Funded in part by ies INSTITUTE OF EDUCATION SCIENCES
U.S. Dept.of Education (#R305H050125)

Evolution of Student Knowledge in a Traditional Introductory Classroom

Eleanor C Sayre and Andrew F Heckler

THE OHIO STATE UNIVERSITY

When do students learn?

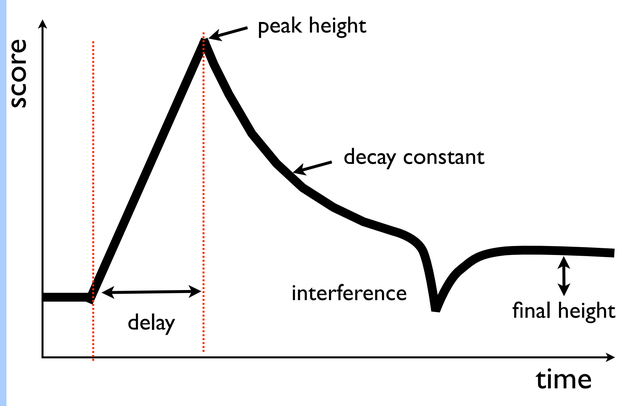
Three well-known effects

- Learning[1] (logarithmic, error-driven)
- Forgetting[2] (exponential, long-term)
- Interference (rapid, short-term)

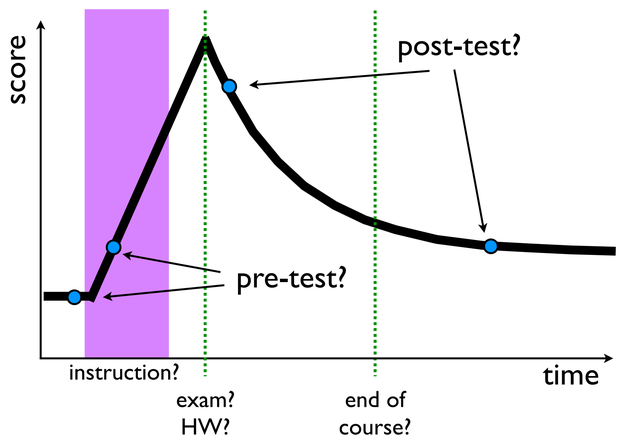
Combined for PER

- Track changing responses over time
- Better resolution than pre/post tests
- Connect learning with course events

Curve Features



Connection to course



Courses

- Calculus-based intro physics
- Traditional lecture/recitation
- Homework via WebAssign
- Primarily first-year engineering majors
- Off-sequence classes
  - Winter and Spring 2008
- 10 week academic quarter

Laboratory

- One hour per student
- Homework grade for participation
- Approx 5-10 min/task, 5 tasks/student
- Winter, Spring 2008: ~95% of class

Study design

- Between-subjects design
  - no relationship between final grade and day of lab visit
  - no evidence of inter-student communication
- Ask same questions (almost) every day
  - pre/post/during instruction
- Classic PER-inspired tasks
  - Newton's third Law
  - Math and vectors tasks
  - High-gain CSEM excerpts
  - ... and other tasks
- Some students interviewed
- All students tutored on physics afterwards

Building detectors

Newton's Third Law Task

Car and trailer

This picture shows a car pulling a trailer. The trailer weighs more than the car.

Which option(s) best describe the following situations?

Trailer pulls more	T
Equal pulls	E
Car pulls more	C

- The car was stopped, and starts to move. E T C C
- The car drives at constant speed on a flat road. E T C ?
- The car drives at constant speed up a hill. E T C ?
- The car slows down. E T C T

Models

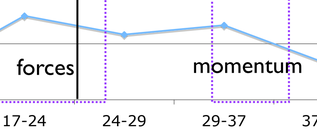
A model is a four-question answer pattern. Students exhibit a model when their responses agree with it 75%.

Only popular models are graphed.

- Newtonian
- Massive
- Active
- Mix: C??T

Car and truck

The picture shows a car and a truck. The truck weighs much more than the car.



Which option(s) best describe the following situations?

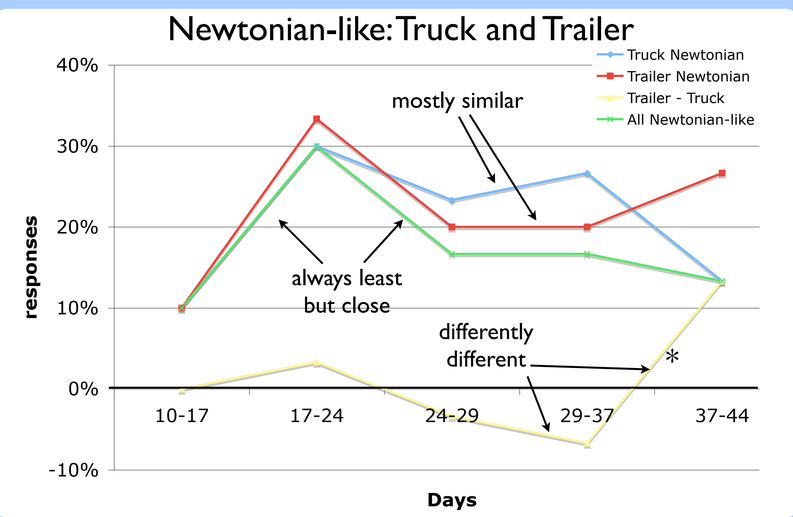
Truck pushes more	T
Equal pushes	E
Car pushes more	C

