Manager: _____
Recorder: _____
Skeptic: _____
Summarizer: _____

Analyzing Force Concept Inventory Questions

Group Task:

The top of each attached page shows a question from the Force Concept Inventory. The "Pre" and "Post" columns show the percentage of students in the calculus-based course that selected each of the possible answers on the pretest (given at the beginning of the term) and the posttest (at the end of ten weeks of instruction).

1. Individually read all the questions.
2. For each question assigned to your group:
   a. Describe briefly how a student might be thinking who selected each incorrect answer. (Hint: Review the alternative conceptions from the McDermott and Wandersee et. al., articles.)
   b. Which of the possible "alternative conceptions" were successfully addressed by instruction? Which were not?
3. For one question assigned to your group, imagine you were tutoring a student with the indicated alternative conception. Discuss what example situation, reference to a common experience the student is likely to have, or set of questions that you think might help move this student away from their alternative conception. Write your answer on the back of this page.

Group Roles

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities. (earliest birthday in year)

Manager: Suggest a plan for answering the questions; make sure everyone participates and stays on task; watch the time. (next later birthday in year)

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, write down, and edit your group's answers to the questions. (next later birthday in year)

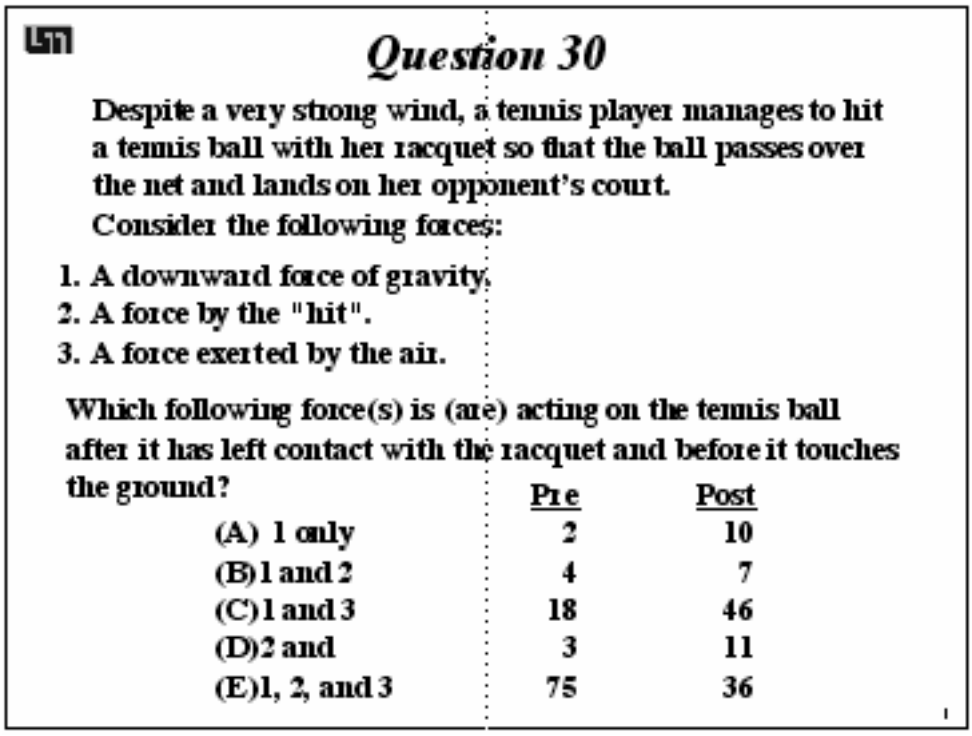
TIME: 25 minutes.

One member from each group will be randomly called on to contribute answers to the questions.

Group Product:

Activity #2 Answer Sheets.

2.



