W14
Teaching Assistants: Getting them Ready and Supporting Their Teaching

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15 year continuing project to improve undergraduate education with contributions by:
Many faculty and graduate students of U of M Physics & Education
In collaboration with U of M Physics Education Group

*** Supported in part by the U.S. Department of Education (FIPSE) and the National Science Foundation**

AGENDA

1. **Introduction and Goals (≈ 15 minutes)**
   - √ **Who are you and what are your goals?**

2. **TAs and Their Role at Minnesota – Similarities and Differences to Your Situation (≈ 15 minutes)**
   - √ **What are the abilities of TAs?**
   - √ **What role do TAs take in undergraduate courses?**

3. **Supporting TAs for Success (≈ 2 hours)**
   - √ **What?**
   - √ **Why?**
   - √ **How?**

TASK

1. What do your TAs do at your institution?
2. What problems arise when you use TAs?
3. What is the most important thing you would like to learn?

TIME ALLOTTED

10 minutes

PROCEDURES

Formulate a response individually.
Discuss your response with your partners.
Listen to your partners' responses.
Create a new group response through discussion.

PRODUCT

List your group's answers to the three questions.

From the group

What do your TAs do at your institution?

- TA's in studio physics – help answer physics-based physics while groups solve problems
- Teach lab and recitations – interactive question and answer with short quiz
- Teach tutorials == Socratic dialoging and standard labs and some regular recitations solving problems for students, physics study center
- Grading – developing rubrics, labs, office hours
- helping with computers, demo area, develop new labs, primary teach labs

From the group

What problems arise when you use TAs?

- Can’t speak English
- Can’t communicate
- Meeting their responsibilities – showing up on time
- Unwilling to do task
- Quality control – grade like supposed to, etc.
- Scheduling – people switching – inequities in students’ loads
- TA morale
- Don’t want to teach, don’t care because does not impact grade or degree
- TAs don’t want to teach except by telling

Minnesota Introductory Classes -- The Structure

7 - 8 Lecture Sections*
(1 section / professor)

150 - 250 students

3 hrs/week

10 TA-led Sections
(2 sections / TA)

15 - 16 students

Discussion
1 hr/week

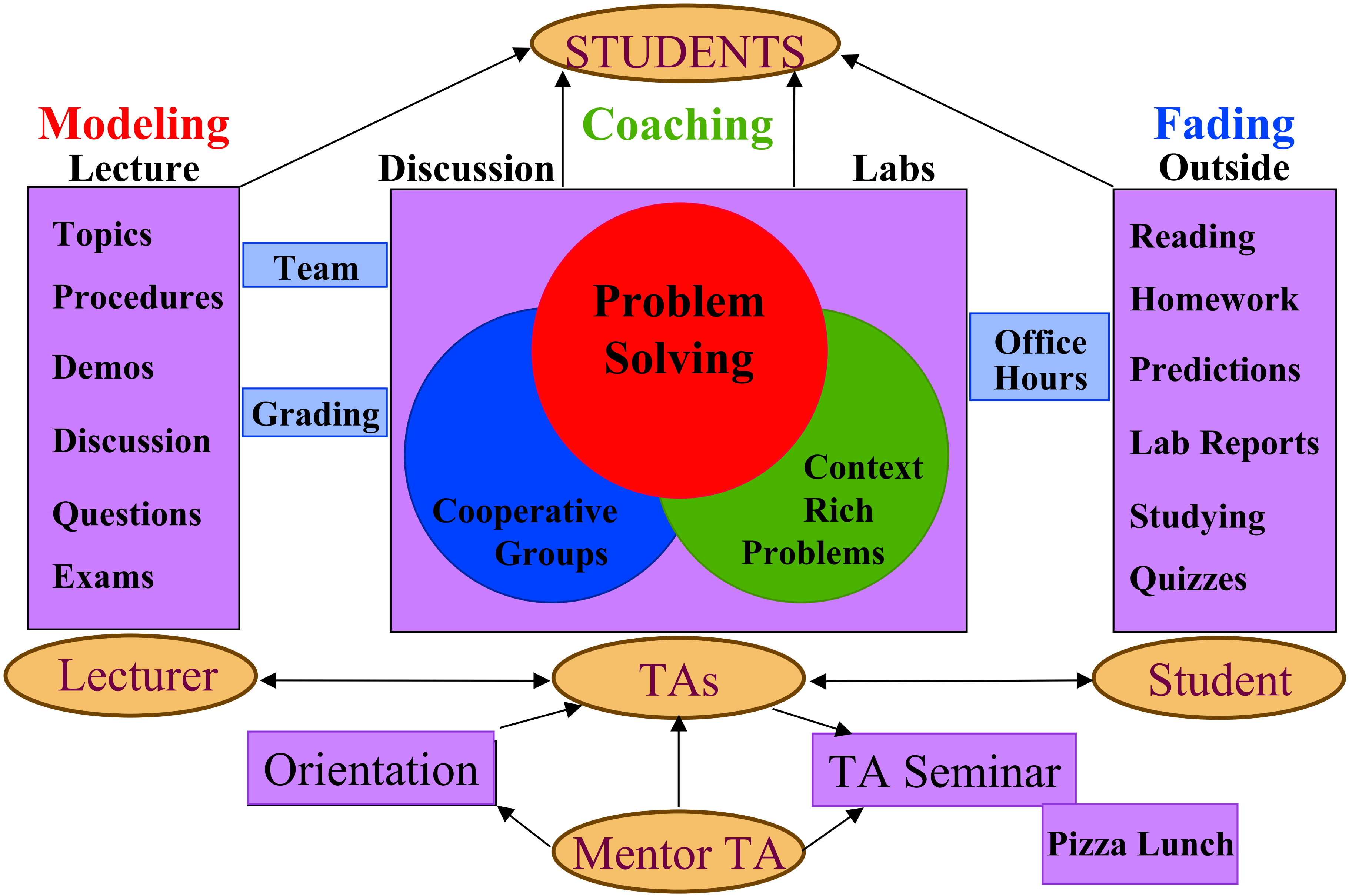
Solve Context-rich Written Problems

Laboratory
2 hr/week

Solve Context-rich Experimental Problems
Writing Intensive

* 6-7 Calculus-based
1 Algebra-based

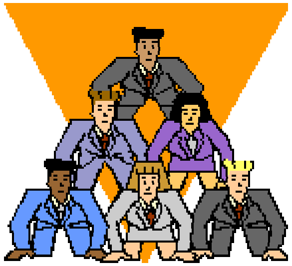
SYSTEM FOR LARGE INTRODUCTORY COURSE



Physics Education Research & Development

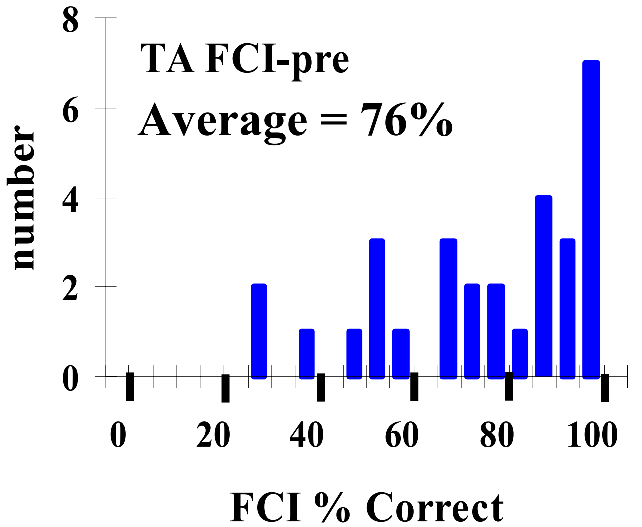
TA Inventory – Fall 02

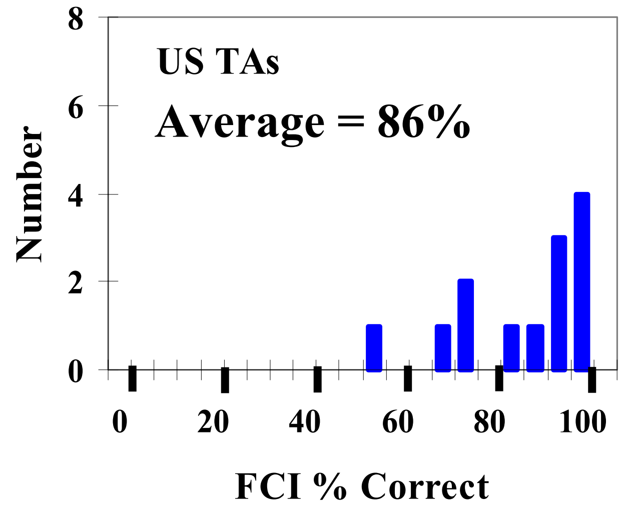
- Number = 79
- 76% male 24% female
- 90% physics 10% engineering
- 33% first year graduate students
- 6% undergraduates
- 66% international 34% US



Country	%
US	34
China	32
India	10
Russia	8
Korea	5
Germany	3
Other	8

TA FCI


TA FCI-pre
Average = 76%
number
8
6
4
2
0
0
20
40
60
80
100
FCI % Correct


US TAs
Average = 86%
Number
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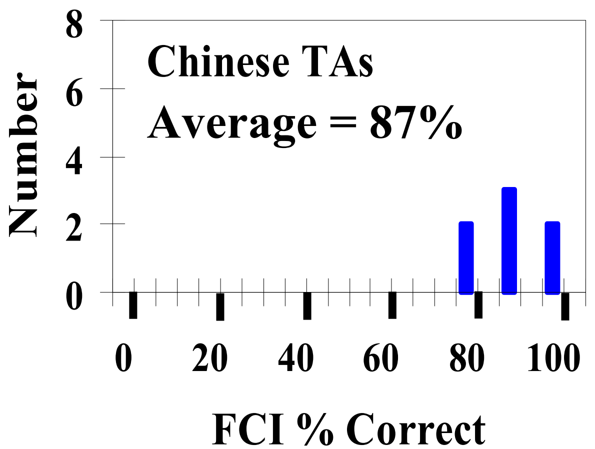
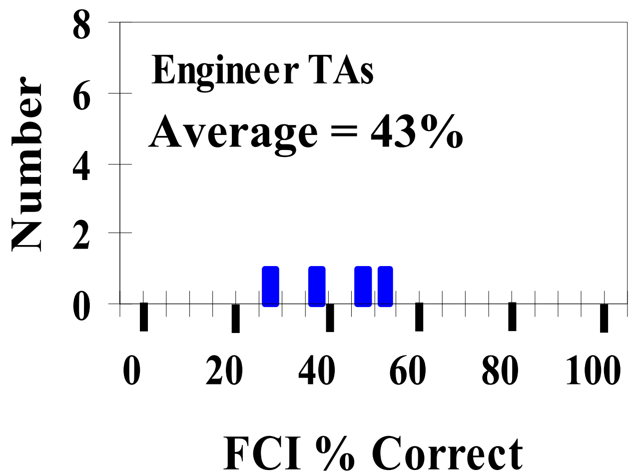
100
FCI % Correct


