

Learning Classical Mechanics Through Visual Modelling

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Why modelling?

Students seem to filter out much of what is said in a lecture according to their own preconceptions

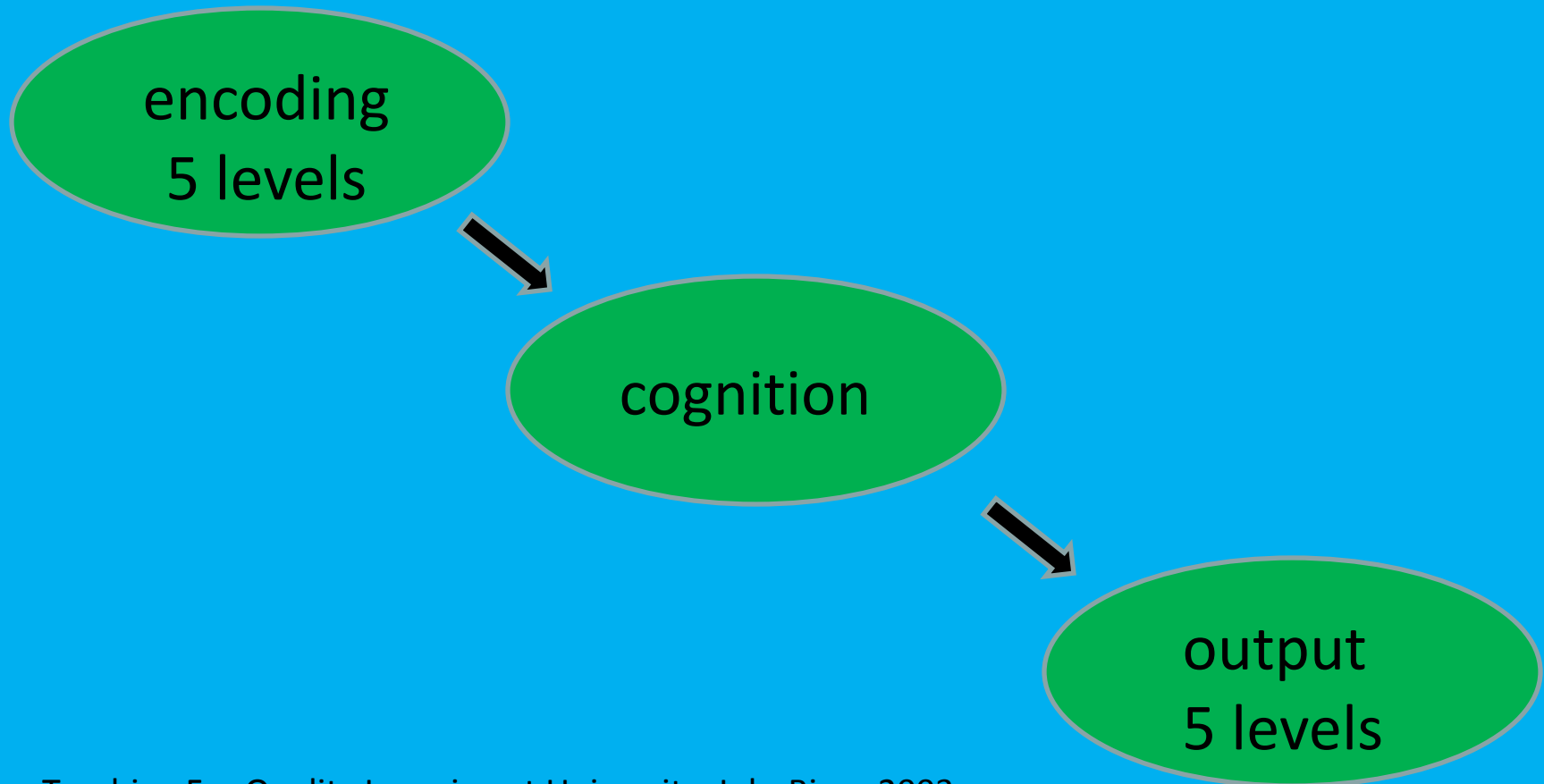
What is not filtered out is distorted by naïve beliefs about the world which do not accord with the scientific view.