Question 30

Despite a very strong wind, a tennis player manages to hit a tennis ball with her racquet so that the ball passes over the net and lands on her opponent's court.
Consider the following forces:

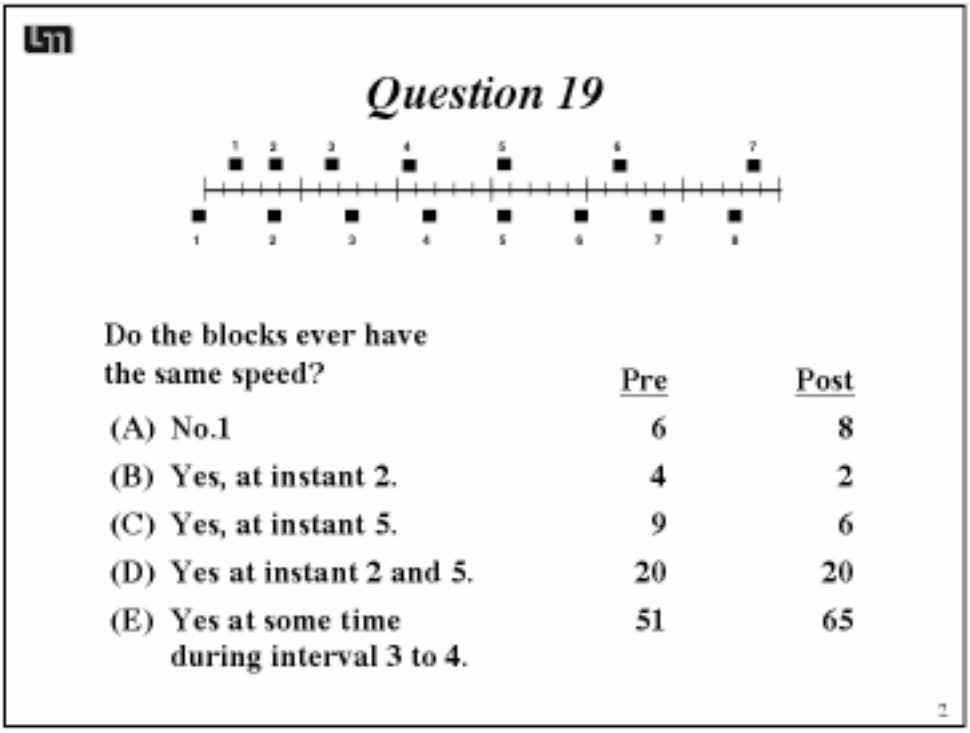
1. A downward force of gravity.
2. A force by the "hit".
3. A force exerted by the air.

Which following force(s) is (are) acting on the tennis ball after it has left contact with the racquet and before it touches the ground?

	Pre	Post
(A) 1 only	2	10
(B) 1 and 2	4	7
(C) 1 and 3	18	46
(D) 2 and	3	11
(E) 1, 2, and 3	75	36

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?



a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

Question 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):

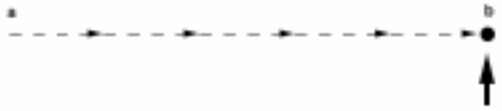
		Pre	Post
(A)	a downward force of gravity along with a steadily decreasing upward force.	1	2
(B)	a steadily decreasing upward force from the moment it leaves the boy's hand until it reaches its highest point; on the way down there is a steadily increasing downward force of gravity as the object gets closer to the earth.	17	3
(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 after there is only the constant downward force of gravity.	65	38
(D)	an almost constant downward force of gravity only.	17	57
(E)	none of the above -- the ball falls back to ground because of its natural tendency to rest on the surface of the earth.	0	1