Chinese TAs
Average = 87%
Number
8
6
4
2
0
0
20
40
60
80
100
FCI % Correct


Engineer TAs
Average = 43%
Number
8
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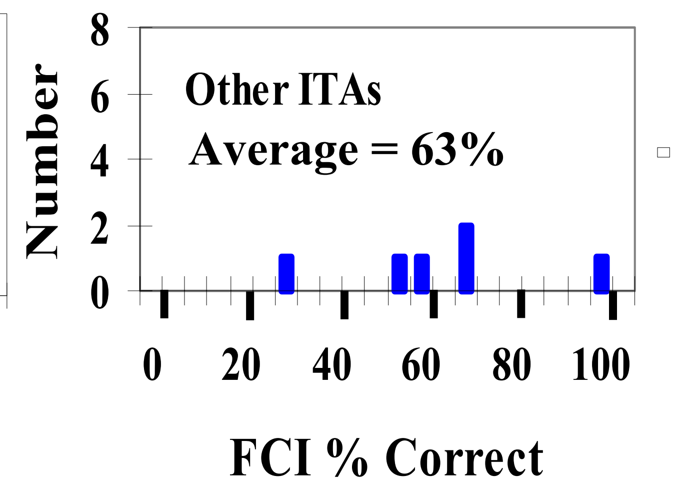
0
20
40
60
80
100
FCI % Correct

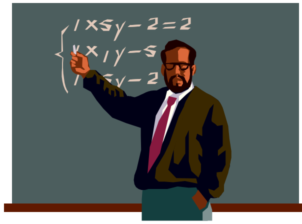

Other ITAs
Average = 63%
Number
8
6
4
2
0
0
20
40
60
80
100
FCI % Correct

The New TAs at Minnesota

Essentially all new graduate students - a few undergrads.

Bright Students Eager to Teach:

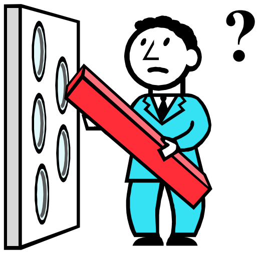
Major Teaching Misconception - Students will understand if material is clearly explained



Physics Knowledge Typical of an Undergraduate:

- Gaps in knowledge
- Some “alternative conceptions”
- No teaching experience

Teaching Skills:



- Cannot give a coherent presentation
- Cannot give a logical explanation
- Enough “wrong physics” so cannot explain a problem solution.
- Cannot manage a group of people
- No knowledge of how people learn

Course Environment -- TA Success

TAs Know What’s Going On:

- definite course goals that TAs know
- definite topic goals that TAs know
- TAs know all changes before students
- TAs know lecturer’s view of the material
  - What are the pitfalls

Clarifying Goals - Grading

TASK

1. Grade the 2 student solutions on a scale of 1 - 10
2. Justify your grade.
3. After you have arrived at a grade and a justification for each paper compare with your group. Try to come to an agreement.

TIME ALLOTTED

10 minutes

PROCEDURES

Formulate a response individually.
Discuss your response with your partners.
Listen to your partners' responses.
Create a new group response through discussion.

PRODUCT

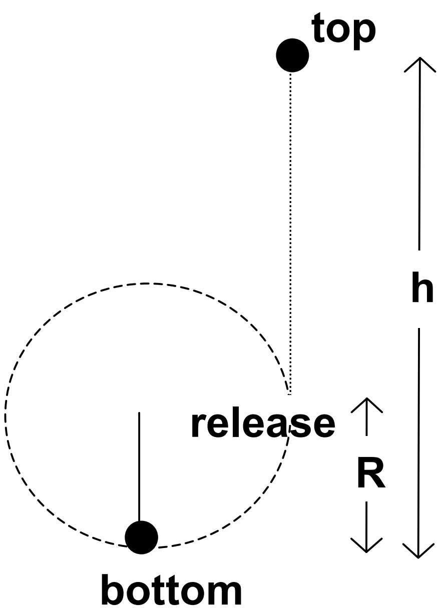
A grade and its justification for each paper.

Problem

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a **maximum height of 23 meters** above the lowest point in the circle. In order to do this, **what force will you have to exert on the string** when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. **Assume also that air resistance can be neglected.** The stone weighs 18 N.

Final examination question (Fall, 1997)

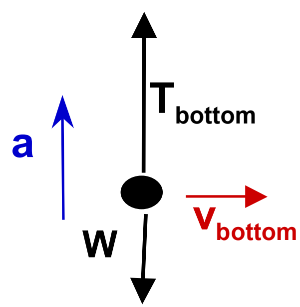
An Expert Solution



- No work is done by string (since T ⊥ υ),
- so all work is done by gravity. Using conservation of energy between bottom and top:

$$\frac{1}{2}mv_{bottom}^{2} = mgh$$

Using Newton's 2nd Law at the bottom.

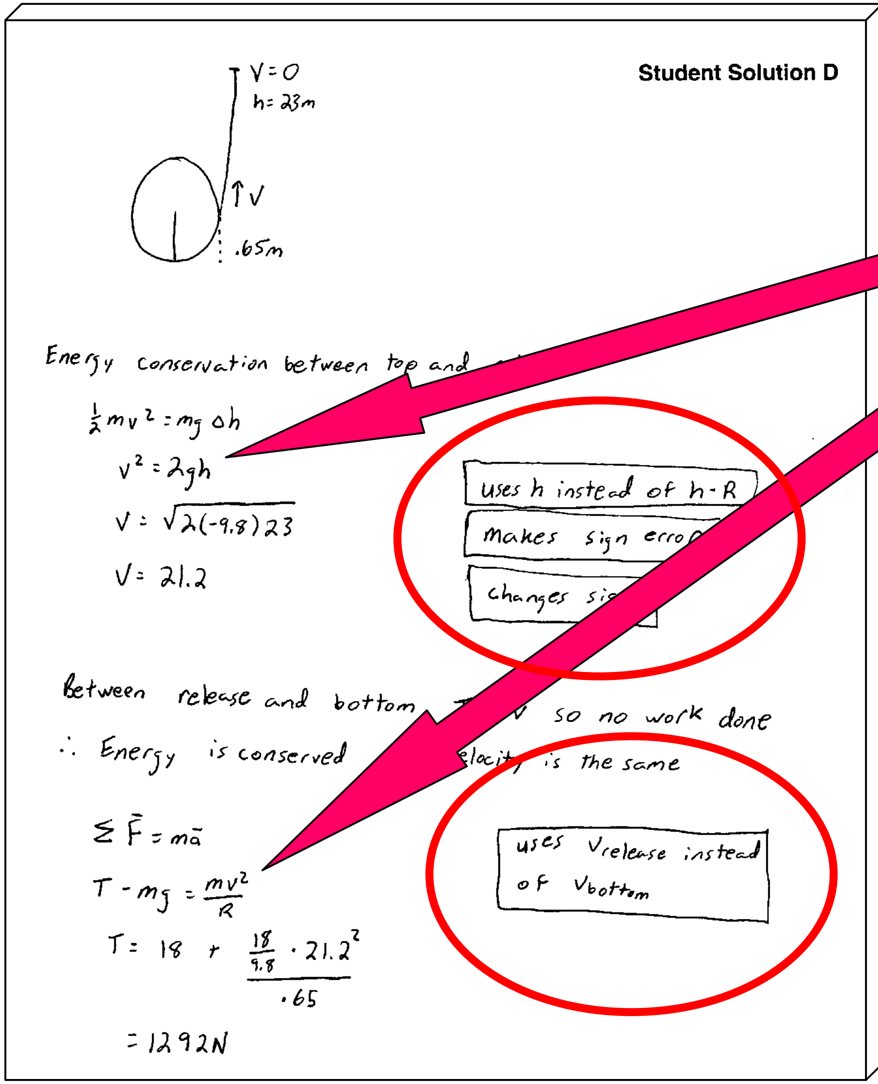


Free body diagram at bottom

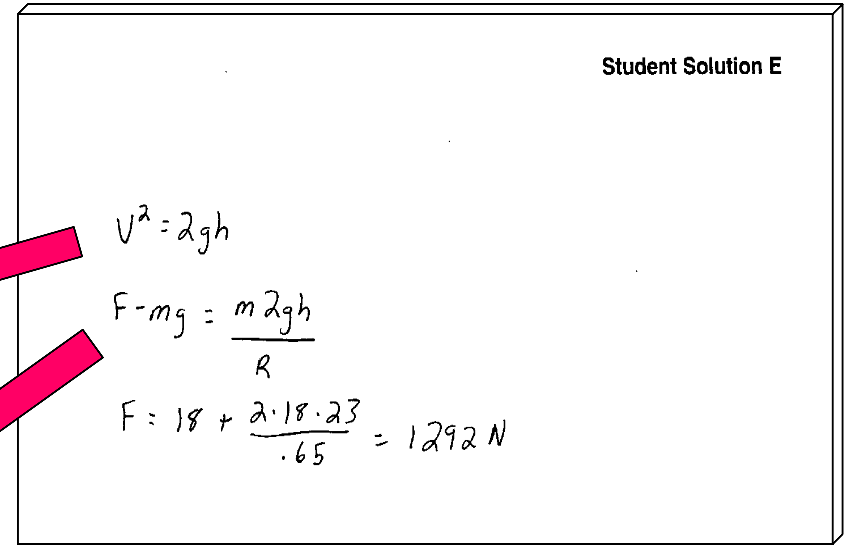
$$T_{bottom} - mg = m\frac{v_{bottom}^{2}}{R}$$