These beliefs are very difficult to change

In addition, modelling does not require much maths

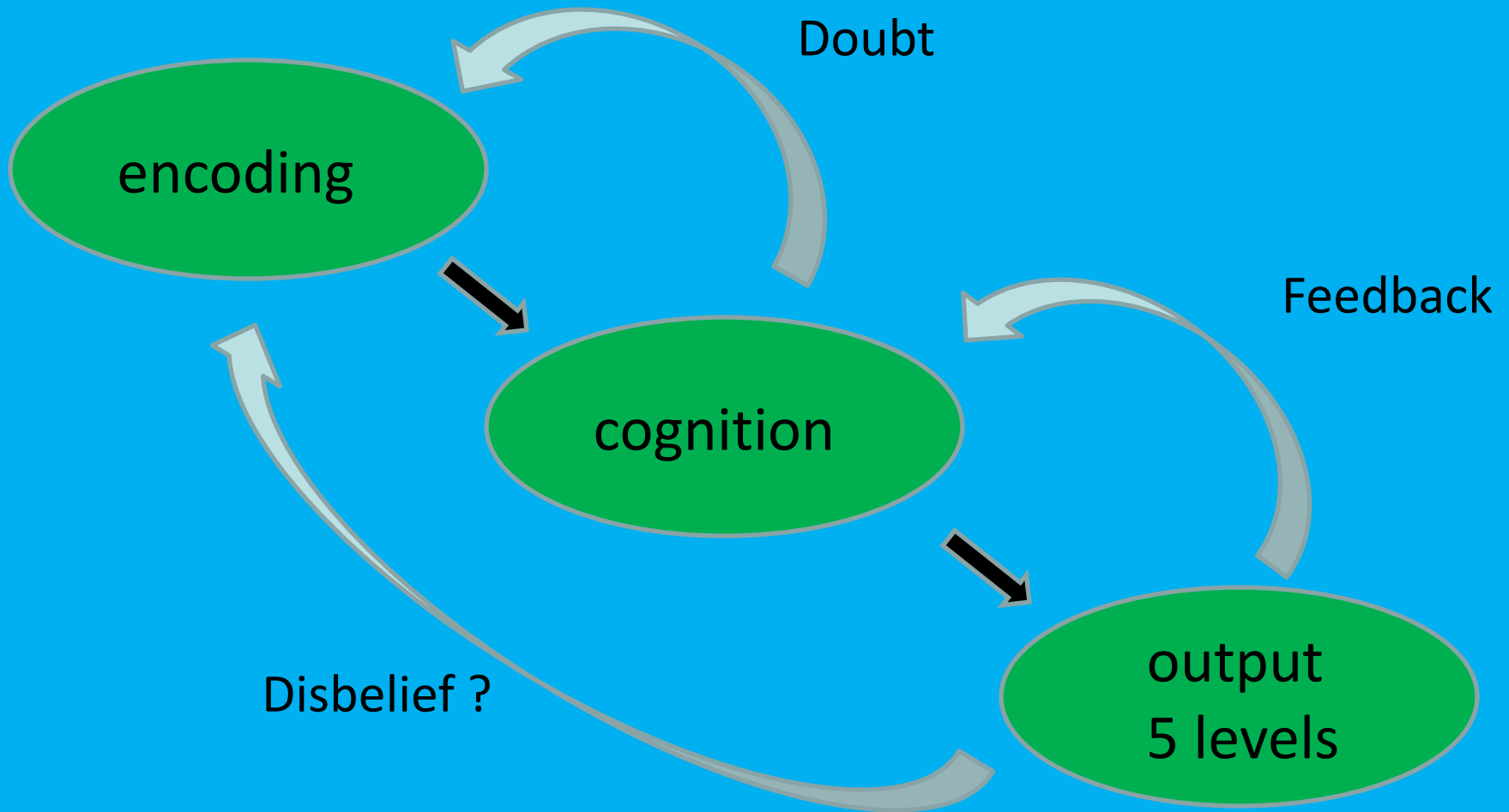


Biggs : SOLO – structure of observed learning outcomes



Teaching For Quality Learning at University, JohnBiggs 2003

Thinking styles
Learning preferences



The course:

20 “lectures” delivered to first year undergraduates (51 in total)

Mixed backgrounds and abilities

As well as mechanics, also need to cover SHM

Modelling assignment & standard exam

Pre- and post-instruction FCI (39 and 27 students resp.)

(FCI: Teaching Physics with the Physics Suite, E F Redish, 2003)



Structure:

A mixture of walk-through exercises, modelling sessions, and Powerpoint presentations.

Models based on Taylor expansion of position

$$s(t_0 + \Delta t) = s(t_0) + \frac{ds}{dt} \Delta t + \frac{1}{2} \frac{d^2s}{dt^2} \Delta t^2$$

Models mostly based on 1st and 2nd laws of motion

Reduce time step until stable solution reached.