3

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

Question 11



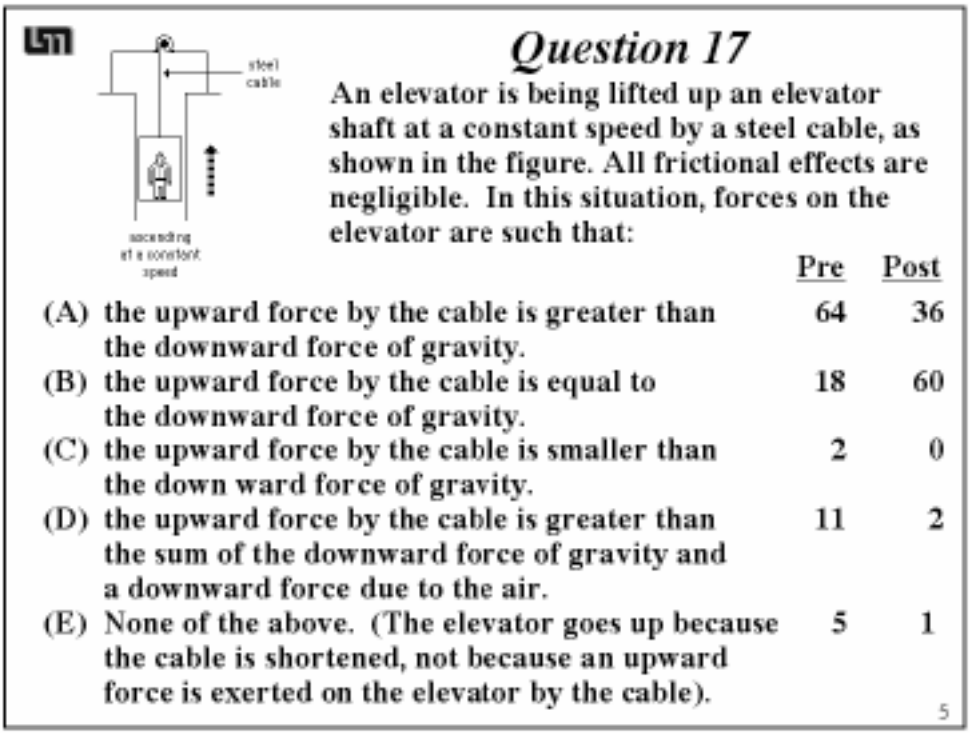
The main force(s) acting on the puck after the "kick" is (are):

	Pre	Post
(A) a downward force of gravity	9	3
(B) a downward force of gravity and a horizontal force in the direction of motion.	3	34
(C) a downward force of gravity, an upward force exerted by the surface, and a horizontal force in the direction of motion.	44	34
(D) the downward force of gravity and an upward force exerted by the surface.	13	59
(E) None. (No forces act on puck.)	0	0

4

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?



a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

Question 4

A large truck collides head-on with a small compact car.
During the collision,

	Pre	Post
(A) the truck exerts a greater amount of force on the car than the car exerts on the truck	79	46
(B) the car exerts a greater amount of force on the truck than the truck exerts on the car.	2	1
(C) neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.	0	0
(D) the truck exerts a force on the car, but the car doesn't exert a force on the truck.	0	0
(E) the truck exerts the same amount of force on the car as the car exerts on the truck.	19	53

6

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

Question 15

While the car, still pushing the truck, is *speeding up* to get up to cruising speed;

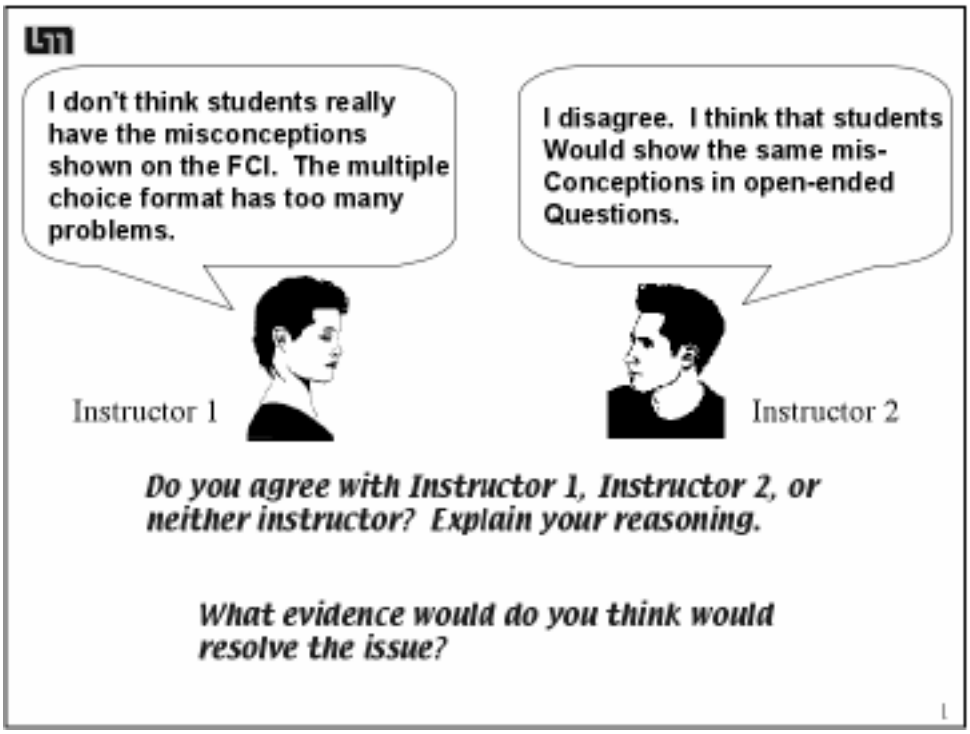
	Pre	Post
(A) the amount of force of the car pushing against the truck is equal to that of the truck pushing back against the car.	19	25
(B) the amount of force of the car pushing against the truck is less than that of the truck pushing back against the car.	9	5
(C) the amount of force of the car pushing against the truck is greater than that of the truck pushing against the car.	68	69
(D) the car's engine is running so it applies a force as it pushes against the truck, but the truck's engine is not running so it can't push back against the car -- the truck is pushed forward. simply because it is in the way of the car.	3	1
(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.	0	0