$$T_{bottom} = 1292 \text{ N}$$

Student Solutions D and E



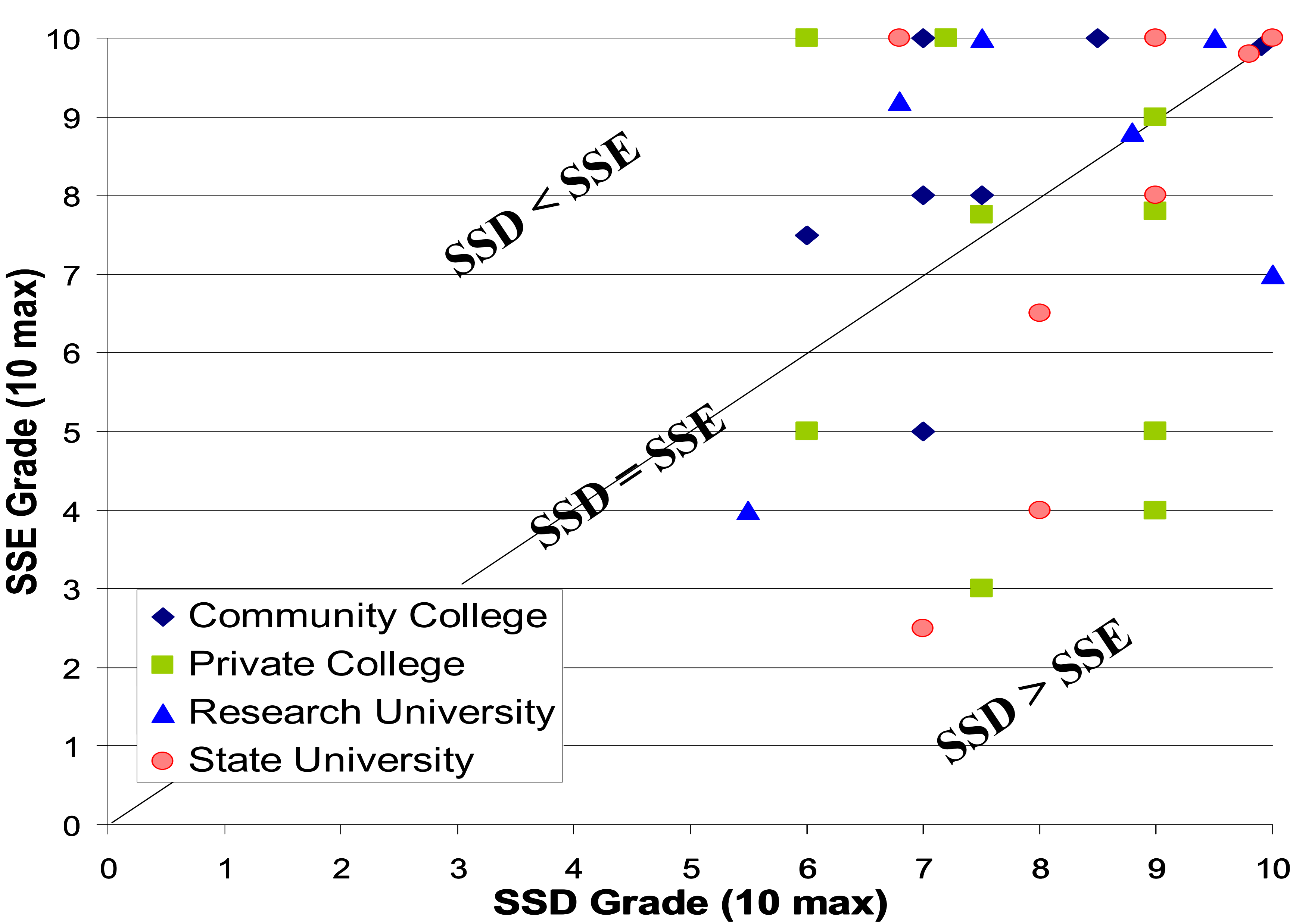
comments inserted to help grading



could have made the same mistakes as SSD

Instructors were asked to grade these solutions on a 10-point scale

How did Interviewees Grade?



Looking at faculty from RU

5 (out of 6) of the instructors expressed conflicting values when grading Student Solution E.

- **Value 1: Instructors want to see student reasoning so they can know if a student really understands.**
  - **Burden of Proof on Students**
    - **"There's not a single word to tell you that he put these things down and didn't guess." (Instructor 4)**
- **Value 2: Instructors are reluctant to penalize a student who *might* be correct.**
  - **Burden of Proof on Instructor**
    - **"There's nothing in here that's wrong. Yeah, it's not clear what *v* is in $v^2=2gh$, but in the end the equation would come out the same." (Instructor 5: 10 pts.)**
  - **Viewing solution in best possible light:**
    - **"He had to know the 3 principles involved in the problem perfectly. Just had to." (Instructor 4: 7 pts.)**

Resolving the Conflict

- Value 1: Instructors want to see student reasoning so they can know if a student really understands.

Value 2: Instructors are reluctant to penalize a student who *might* be correct.

Insist on Reasoning ⟷ Compromise ⟷ Give Full Credit

Instructor 1
6 point penalty

Instructor 4
3 point penalty

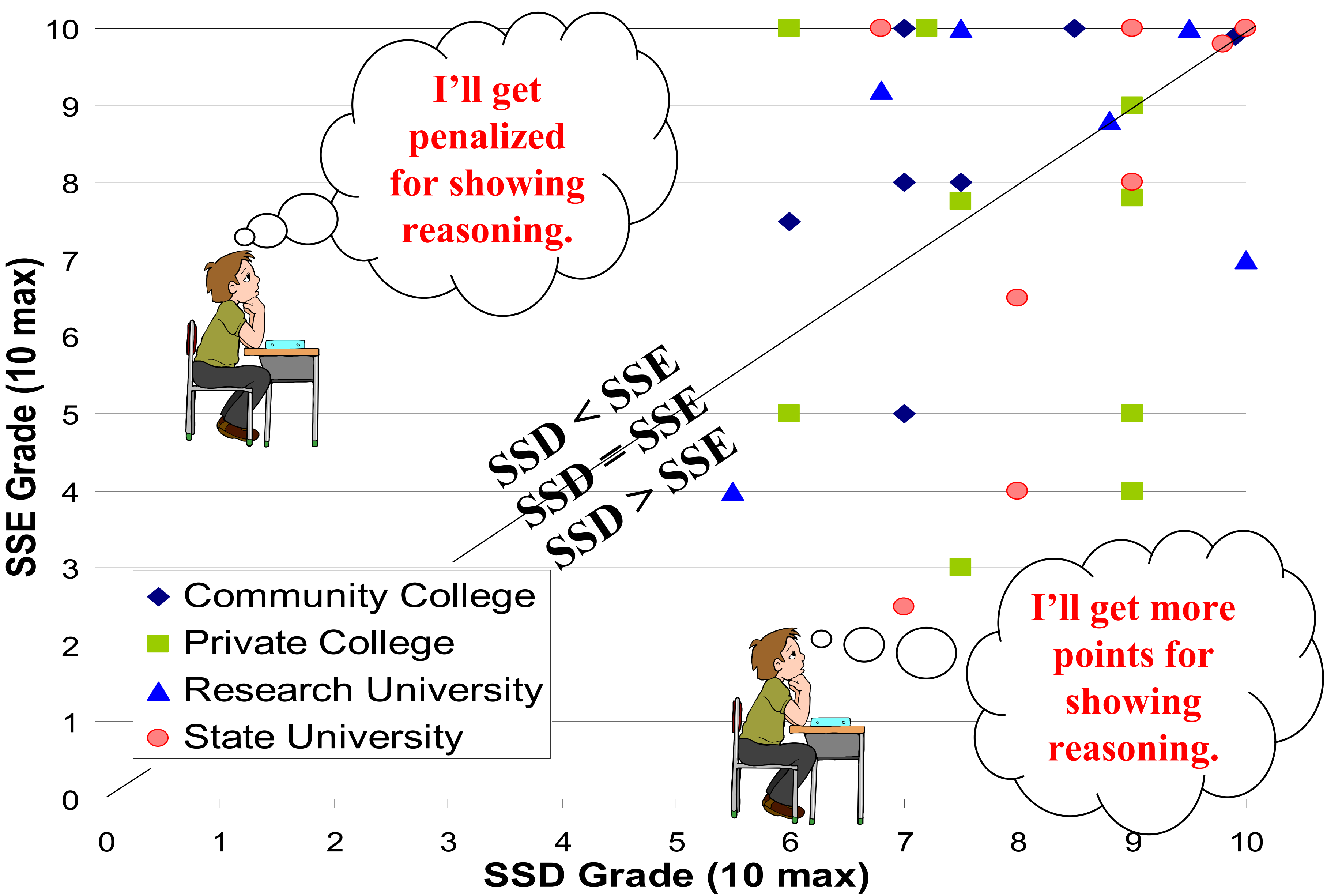
Instructor 3
~1 point penalty

Instructor 5
No Penalty

Instructor 6
1 point penalty

Instructor 2
No Conflict
No Penalty

What Message Is Sent to Students?



Course Environment -- TA Success

TAs Know What's Going On:

- definite course goals that TAs know
- definite topic goals that TAs know
- TAs know all changes before students
- TAs know lecturer's view of the material

  What are the pitfalls

Students Know What TAs Do is Important:

- TAs deal with the same content at the same time as the lecturer
- TAs deal with the same content in the same format as the lecturer
- references to lab and discussion section work in lectures.
- lecturer knows what TAs are doing and why

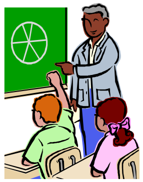
Class Environment -- TA Success

Limit presentations:

- short and planned
- student - student interaction to clarify and correct

Limit time dealing with entire section:

- minimize classroom management problems



Limit total number of students:

- same students in discussion section and lab

Enhance interactions with individual students

Coaching Using Cooperative Groups

TA Support

Creating a “culture of teaching”

➤ **While Teaching:**

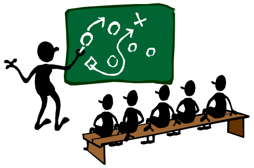
Lecture section teams meet at least once/wk to coordinate discussion and lab work with lecture.