Outcome:

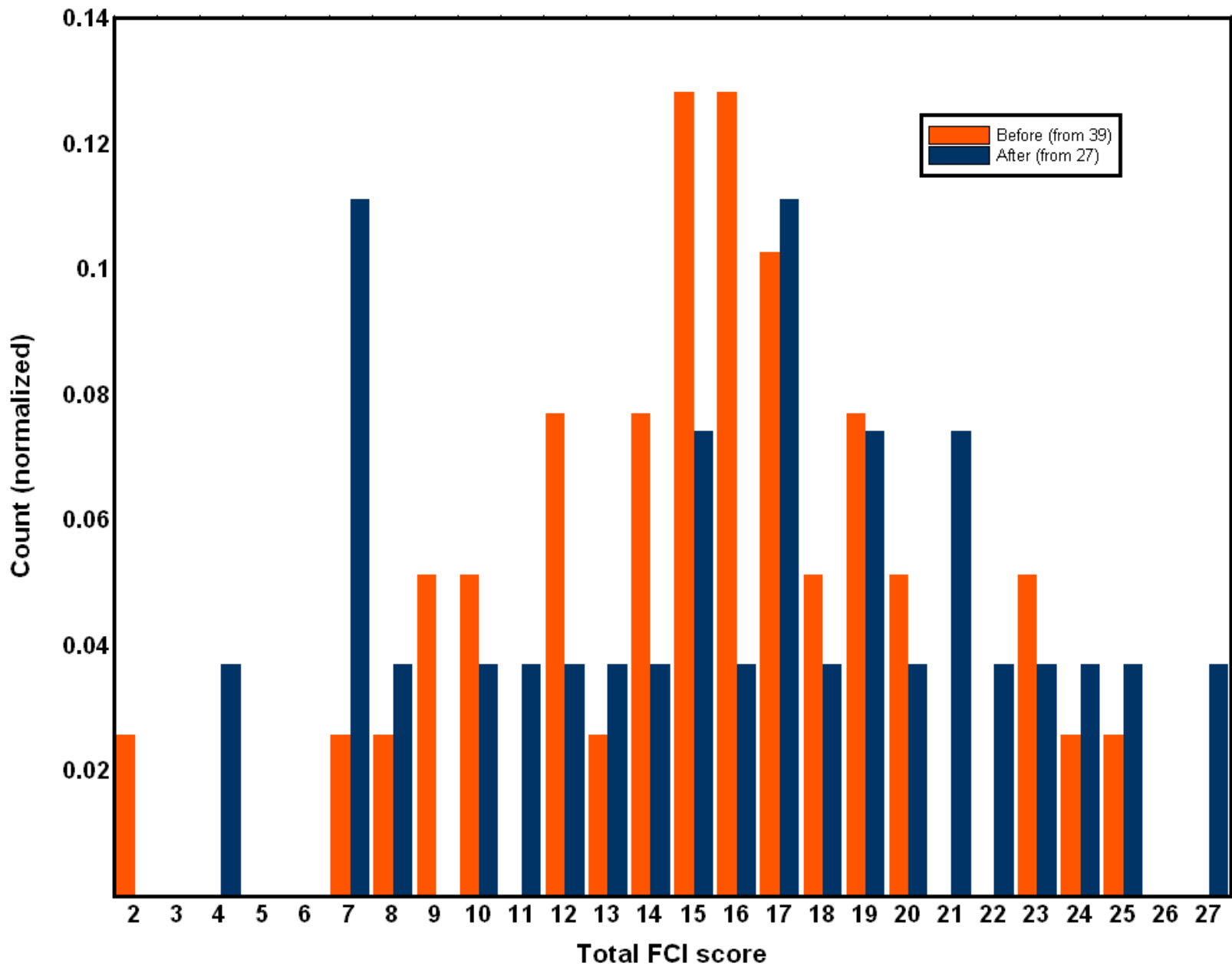
Verbal feedback positive

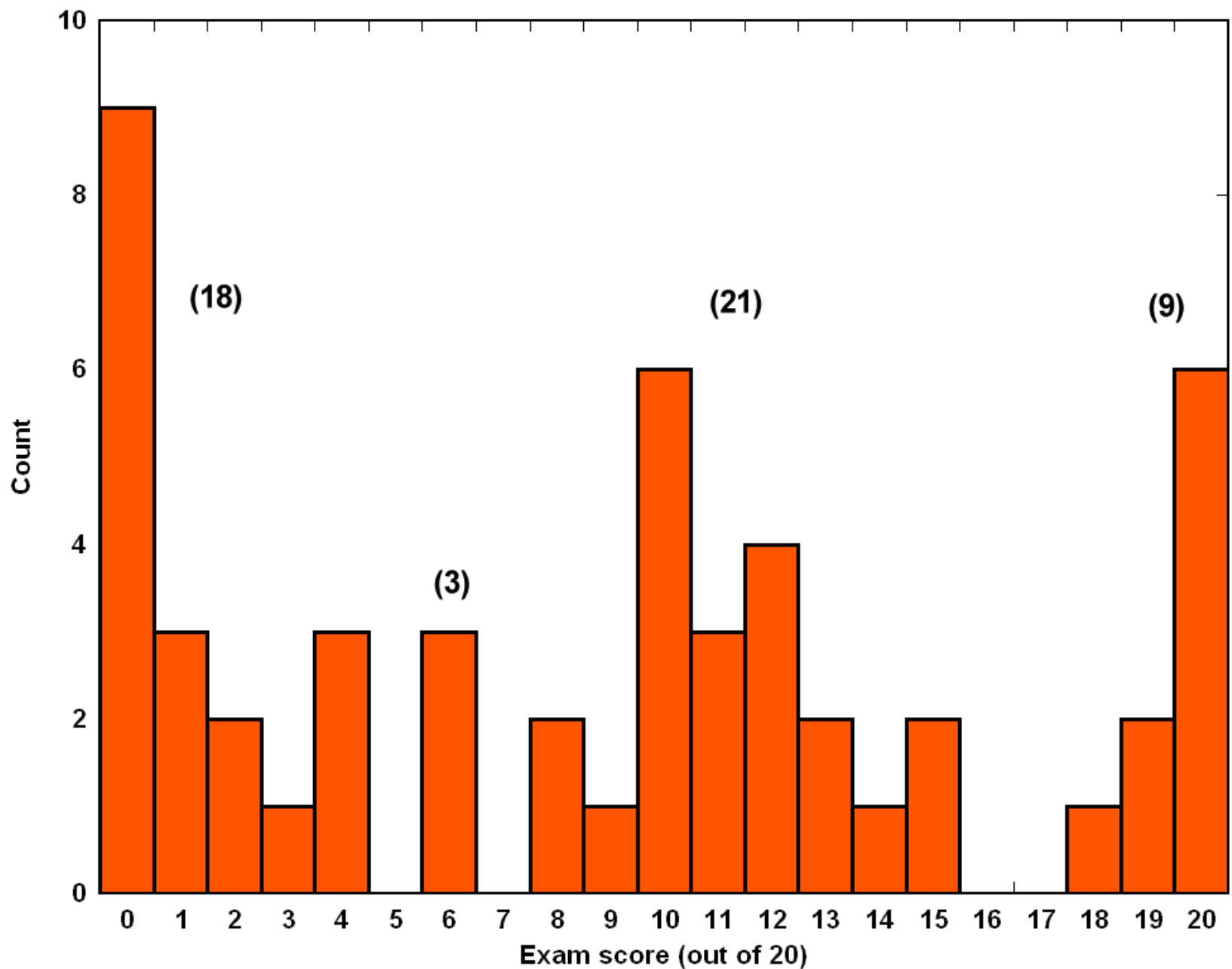
Students enjoyed the course

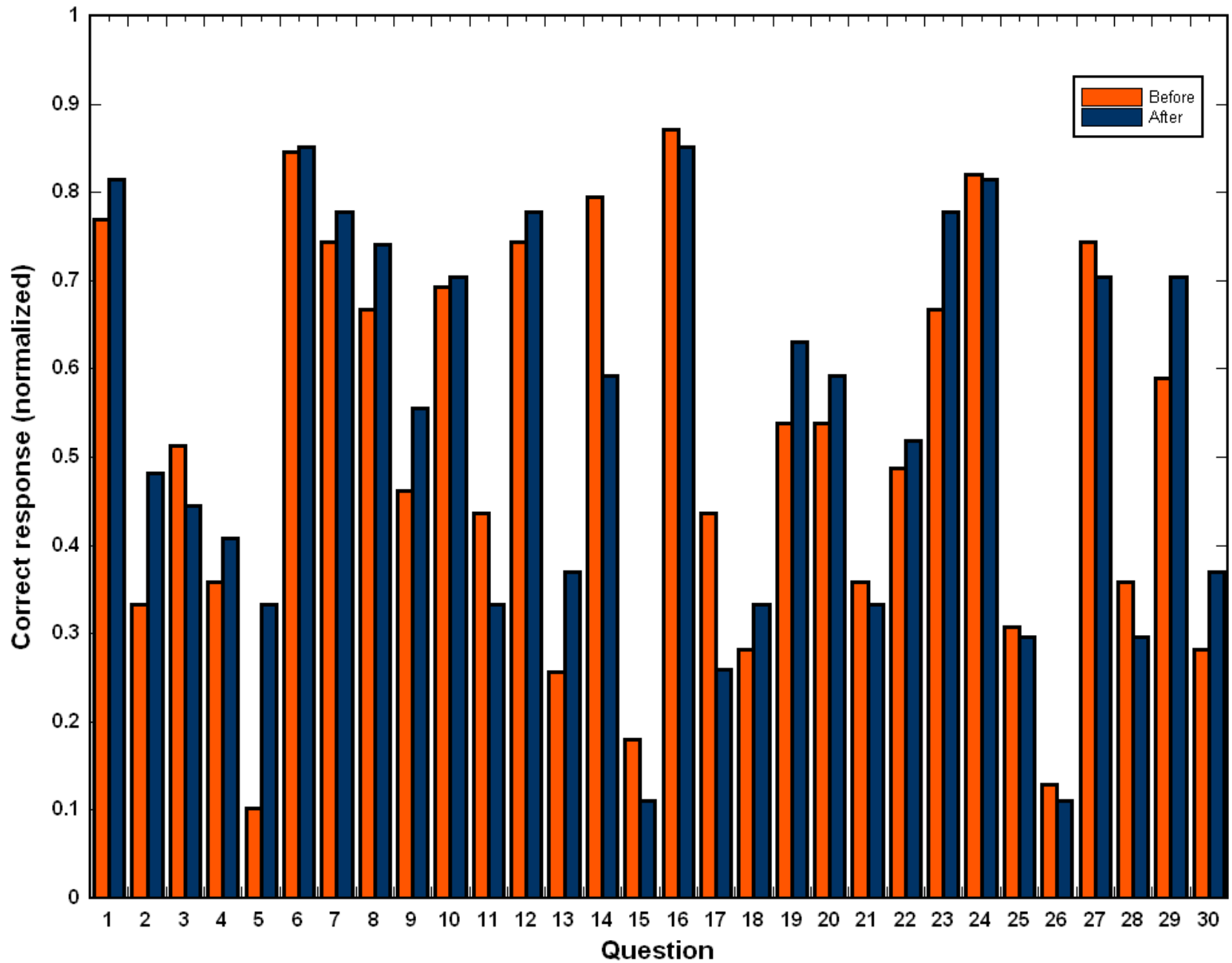
Some struggled with VPython but eventually got the hang of it.

FCI scores show some gains in understanding









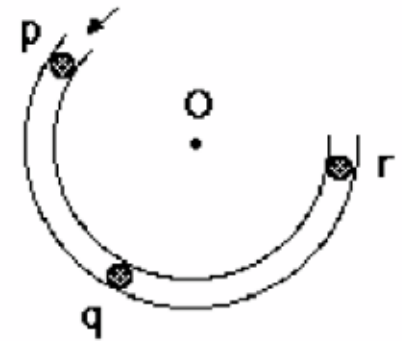
USE THE STATEMENT AND FIGURE BELOW TO ANSWER THE NEXT TWO QUESTIONS (5 and 6).
 The accompanying figure shows a frictionless channel in the shape of a segment of a circle with center at "O". The channel has been anchored to a frictionless horizontal table top. You are looking down at the table. Forces exerted by the air are negligible. A ball is shot at high speed into the channel at "p" and exits at "r."