7

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

3. Imagine you are tutoring a student who has an "alternative conception" similar to that of Question # _____. What example situation, reference to a common experience the student is likely to have, or set of questions do you think might help move this student away from their alternative conception?


I don't think students really have the misconceptions shown on the FCI. The multiple choice format has too many problems.
I disagree. I think that students Would show the same mis-Conceptions in open-ended Questions.
Instructor 1
Instructor 2
Do you agree with Instructor 1, Instructor 2, or neither instructor? Explain your reasoning.
What evidence would do you think would resolve the issue?

Question 21

~35% "Confuse v and a" on FCI Pretest

21. The acceleration of the blocks are related as follows:	Pre	Post
(A) acceleration of "a" > acceleration of "b"	16	7
(B) acceleration of "a" = acceleration "b" > 0	6	1
(C) acceleration of "b" > acceleration "a"	29	16
(D) acceleration of "a" = acceleration of "b" = 0	*41*	*73*
(E) not enough information to answer.	8	2

2

Ramp Problem (1993)

A steel ball is launched with some initial velocity, slows down as it travels up a gentle incline, reverses direction, and then speeds up as it returns to its starting point. Assume friction is negligible.

(a) Suppose we calculated the acceleration of the ball as it's moving up the ramp (from 1 to 2), and the acceleration as it's moving down the ramp (from 2 to 3). How would these two accelerations compare? (i.e., Are the accelerations the same size? The same direction?) Explain your reasoning.

(b) Does the ball have an acceleration at its highest point on the incline (at position 2)? Explain your reasoning.

3

How Does the Acceleration Compare Up and Down a Ramp?

~74% "Confuse v and a" on Open-ended Question

Type of Response	Algebra-based (n = 112) pre (%)	Algebra-based (n = 112) post (%)	Calculus-based (n = 100) pre (%)	Calculus-based (n = 100) post (%)
1. Includes accepted idea	6	79	19	40
2. Includes alternative conception				
a. confuse v and a, but believe motion up and down is the same	58	16	57	51
b. confuse v and a, but believe motion up and down is different	35	2	17	6
3. Uncodeable	1	3	7	3

4

Question 30

Despite a very strong wind, a tennis player manages to hit a tennis ball with her racquet so that the ball passes over the net and lands on her opponent's court.
Consider the following forces:

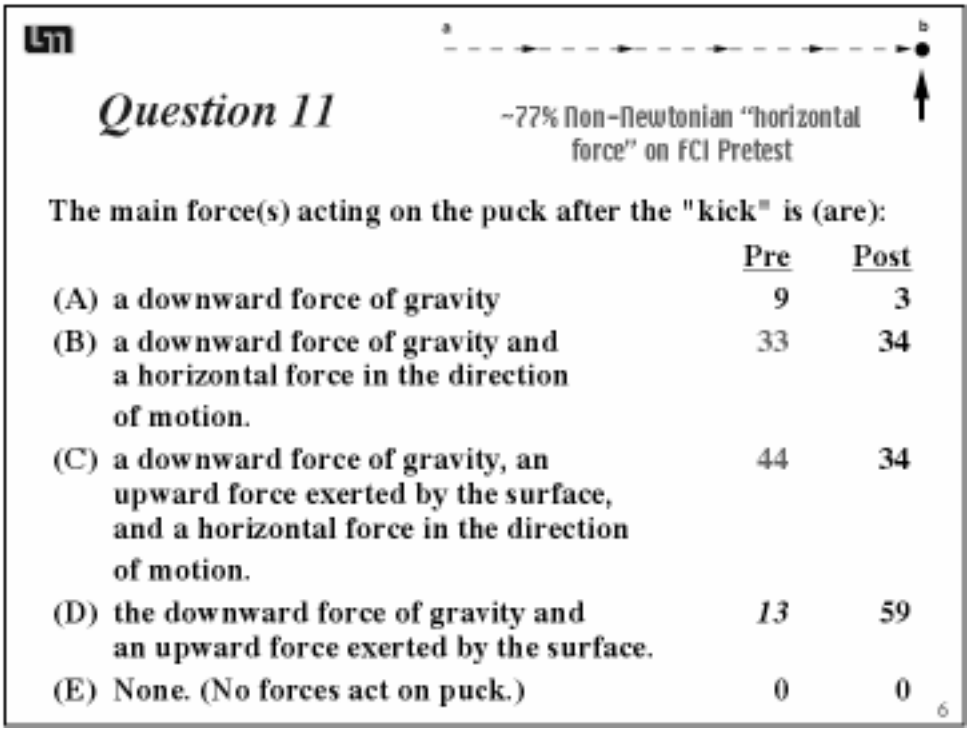
1. A downward force of gravity.
2. A force by the "hit".
3. A force exerted by the air.

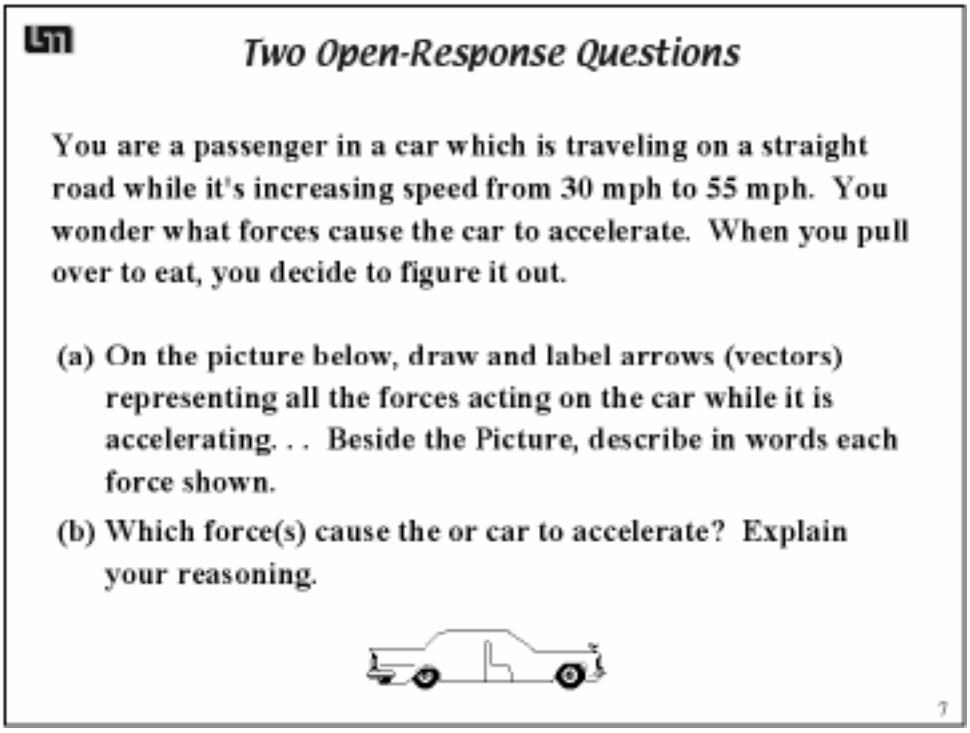
~80% Non-Newtonian Force of "hit" on FCI Pretest

Which following force(s) is (are) acting on the tennis ball after it has left contact with the racquet and before it touches the ground?