1 professor + 6 TAs

Mentor TAs observe new TAs teach and offer suggestions

New TAs meet once/wk for teaching seminar
Required – Class Credit with Grades

All TA’s meet once/2 wks without professors
Optional -- Department supplies Pizza

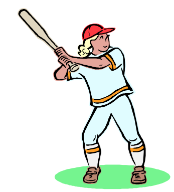


➤ **Before Teaching:**

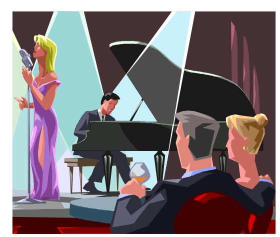
Orientation course for new TAs -- 49 hours (7 days)

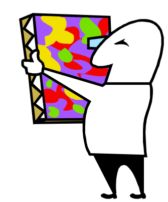
Paradox

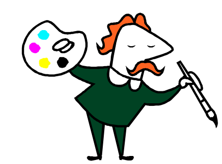
You can not learn how to teach before you teach!



Being a student does NOT make you a teacher.







Being a batter does make you a pitcher .

Listening to music does not make you a piano player.

Being an art collector does not make you a painter.

TA Orientation Course (49 hours)

	Hours
➢ **Introduction**	1
• Course structure, students & TA duties	
➢ **Alternative Conceptions of Students**	5
➢ **Teaching the Discussion Sessions**	
• Student Difficulties with Problem Solving	5
• Demonstration Discussion Section	2
• Peer Teaching of Discussion Section	4
• Characteristics of Good Problems	1
• Coaching	1
➢ **Teaching the Problem-solving Labs**	
• Demonstration Lab	4
• Peer Teaching of Labs	12
• Peer Teaching Prep.	4
• Evaluating Lab Reports	3
➢ **Professionalism and Diversity Issues**	
• Case Studies	3
➢ **Preparing the First Week**	
• Lesson Plans & Team Meetings	4
➢ **Total**	49

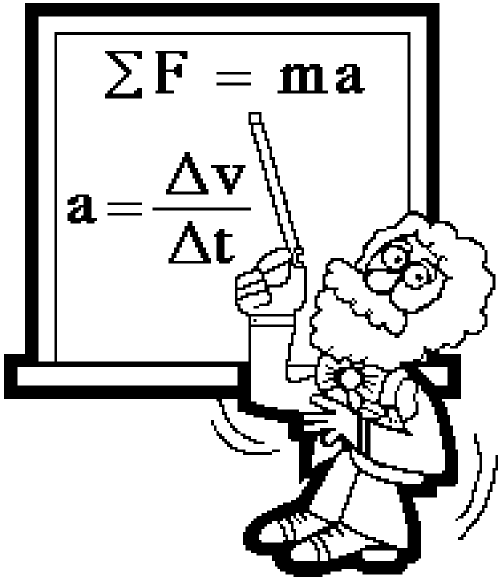
Teaching Seminars
Respond to TA need (1 hour/week)

Fall Semester

- Classroom management
- Grading
- Coaching
  - Office hours
  - Groups
- Analyzing Problems
- Comfort

Spring Semester

- Laboratory preparation
- Classroom management
- Leading discussions
- Useful team meetings



What We've Learned

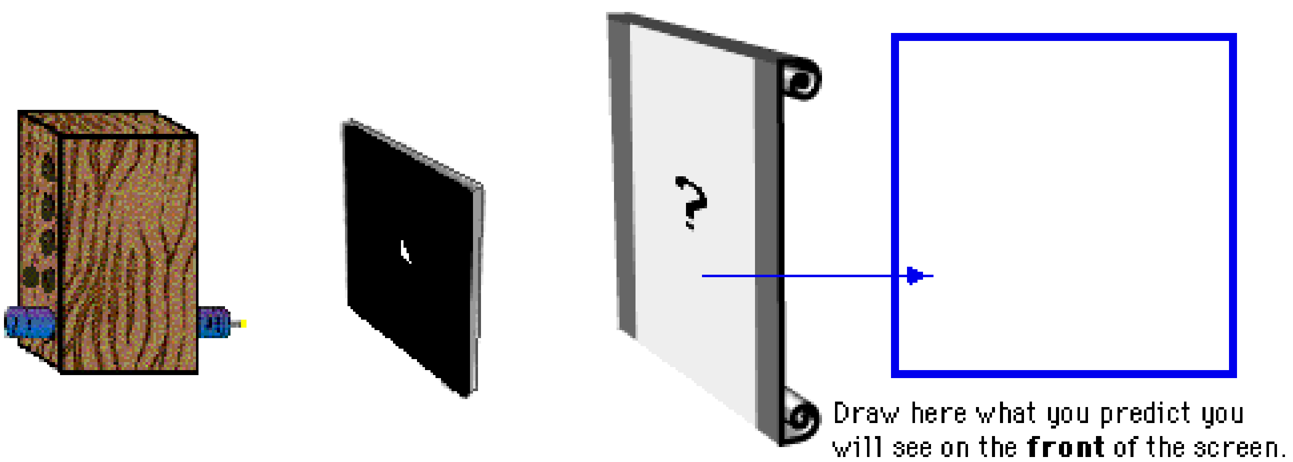
- Teach Orientation using the same techniques as you expect your students to use.
- Organize any "theory" around what TAs will be doing (e.g., teaching labs, tutoring, etc.).
- Have experienced TAs teach most of the class, particularly modeling how to teach and supervising peer teaching.
- As much as possible, use real examples of students' work and real case studies.
- Grade everything you want the TAs to do -- if you don't grade it, they won't do it.

Students' Alternative Conceptions

Introduction (page 15)

The purposes of this activity is to:

- **have TAs experience what it is like to have a strong alternative conceptions;**
- **illustrate the effectiveness of having students make a prediction *before* carrying out an experiment.**



Students' Alternative Conceptions

Dynamics (page 33)

Most TAs do not believe the alternative conceptions research. The purposes of the two activities are to:

- **begin to convince TAs that *the students they will teach* have many conceptual difficulties;**
- **introduce TAs to the way students "talk physics."**

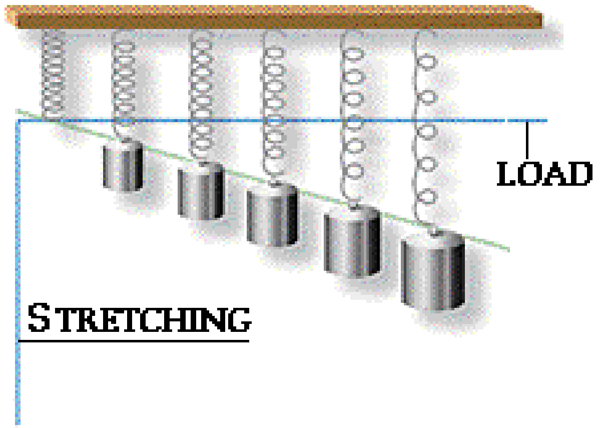
Need to use data from your own students.

If use a multiple-choice test (like the FCI), you also need open-ended questions because TAs find many reasons why students could answer multiple-choice questions incorrectly.

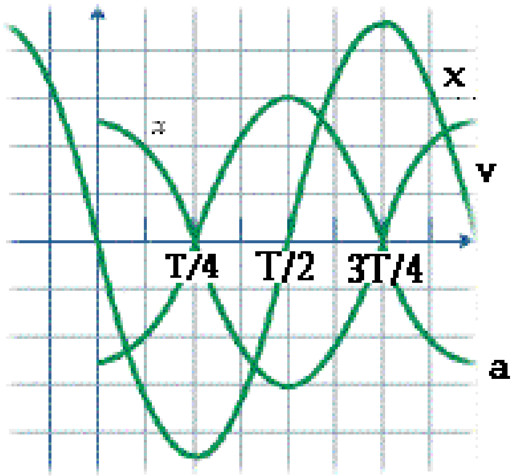
Teaching the Problem-solving Labs

Demonstration Lab (page 121)

An experienced TA models how to introduce our lab structure to students and conduct a typical lab session.

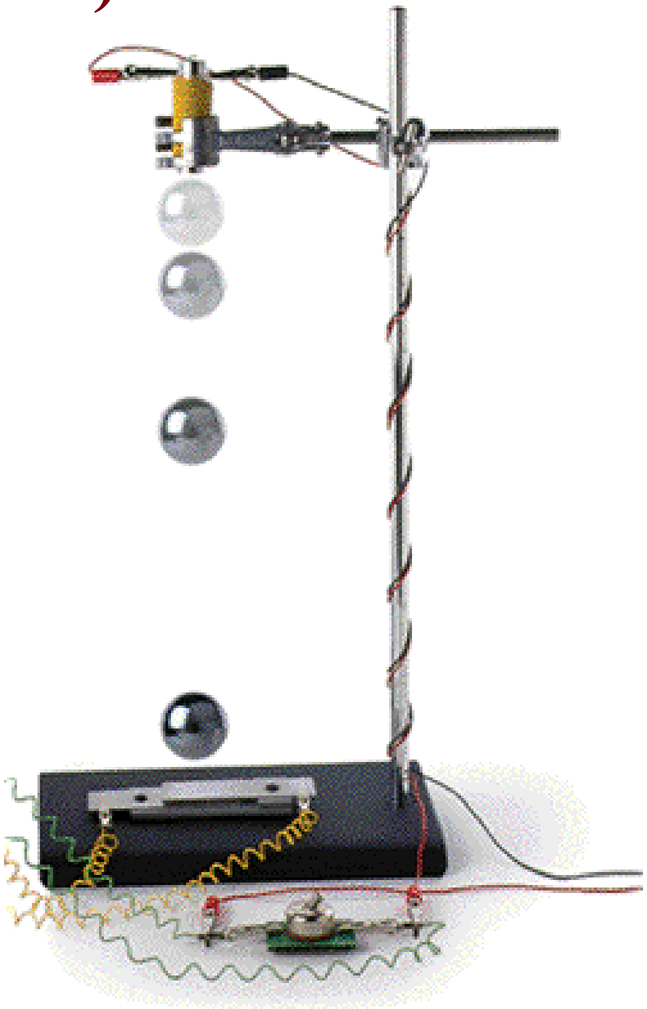


The purpose of this activity is to have students think about and discuss the purpose or rationale for instructor action.