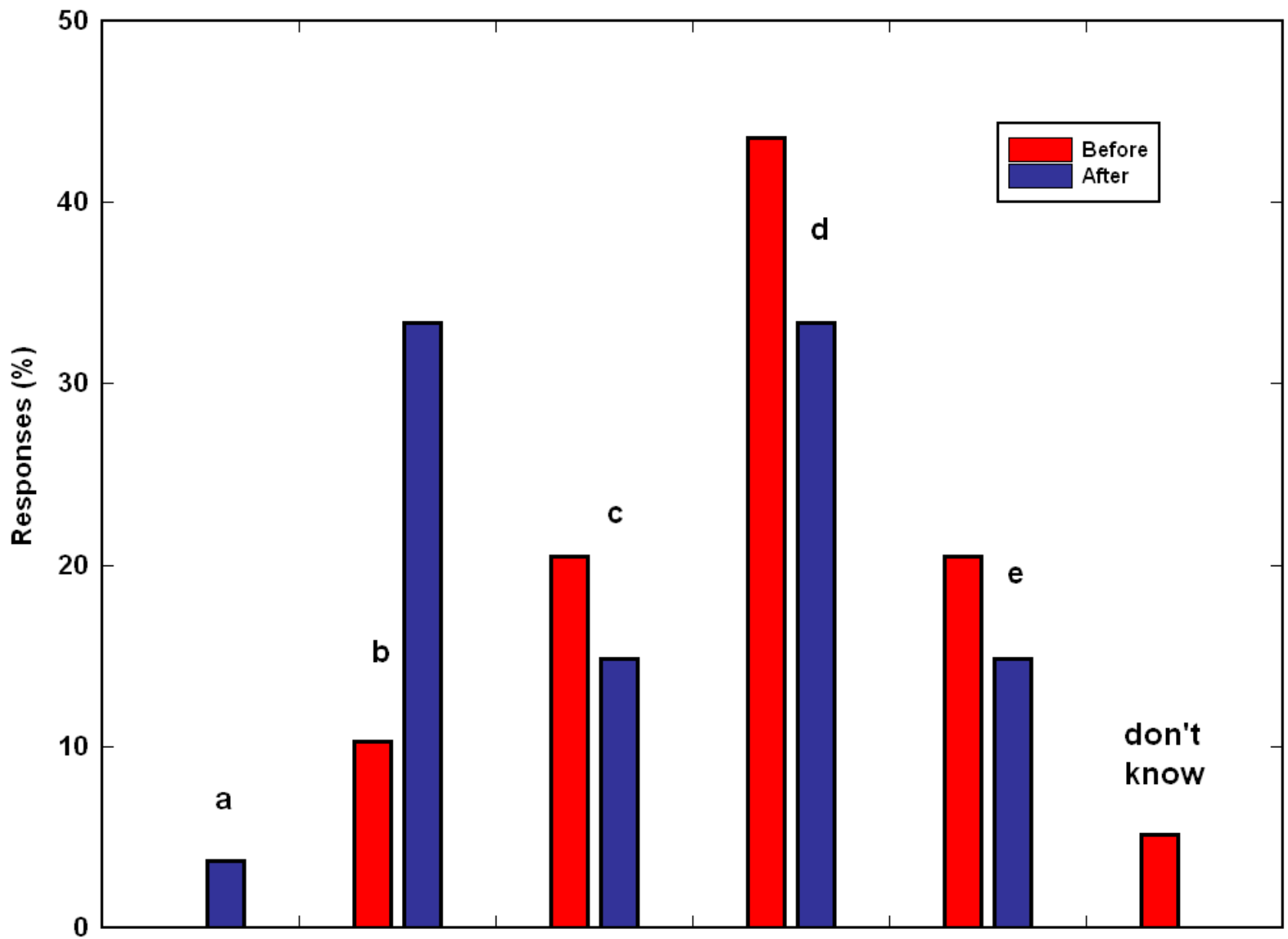
5. Consider the following distinct forces:

1. A downward force of gravity.
2. A force exerted by the channel pointing from q to O.
3. A force in the direction of motion.
4. A force pointing from O to q.



Which of the above forces is (are) acting on the ball when it is within the frictionless channel at position "q"?