	Pre	Post
(A) 1 only	2	10
(B) 1 and 2	4	7
(C) 1 and 3	*18*	*46*
(D) 2 and 3	1	1
(E) 1, 2, and 3	75	36

5


a
b
Question 11
~77% Non-Newtonian "horizontal force" on FCI Pretest
The main force(s) acting on the puck after the "kick" is (are):
Pre
Post
(A) a downward force of gravity 9 3
(B) a downward force of gravity and a horizontal force in the direction of motion. 33 34
(C) a downward force of gravity, an upward force exerted by the surface, and a horizontal force in the direction of motion. 44 34
(D) the downward force of gravity and an upward force exerted by the surface. 13 59
(E) None. (No forces act on puck.) 0 0
6


Two Open-Response Questions
You are a passenger in a car which is traveling on a straight road while it's increasing speed from 30 mph to 55 mph. You wonder what forces cause the car to accelerate. When you pull over to eat, you decide to figure it out.
(a) On the picture below, draw and label arrows (vectors) representing all the forces acting on the car while it is accelerating. . . Beside the Picture, describe in words each force shown.
(b) Which force(s) cause the or car to accelerate? Explain your reasoning.
7

What is the Nature of the Forces on the Car?

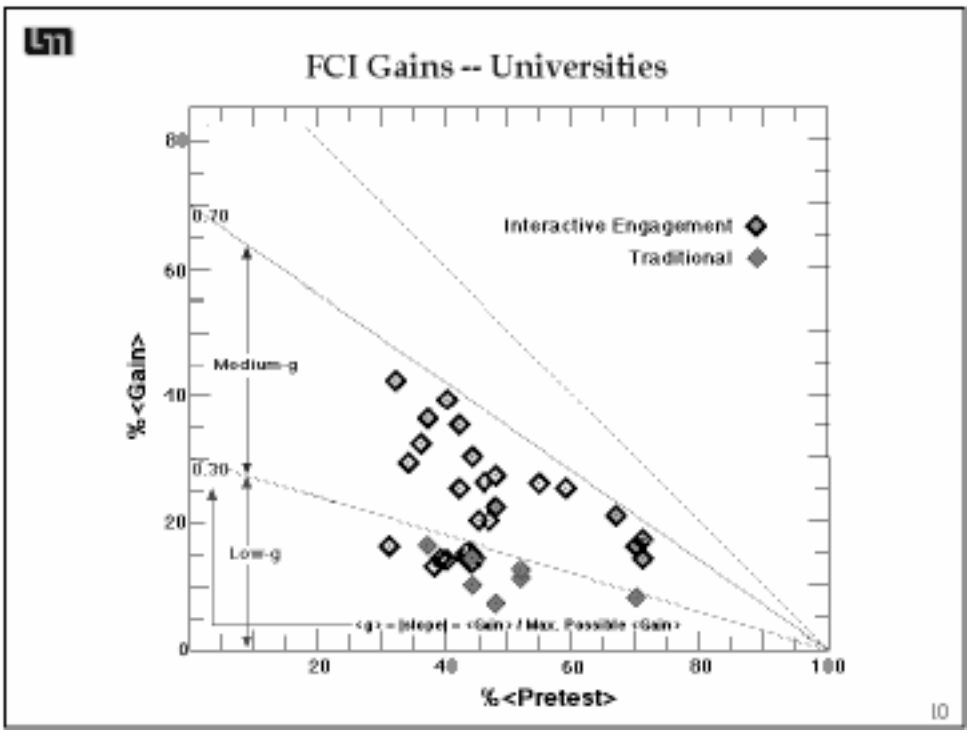
Type of Response	FCI post 68% 1993 Baseline (n = 100) pre (%)	FCI post 68% 1993 Baseline (n = 100) post (%)	FCI 72% 1996 Coop. Group (n=85) post (%)	FCI 82% 1996 Full Model (n=71) post (%)
1. Only Newtonian forces	*10*	39	58	73
2. Newtonian forces, but some are 3rd Law pair on wrong object	4	15	4	2
3. Include non-Newtonian forces (e.g., acceleration of car, engine, inertia, etc.)	73	39	38	25
4. Uncodeable	8	1	0	0