Teaching the Problem-solving Labs

Peer Teaching (page 131)



TAs spend about 45 minutes "teaching" a lab to their peers. The purposes of this activity are to:

- **have TAs become familiar with the content of the labs, the equipment, typical data, and the kinds or errors students make;**
- **give TAs practice following the instructional steps in teaching a problem-solving lab;**
- **have TAs become familiar and comfortable with the type of feedback they will receive from their mentor TAs.**
- **Get over first time jitters.**

The Role of Writing in Labs
(page 179)

Emphasize the importance of communication using writing:

- introduce TAs to their responsibilities in a Writing Intensive course.
- have TAs become familiar with typical student lab reports and the kinds or errors students make;
- give TAs practice using a grading rubric to give feedback to students;

Teaching Problem-solving Discussion Sections

Structure and Rationale (page 67)

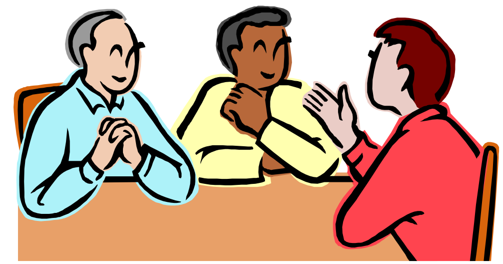
Structure: An experienced TA models how to teach a typical discussion section. To give TAs a more realistic experience, they solve a problem an old Graduate Written Exam problem.

Rationale: It is important to discuss with the TAs the goals of the introductory course(s) and the role of discussion/recitation sections in helping students to meet these goals. Support goals with data.

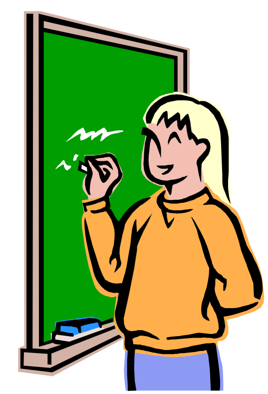
Teaching the Discussion Sections

Peer Teaching (page 134)

TAs spend about 30 minutes "teaching" a discussion section to their peers. The purposes of this activity are to:



- **have TAs become familiar with the types of problems that work best in groups;**
- **give TAs practice following the instructional steps in teaching a cooperative group discussion section;**
- **have TAs become familiar and comfortable with the type of feedback they will receive from their mentor TAs.**
- **Get over first time jitters.**



Problem-solving Discussion Sections

Student Difficulties (page 91)

STEP #1

STEP #2

STEP #3

STEP #4

The purposes of the three activities are to:

- introduce TAs to the kinds of difficulties their students will have solving quantitative problems;
- analyze different strategies and discuss how the strategies will help TAs become better coaches and graders;
- have TAs practice solving a problem using an explicit strategy;

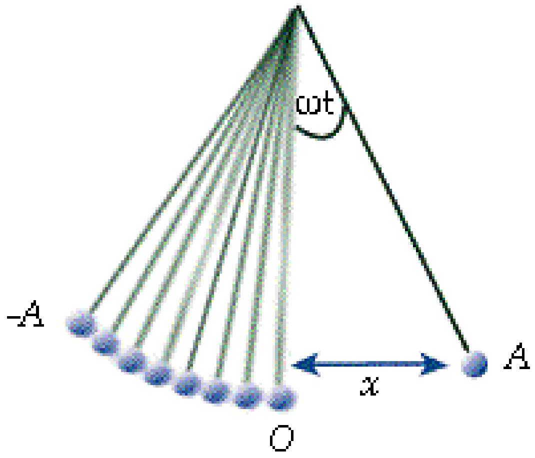
Problem-solving Discussion Sections

Characteristics of Good Problems (page 135)

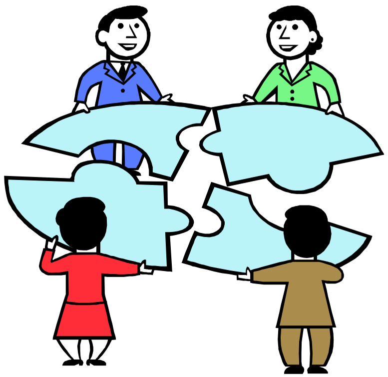
TAs are often asked to critique a rough draft of a group problem written by the professor, or to design a rough draft of a problem for the team to critique.

The purpose of the two activities are:

- **to introduce the criteria for good group problems;**
- **give TAs practice in selecting a group problem;**
- **give TAs practice in using the criteria to judge whether a problem is a good group problem.**



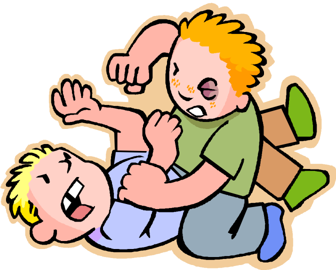
Using Cooperative Groups for Problem Solving
(page 157)



The purpose of the activities are to:

- **dispel some of the doubts and misconceptions about the disadvantages of cooperative-group problem solving;**
- **have TAs begin to realize that, at times, they can and should intervene to help groups function better;**
- **give students a few "one-liner" responses for students in some typical situations.**

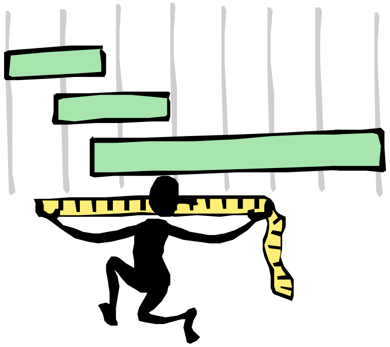
Professionalism & Diversity Issues
(page 191)



The purposes of the activities are to:

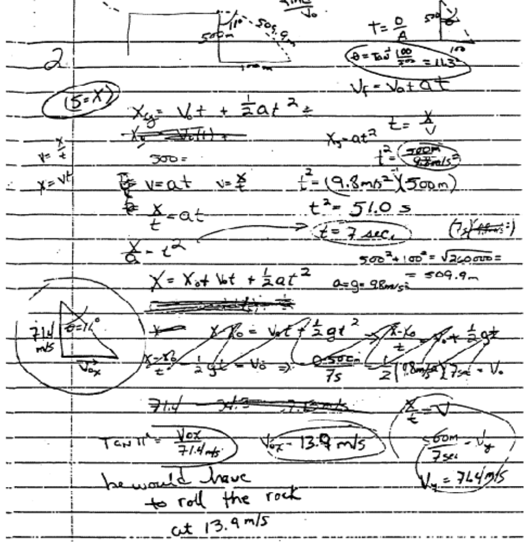
- **introduce students to strategies for establishing a positive classroom climate;**
- **relate positive classroom climate to strategies that prevent cheating;**
- **have students begin to think about their attitudes and responsibilities with regard to students from diverse cultures, possible sexual harassment, and fellow graduate students in the department.**

Data



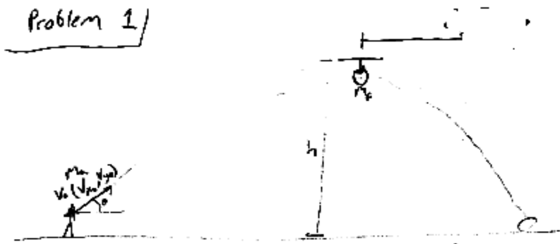
- Analysis of student exams
- Observation of student interactions
- Measures of conceptual understanding
  - FCI (Force Concept Inventory)
  - Other inventories
  - Open ended questions
  - Interviews
- Measures of hierarchical structure of physics
- Measures of student satisfaction
- Ease of implementation

Student Problem Solutions



Initial State

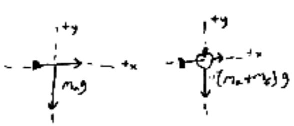
Problem 1



Question: how far away from the tree does the fruit and arrow combination land?

Approach: use conservation of momentum and kinematics
assume constant acceleration due to gravity
assume no momentum is lost in the collision
neglect wind resistance
use two intervals; from the time the arrow leaves the bow until just before it hits the fruit and just after it hits the fruit until they hit the ground

Diagram



known: h, m_a, m_f, v_0, θ
unknown: d

Qualitative relationships:

$V_{x0} = V_0 \cos\theta \quad P_f = (m_a + m_f)V_{xf}$

$h = \frac{1}{2}gt^2 \Rightarrow \frac{2h}{g} = t^2, \sqrt{\frac{2h}{g}} = t$

$d = V_{xf} t$

$P_i = P_f \Rightarrow m_a V_{x0} = (m_a + m_f)V_{xf} \Rightarrow V_{xf} = \frac{m_a}{m_a + m_f} V_{x0}$

$P_i = m_a V_{x0}$

Target: d

Plan the Solution: unknown: d, V_{xf}, t, V_{x0}

$d = V_{xf} t$

$V_{xf} = \frac{m_a}{m_a + m_f} V_{x0}$

$V_{x0} = V_0 \cos\theta$

$t = \sqrt{\frac{2h}{g}}$

$$d = \frac{m_a}{m_a + m_f} V_0 \cos\theta \sqrt{\frac{2h}{g}}$$

Check units!

