## Table 1 Problem Domains Used in Part I

	Domain						
	Springs		Slopes		Sinking		
Primary materials	Eight springs that vary on three variables		Two ramps, each with adjustable angle and "starting gate" location Two sets of two balls, golf and rubber (squash)		Two water-filled cylinders, with two drop heights indicated Eight objects that vary on three variables		
	A frame for hanging two springs Two sets of weights, a heavy pair and a light pair						
			Two two-sided surface inserts (for ramps) with different coeffi- cients of friction		Scooper and magnet for retrieving sunken objects		
To be determined	What factors det spring will str	ermine how far a retch?	What factors determine how far a ball will roll down a ramp?		What factors determine how fast an object will sink in water?		
Variables: 2 independent values for each of 4 variables <sup>a</sup>	<ul> <li>length</li> <li>coil diameter</li> <li>wire diameter</li> <li>weight size</li> </ul>	long, short wide, narrow thick, thin heavy, light	<ul> <li>angle</li> <li>starting gate</li> <li>surface</li> <li>ball</li> </ul>	high, low short, long smooth, rough golf, rubber	<ul> <li>shape</li> <li>material</li> <li>size</li> <li>height</li> </ul>	cube, sphere steel, Teflon large, small high, low	
Dependent measure	Length of extension (or distance from base of rack) when weight is added		Distance ball rolls at end of ramp		Speed of sinking in water (or which reaches bottom first)		
Subject activity Experimental design	<ul><li>From set of 8 springs:</li><li>Select 2 springs</li><li>Hang springs on rack hooks</li><li>Select weights to go with each spring</li></ul>		For each of 2 ramps: • Select one of two angles • One of two surfaces • One of two starting positions • Select one of two balls to run		<ul><li>From set of 8 objects:</li><li>Select 2 objects</li><li>For each object, select one of two heights from which to drop object</li></ul>		
Experiment execution	Hang weights on springs Observe amount of stretching (or distance from base)		Release gates (not necessarily simultaneously), allowing balls to roll Observe distance balls roll after leaving ramp		Simultaneously drop each object into water-filled cylinder Observe relative sink rates (or arrival times at bottom of cylinder)		
Notable aspects of domain and procedure	All variables investigated are integral to selected spring Choice is from among pre-existing springs having a "cluster" of		Variables are independent, object is constructed from choice of values for each variable Comparison objects are constructed; variable values are not clustered		All variables investigated are integral to selected object Choice is from among pre-existing objects having a "cluster" of variable values Easy to set up (simply choose two objects and heights)		
	variable values Experiment is easy to set up and execute (no timing issues)						
	Measurement is easy (stable outcome)		Outcome is evanescent (if based on speed), or stable (if based on final distance)		Simultaneity necessary at start of drop		
					Outcome must be observed instantly, otherwise it is lost		

<sup>a</sup> Children were asked to investigate the first three variables listed in each task. The remaining variable was identified by the experimenter at the outset, but the participants were never asked to investigate its effect.



Figure 1 The Slopes Domain. On each of the two slopes, children can vary the angle of the slope, the surface of the ramp, the length of the ramp, and the type of ball. The confounded experiment depicted here contrasts (A) the golf ball on the steep, smooth, short ramp with (B) the rubber ball on a shallow, rough, long ramp. See Table 1 for additional information.

## Table 2 Procedure Table

		Condition				
		Training-Probe	No Training-Probe	No Training–No Probe		
Day 1	Phase 1a—Exploration					
5	Cover story, Task 1	Х	Х	Х		
	Identify variables A, B, C, and D <sup>a</sup>	Х	Х	Х		
	Initial conceptual understanding	Х	Х	Х		
	Produce two comparisons each for A and B	Х	Х	Х		
	Explanations (probes)	Х	Х	—		
	Phase 1b—Training					
	Training on variables A and B	Х	—	—		
	Phase 2—Assessment					
	Produce two comparisons each for C and B	Х	Х	Х		
	Explanations (probes)	Х	Х	_		
	Final conceptual understanding	Х	Х	Х		
Day 2	Phase 3—Transfer-1					
,	Cover story, Task 2	Х	Х	Х		
	Identify variables E, F, G, and H	Х	Х	Х		
	Initial conceptual understanding	Х	Х	Х		
	Produce two comparisons each for E and F	Х	Х	Х		
	Explanations (probes)	Х	Х	—		
	Final conceptual understanding	Х	Х	Х		
	Phase 4—Transfer-2					
	Cover story, Task 3	Х	Х	Х		
	Identify variables I, J, K, and L	Х	Х	Х		
	Initial conceptual understanding	Х	Х	Х		
	Produce two comparisons each for I and J	Х	Х	Х		
	Explanations (probes)	Х	Х	—		
	Final conceptual understanding	Х	Х	Х		
	Similarity questions	Х	Х	Х		
	Final Training for School A		Х	Х		

<sup>a</sup> Capital letters refer to variables used. All four variables were identified for the children, and their prior beliefs about all four were elicited. Subjects were then asked to make comparisons, typically for only two of the variables in each phase.



Figure 2 An example of a page from the Posttest Problem Booklet.



Figure 3 Percentage of trials with correct use of CVS by phase and condition.



Figure 5 Initial and final conceptual understanding for each instructional group.



Figure 6 Percentage of children in Training–Probe and No Training–Probe groups who both mentioned and correctly used CVS (Robust Use of CVS) on each trial.



Figure 7 Number of children displaying each type of pattern of Robust Use of CVS across the four phases of Part I. For each pattern type, the results from a specific participant are displayed. These examples depict the number of robust use trials (out of four) during each phase: Ex, Exploration; As, Assessment; T1, Transfer-1; T2, Transfer-2. The pair of bars above each pattern shows the number of children in the Training–Probe and No Training–Probe group whose robust use scores fit that pattern.



Figure 8 Percentage of correct posttest answers by grade and condition.