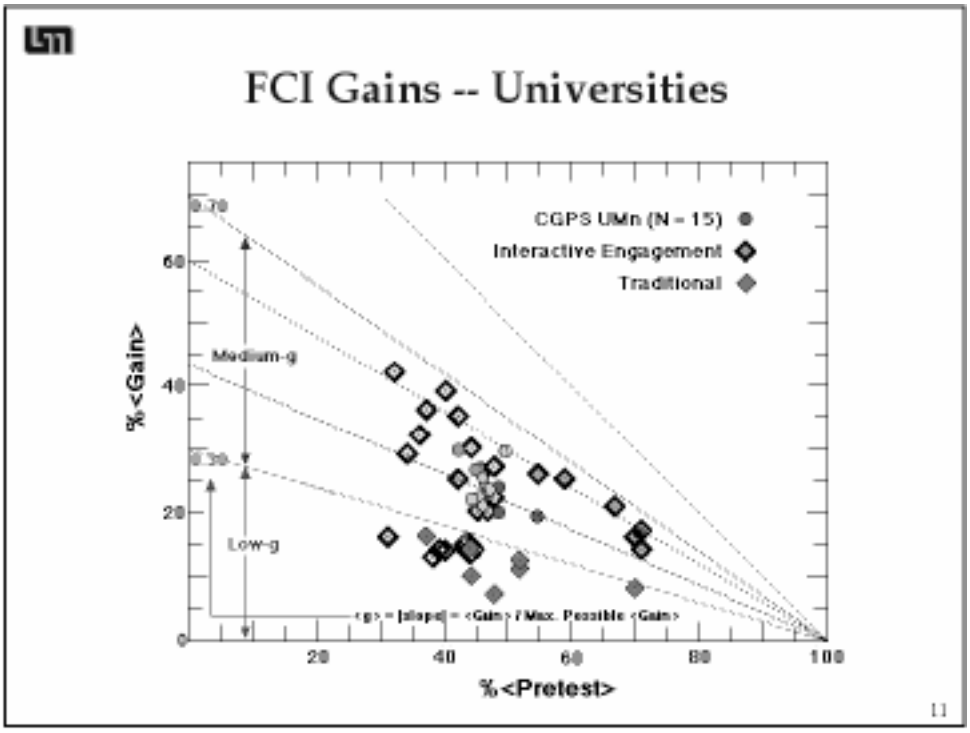
8

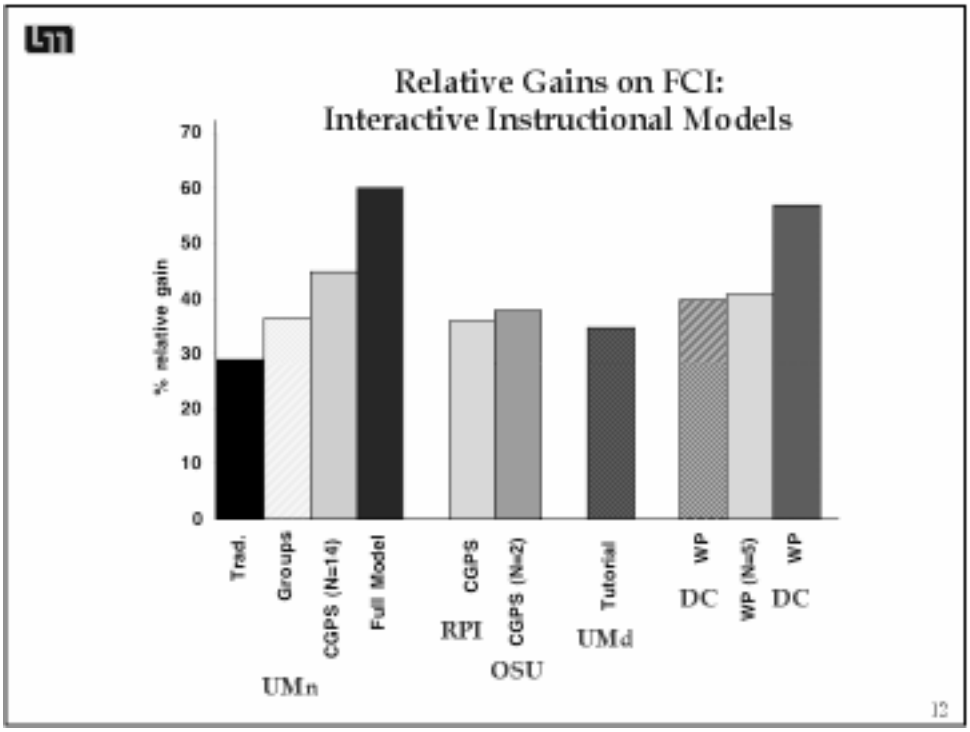
Why Does the Car Accelerate?