$m = \frac{kg}{kg} \frac{m}{s} \sqrt{\frac{m}{m/s^2}} \quad \sqrt{s^2}$

$m = \left(\frac{m}{s}\right) s$

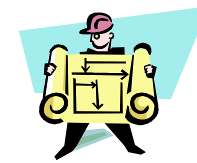
$m = m \Rightarrow ok$

is the answer complete?
yes, the distance was found in terms of the requested values

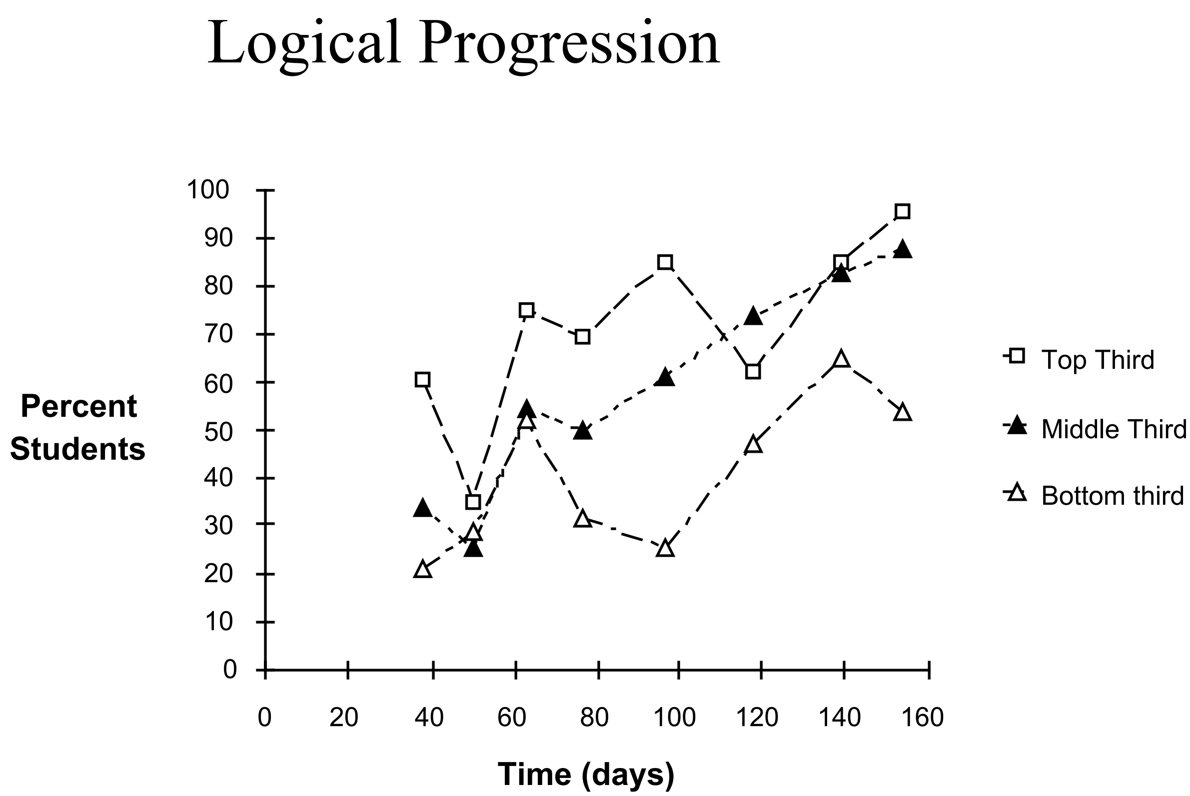
is the answer reasonable?
yes, the units check out ok and d will be smaller than h due to conservation of momentum

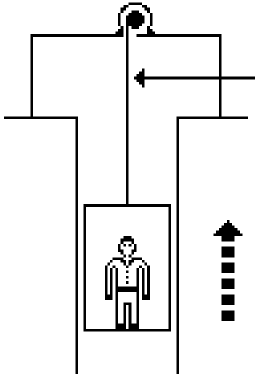
is the answer correctly stated?
yes, it is in units of distance, meters

Final State



Improvement in Problem Solving





FCI Question 17

An elevator is being lifted up an elevator shaft at a constant speed by a steel cable, as shown in the figure. All frictional effects are negligible. In this situation, forces on the elevator are such that:

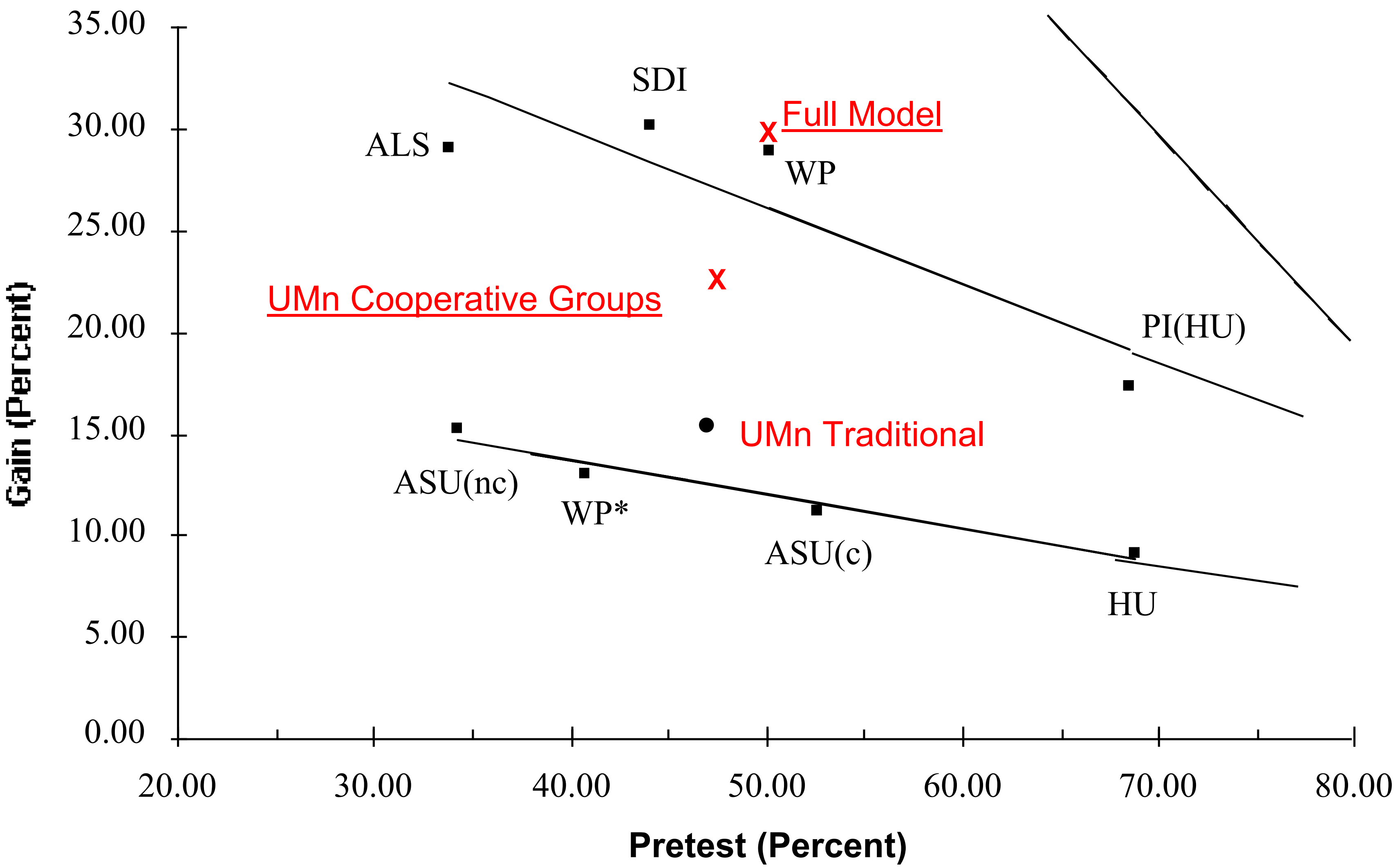
	Pre	Post
(A) the upward force by the cable is greater than the downward force of gravity.	64	36
(B) the upward force by the cable is equal to the downward force of gravity.	18	60
(C) the upward force by the cable is smaller than the down ward force of gravity.	2	0
(D) the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.	11	2
(E) None of the above. (The elevator goes up because the cable is shortened, not because an upward force is exerted on the elevator by the cable).	5	1

FCI Question 4

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

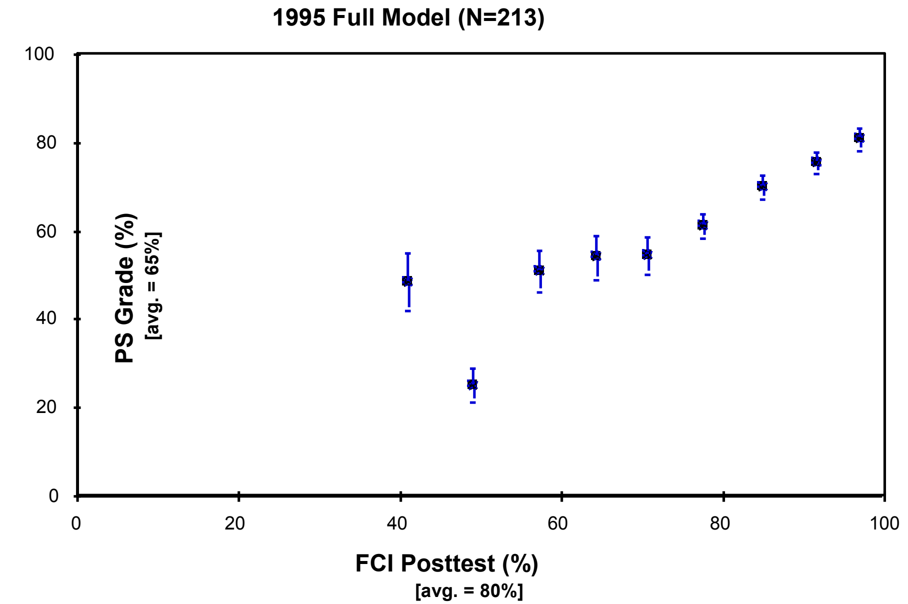
	Pre	Post
(A) the truck exerts a greater amount of force on the car than the car exerts on the truck	79	46
(B) the car exerts a greater amount of force on the truck than the truck exerts on the car.	2	1
(C) neither exerts a force on the other, the car gets smashed simply because it gets in the way of 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