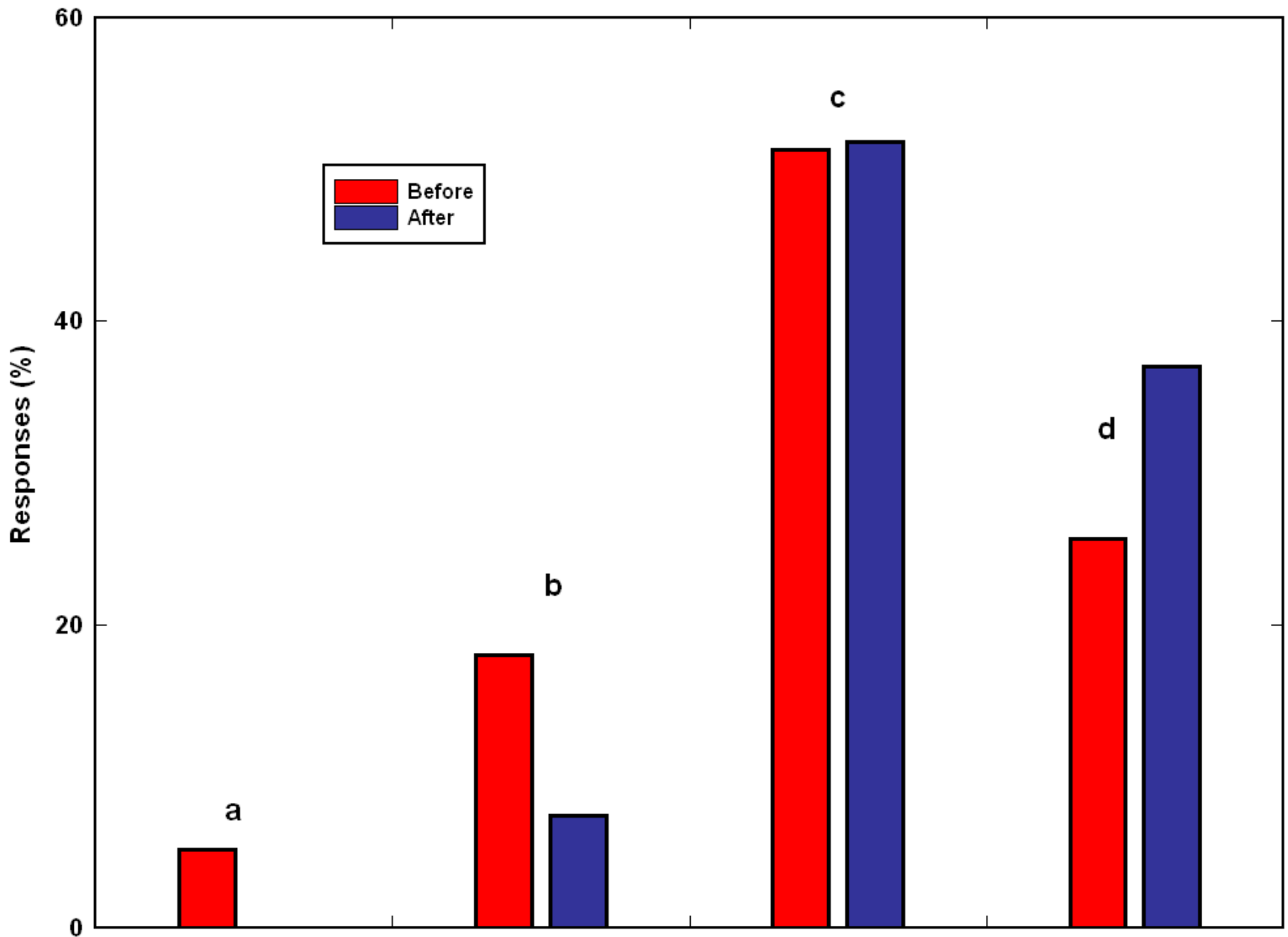
- (A) 1 only.
 (B) 1 and 2. ●
 (C) 1 and 3.
 (D) 1, 2 and 3. ◆
 (E) 1, 3 and 4.





13. A boy throws a steel ball straight up. Consider the motion of the ball only after it has left the boy's hand but before it touches the ground, and assume that forces exerted by the air are negligible. For these conditions, the force(s) acting on the ball is (are):

- (A) a downward force of gravity along with a steadily decreasing upward force.
- (B) a steadily decreasing upward force from the moment it leaves the boy's hand until it reaches its highest point; on the way down there is a steadily increasing downward force of gravity as the object gets closer to the earth.
- (C) an almost constant downward force of gravity along with an upward force that steadily decreases until the ball reaches its highest point; on the way down there is only a constant downward force of gravity. 
- (D) an almost constant downward force of gravity only. 
- (E) none of the above. The ball falls back to ground because of its natural tendency to rest on the surface of the earth.