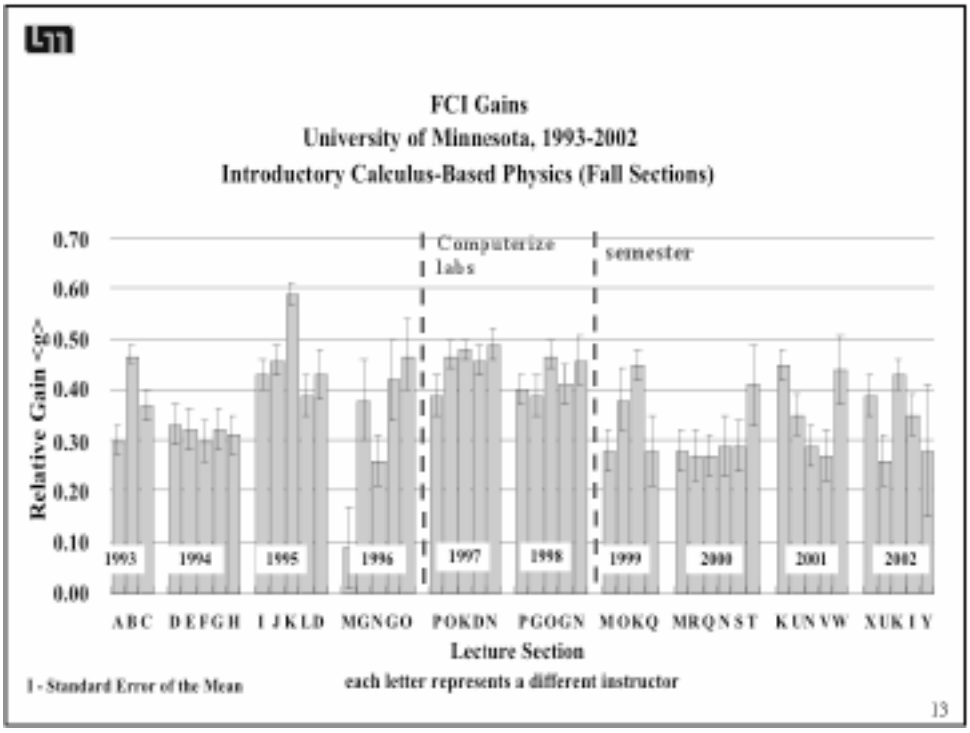
Type of Response	FCI post 68% 1993 Baseline (n = 100) pre (%)	FCI post 68% 1993 Baseline (n = 100) post (%)	FCI 72% 1996 Coop Group (n=85) post (%)	FCI 82% 1996 Full Model (n=71) post (%)
1. Includes correct ideas about summing real forces	7	20	42	58
2. Vague or incorrect summing	25	29	24	21
3. Includes alternative ideas				
a. accel. due to one force	4	23	21	19
b. accel. not due to real force on the car	48	23	7	0
4. Uncodeable	16	7	6	4

9


FCI Gains -- Universities
Interactive Engagement
Traditional
Medium-g
Low-g
0.70
0.30
<g> = |slope| = <Gain> / Max. Possible <Gain>
%<Gain>
%<Pretest>
0
20
40
60
80
100
10


FCI Gains -- Universities
CGPS UMn (N = 15)
Interactive Engagement
Traditional
Medium-g
Low-g
0.70
0.30
<g> = |slope| = <Gain> / Max. Possible <Gain>
%<Gain>
%<Pretest>
0
20
40
60
80
100
11


Relative Gains on FCI:
Interactive Instructional Models
% relative gain
70
60
50
40
30
20
10
0
Trad.
Groups
CGPS (N=14)
Full Model
CGPS
CGPS (N=2)
Tutorial
WP
WP (N=5)
WP
UMn
RPI
OSU
UMd
DC
DC
12


FCI Gains
University of Minnesota, 1993-2002
Introductory Calculus-Based Physics (Fall Sections)
Relative Gain <g>
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Computerize labs
semester
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
A B C
D E F G H
I J K L D
M G N G O
P O K D N
P G O G N
M O K Q
M R Q N S T
K U N V W
X U K I Y
Lecture Section
1 - Standard Error of the Mean
each letter represents a different instructor
13