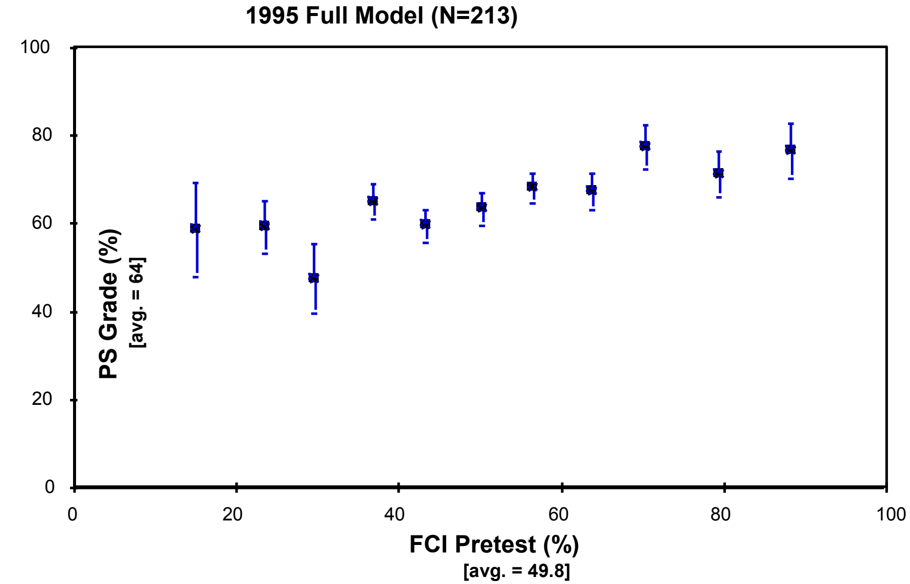
Gain on FCI

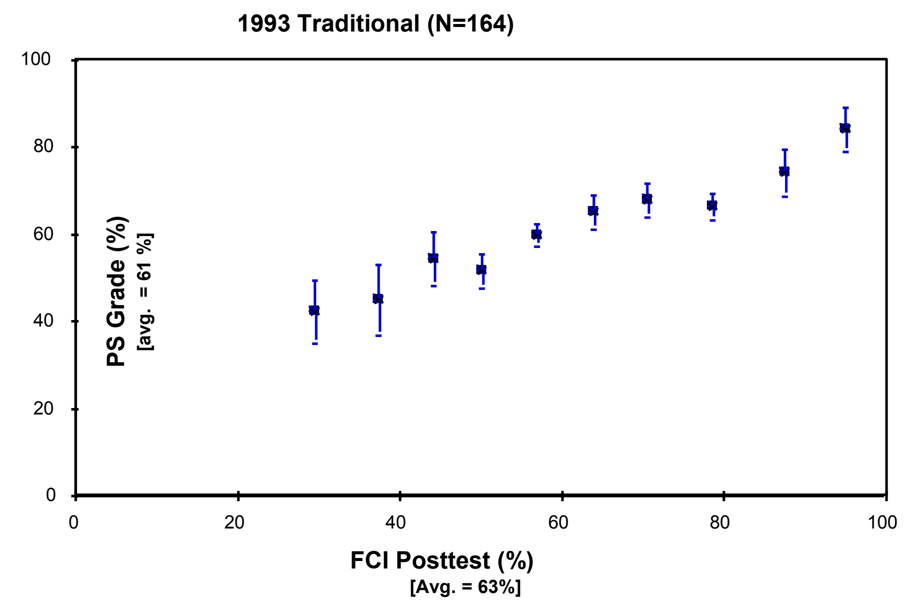


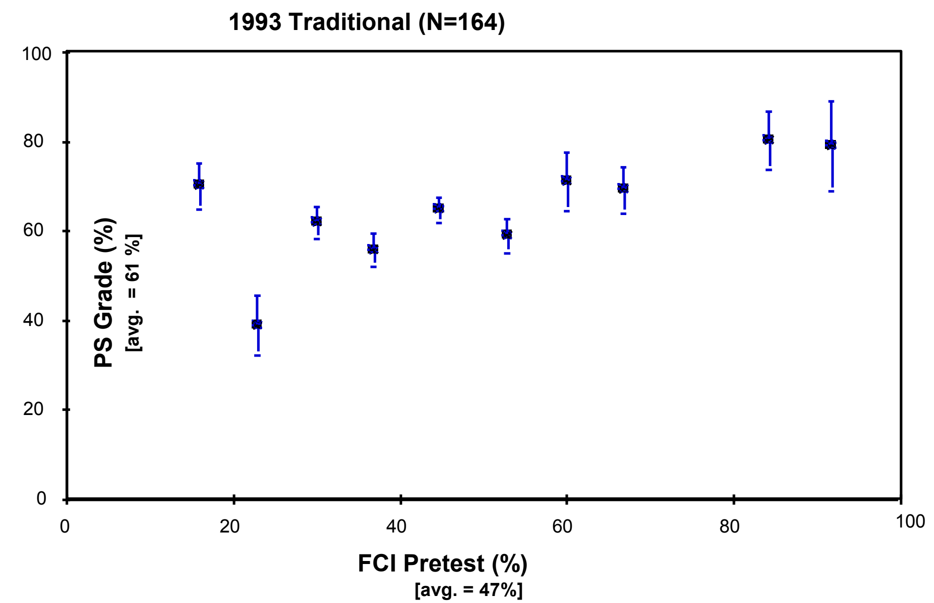
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Gain (Percent)
SDI
Full Model
ALS
WP
X
UMn Cooperative Groups
PI(HU)
UMn Traditional
ASU(nc)
WP*
ASU(c)
HU
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Pretest (Percent)