- The truck and the car are moving at equal speeds towards each other, and then they hit. E T E
- The truck is moving slowly and the car is moving quickly towards each other, and then they hit. E T C
- The truck is parked, and the car runs into it. E T C
- The car is parked, and the truck runs into it. E T T

Models for Car and Trailer over time

Models for Car and Truck over time

Newtonian-like: Truck and Trailer



Differing response to instruction

Electrostatics Task

Three high-gain CSEM[3] questions on electrostatics. (CSEM 10, 15, 13) Only first question shown.

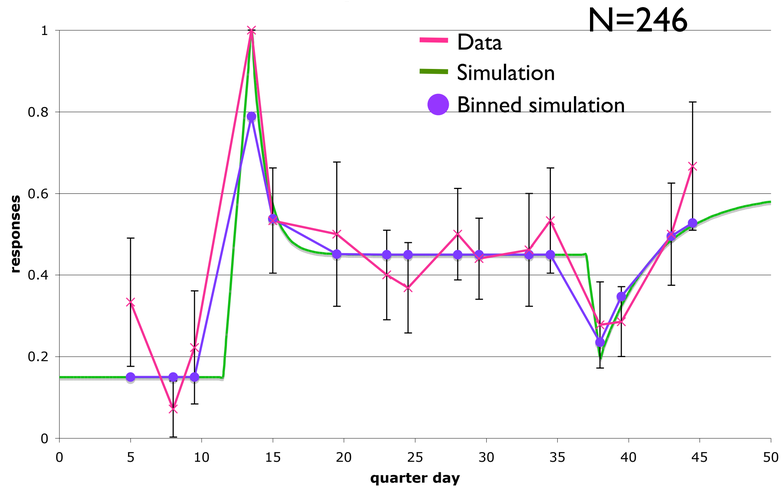
Charge in a uniform field

A positive charge is placed at rest at the center of a region of space in which there is a uniform, three-dimensional electric field ... When the positive charge is released from rest in the uniform electric field, what will its subsequent motion be?

$$\vec{F} = q\vec{E}$$
$$\sum \vec{F} = m\vec{a}$$

a) It will move at constant speed.
b) It will move at constant velocity.
c) It will move at constant acceleration.
d) It will move with linearly changing acceleration.
e) It will remain at rest in its initial position

Correct responses over time



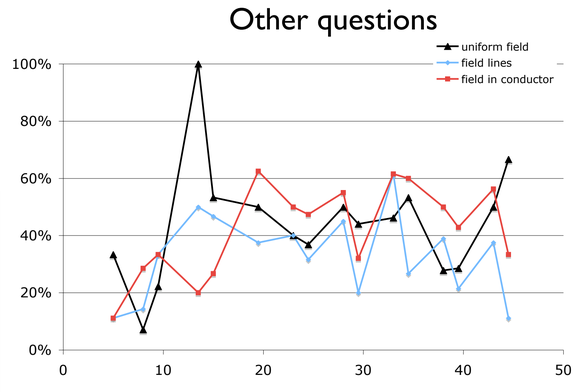
Pink line denotes data with error bars shown. Green line denotes simulation. Purple circles are the result of averaging the simulation over the time windows used to collect data, and best represent what this detector would capture, given this simulated signal.

Peak

The peak is unique to this question (unlike other features), and occurs two days after homework.

	Peak
decay constant	1
peak height	0.85
final height	0.3
stimulus time	11.5
delay	2

Other questions

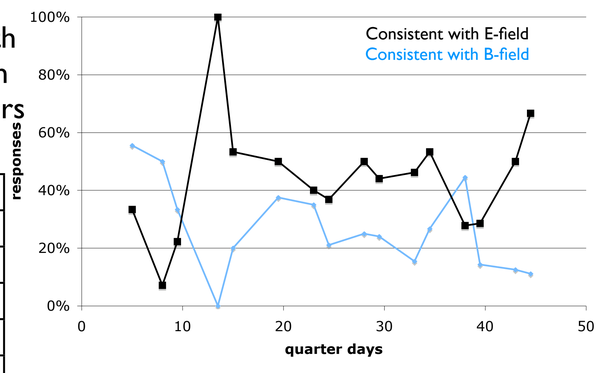


Dip

The dip is concurrent with the start of instruction on (and an increase in answers consistent with) on magnetic fields.

	Dip
decay constant	4
peak height	-0.25
final height	0.15
stimulus time	37
delay	1

Other responses



1. R.A. Rescorla, and A. R. Wagner, "A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement," in Classical Conditioning II, edited by A. H. Black, and W. F. Prokasy, Appleton-Century-Crofts, 1972, pp. 64–99.
2. C. E. B. Hermann Ebbinghaus, Henry Alford Ruger, Memory, Teachers College , Columbia University, 1913.
3. D. P. Maloney, T. L. O'Kuma, C. J. Hieggelke, and A. Van Heuvelen, AJP 69, S12–S23 (2001).