		v ai = ? vi = 8.0 ft/s
Other Elements		d ar
Questions	anituda 2	
Approach	lect the correct answer from the list below. Use the scroll bar if	
Physics Principle	cessary.	
System	$2.5 \text{ m/s}^2$	
Relevant Times	$8.0 \text{ m/s}^2$	
Relevant Info	$0.0 \text{ m/s}^2$	Accumutions
Describe the Physics		Air resistance can be neglected
Plan the Solution	It is not specified and is unknown	The size of the puck can be neglected
Execute the Plan	j it is not specified and is dirknown.	can always measure from its front edge
Evaluate the Solution		
Summary		
	Drahlam	

A screenshot from one of the three types of coaches: The computer guides the student to make decisions using an organized framework (left index bar). The student makes the decisions and the computer assess the student's work.

# Implementation details

- Computer coaches were developed for 35 problems
- The coaches were made available in 3 sections of a university calculus-based introductory mechanics course during two semesters.
  - Fall 2011: One section of 221 students Students could complete their homework using WebAssign or the coaches
  - Spring 2013: Two sections of 148/103 students Although coaches were available to help with some problems, students were required to complete their homework using WebAssign.
- Data collected included:
  - Keystroke data from student use of the coaches
  - Standardized pre-post assessments (FCI/Math/CLASS)
  - Survey of student background data and expectations
  - Mid- and end-of semester surveys
  - 13 written problem solutions from each student: 8 from 4 midterm quizzes and 5 from a final exam

### References

- J. S. Brown, A. Collins & P. Duguid, Educational Researcher 18(1), 32-42 (1989).
- J. Docktor & K. Heller in AIP Conference Proceedings 1179: 2009 PERC (pp. 133-136). Melville, NY: American Institute of Physics.
- L. Hsu & K. Heller in AIP Conference Proceedings 790: 2004 PERC (pp. 197-200). Melville, NY: American Institute of Physics.

# Assessing students' problem-solving skills: Measuring the effect of an intervention



TA graded Final exam score

# User groups (S13)

Score

Rubric

Normed

# Characteristics

	L (N=48)			M (N=27)			H (N=35)		
	male	fema	female 15%		male 67%		female 33%		female
	85%	15%							34%
FCI (pre)	58%±3	% 59%	±11%	53%±	:5%	42%=	±7%	46%±3	% 31%±39
	Ν	Weekly	y time (hrs)		rs)	Expected grade			
		$\leq 5$	6-10	)	≤5		A		B
L	48	25%±3%	6 46%	6 <b>±4%</b>	29%	±3%	71%	±3%	29%±3%
Μ	27	<b>4%</b> ±1%	59%	6±5%	37%	±4%	70%=	±4%	30%±4%
TT	25	00/.10/	620/	/ . 40/	200/	. 20/	100/	10/	600/.10/

- Pre-FCI: H users are less prepared compared to L users. • Self-reported expectations: H users are less confident in their ability and expect to spend more time studying than L users.

# Final Exam Problem-Solving Rubric Score



# **Comparison 2 (preliminary)**

- In Fall 2011, most students (L-, M-, and H-like) used most of the coaches (attempting 28 and completing 21 out of 35, on average).
- Students from the F11 section with coaches and a similar F11 section without coaches (control) were matched to S13 students.
- Scores between the two different final exams used in S13 and F11 were normalized by setting equal the rubric scores of the L-like users from S13 and the F11 control section.

# **Result 2**

- H-like students score lower than L-like students in F11 control section (59.8±3.8% vs. 66.7±2.8%), but H-like students score as well as Llike students in F11 coached section. (65.2±2.9% vs. 65.6±2.9%)
- L-like students in F11 control section scored as well as L-like students in F11 coached class (66.7±2.8% vs. 65.6±2.9%).
- H-like students in F11 coached section scored higher than H-like students in F11 control section ( $65.2\pm2.9\%$  vs.  $59.8\pm3.8\%$ ).

# **Assessment Tools**

- We used a research-validated rubric (Docktor, 2009) to analyze final exam problem solutions. The rubric assigns a score based on five categories: Useful Description, Physics Approach, Specific Application of Physics, Mathematical Procedure, and Logical Progression
- TA-assigned scores are found to be highly correlated with rubric scores (~0.9 for 5 problems together,  $\sim$ 0.82 for individual problems).



(F11)