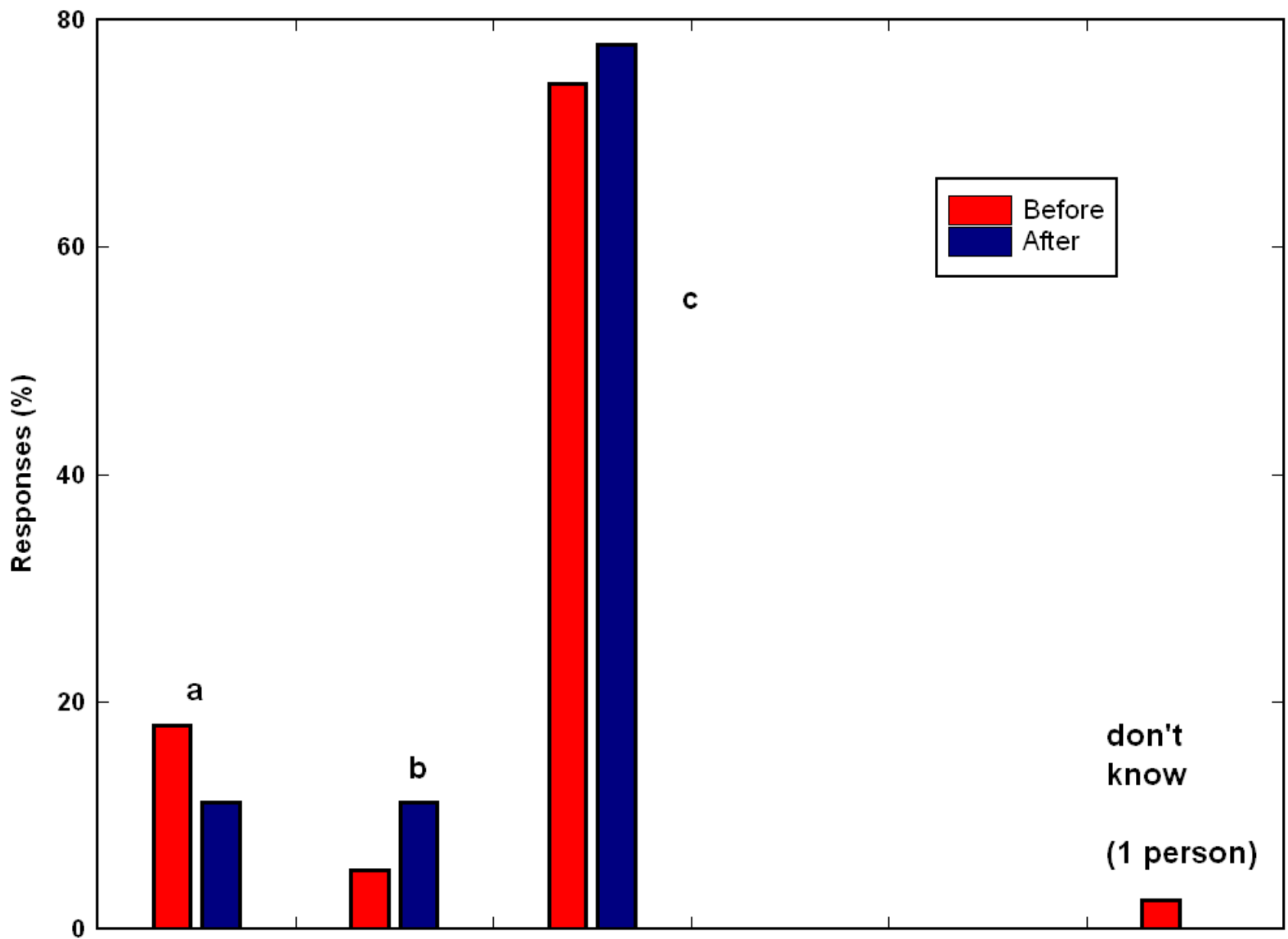
USE THE STATEMENT AND FIGURE BELOW TO ANSWER THE NEXT TWO QUESTIONS (15 and 16).

A large truck breaks down out on the road and receives a push back into town by a small compact car as shown in the figure below.



15. While the car, still pushing the truck, is speeding up to get up to cruising speed:

- (A) the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car. ●
- (B) the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
- (C) the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car. ◆
- (D) the car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
- (E) neither the car nor the truck exert any force on the other. The truck is pushed forward simply because it is in the way of the car.



- 16.** After the car reaches the constant cruising speed at which its driver wishes to push the truck:
- (A) the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
 - (B) the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
 - (C) the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
 - (D) the car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.



Conclusions:

Overall gain in FCI profile: gains in specific areas

Exam results bear out FCI

Naïve and persistent beliefs

Newton's 3rd law causes problems

Look at diagnostics for SHM

VPython was a challenge for some, but once overcome students enjoyed the course

Enjoyable way to teach



**Thank you
for
your time**