FCI and Problem Solving

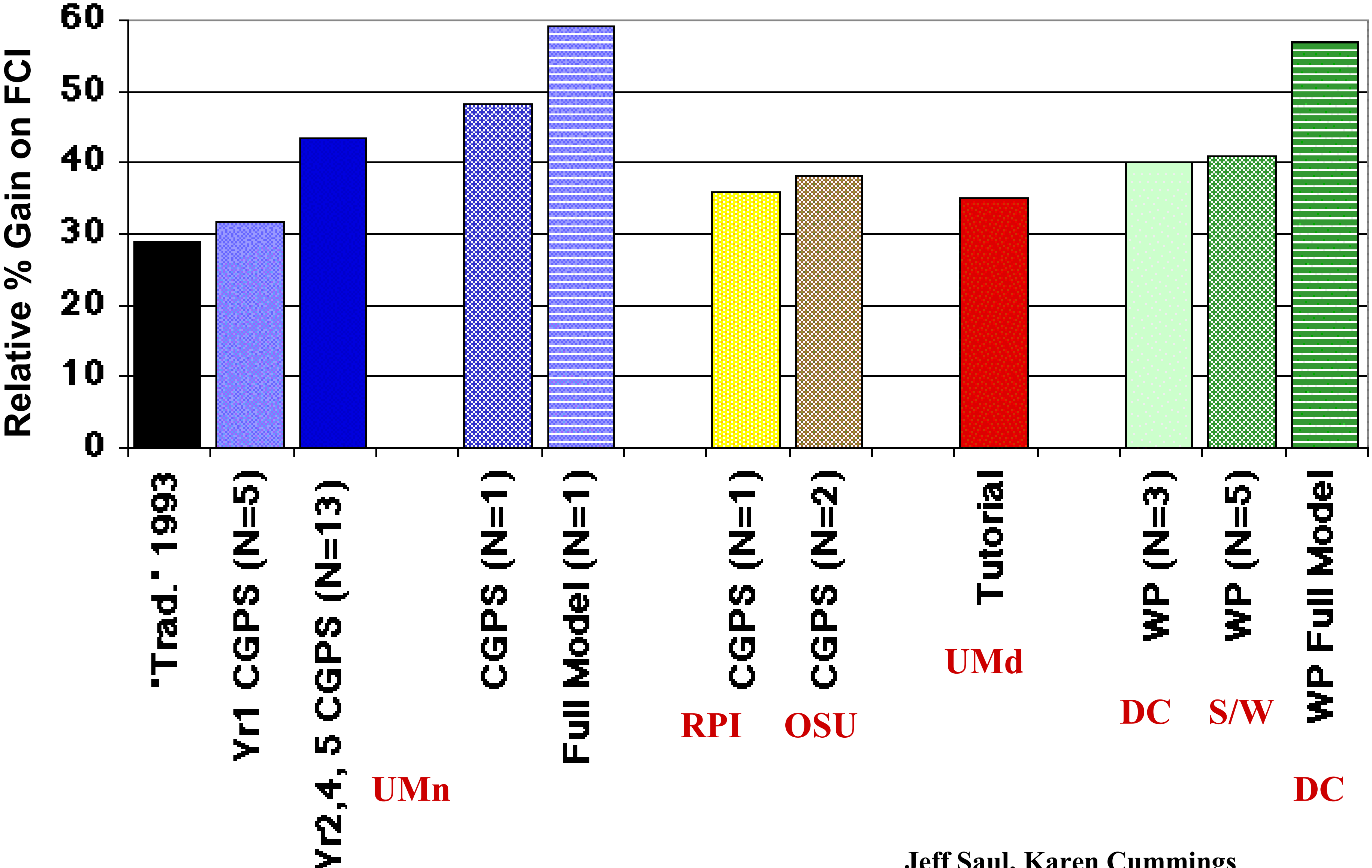






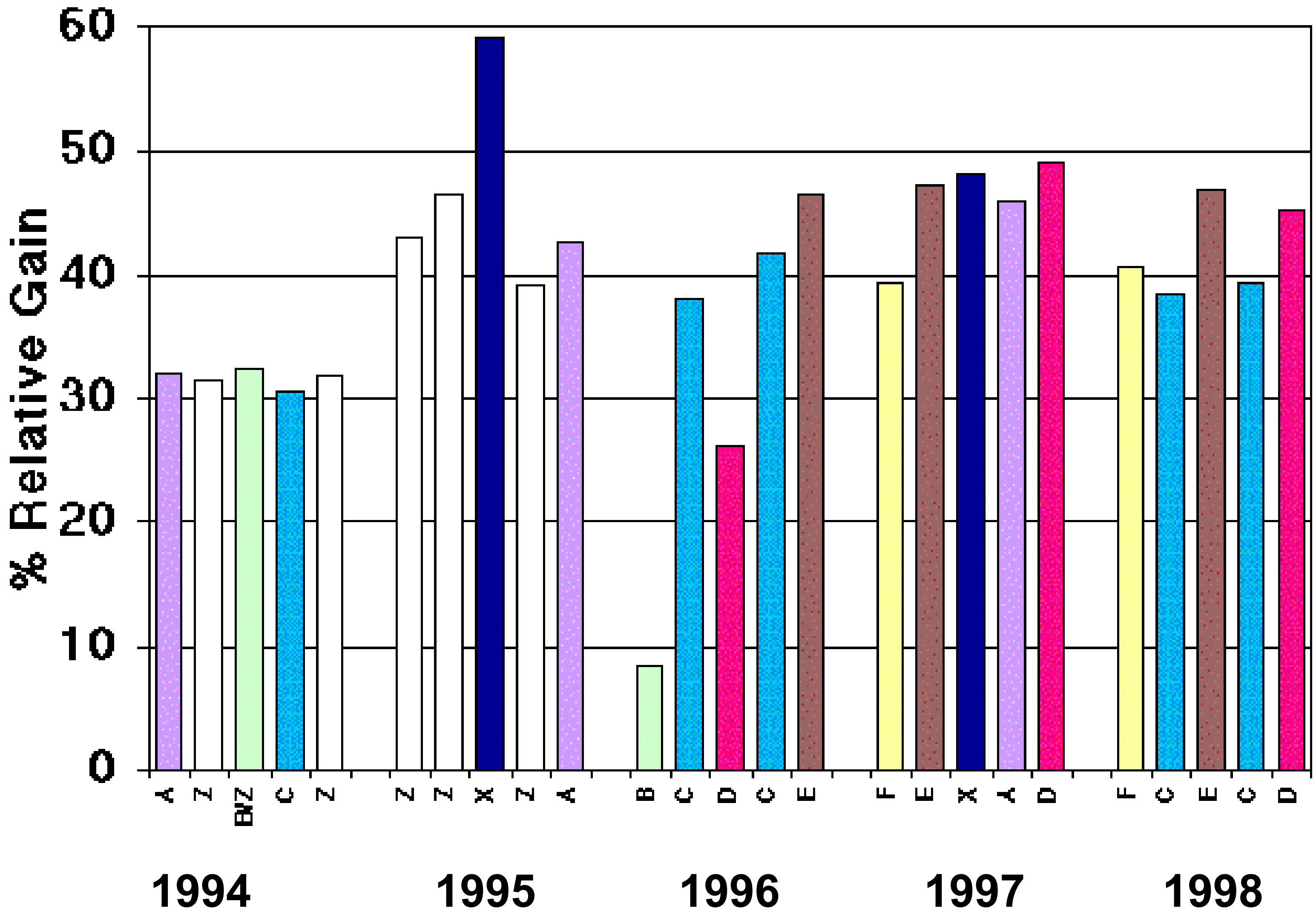


Comparisons of Full and Partial Models



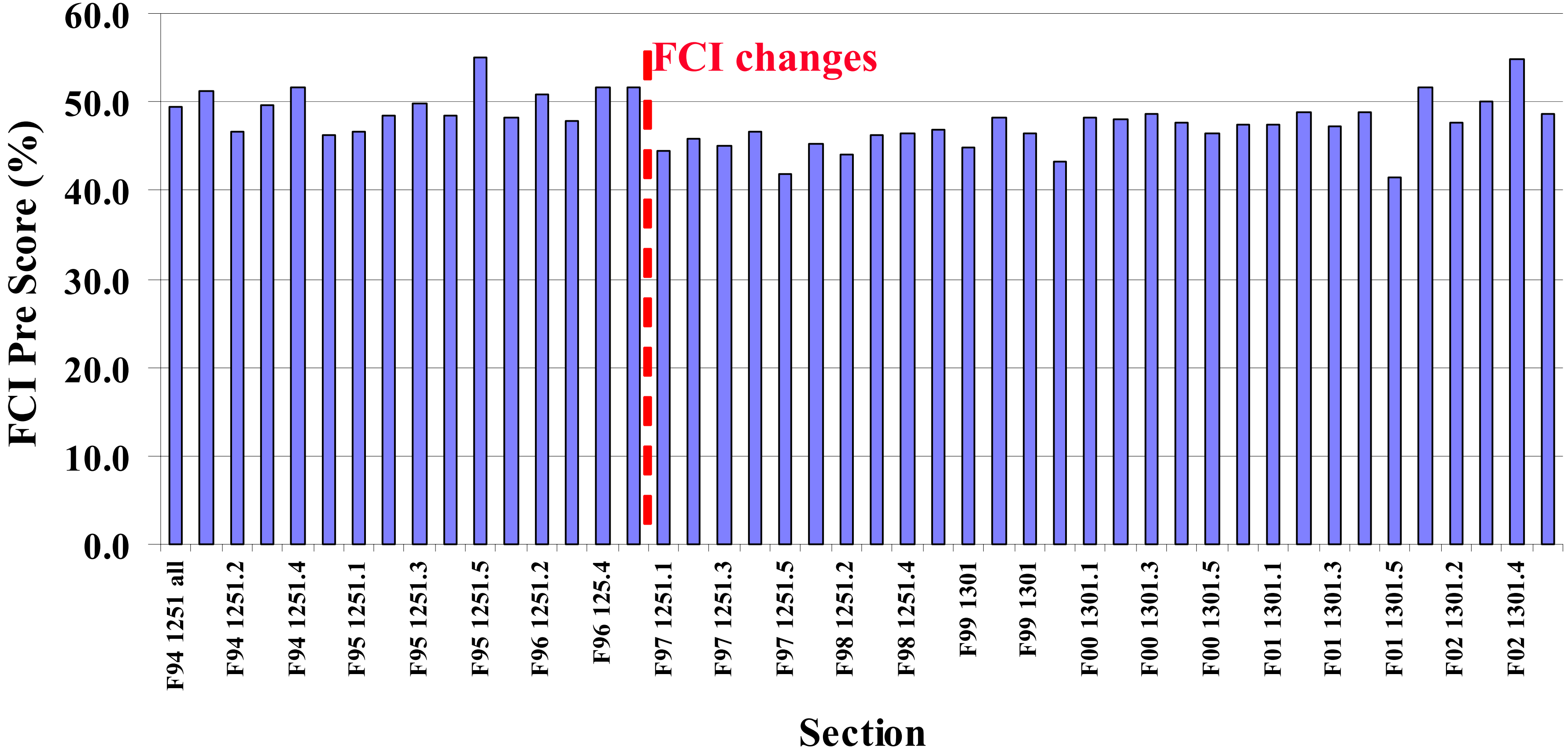
Jeff Saul, Karen Cummings

How Stable is Faculty Implementation of CGPS?

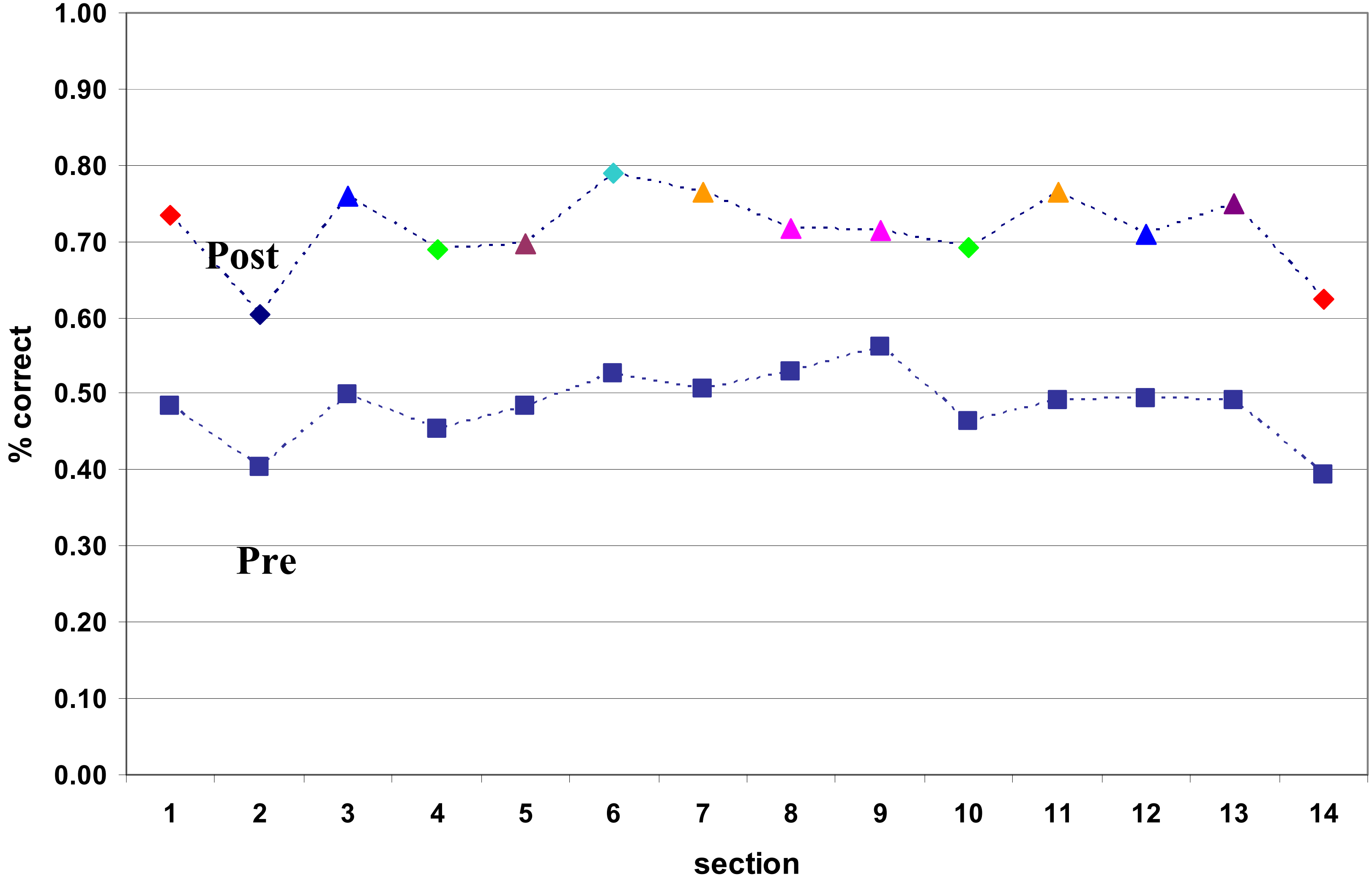


University of Minnesota Faculty

FCI Pre Score by Section

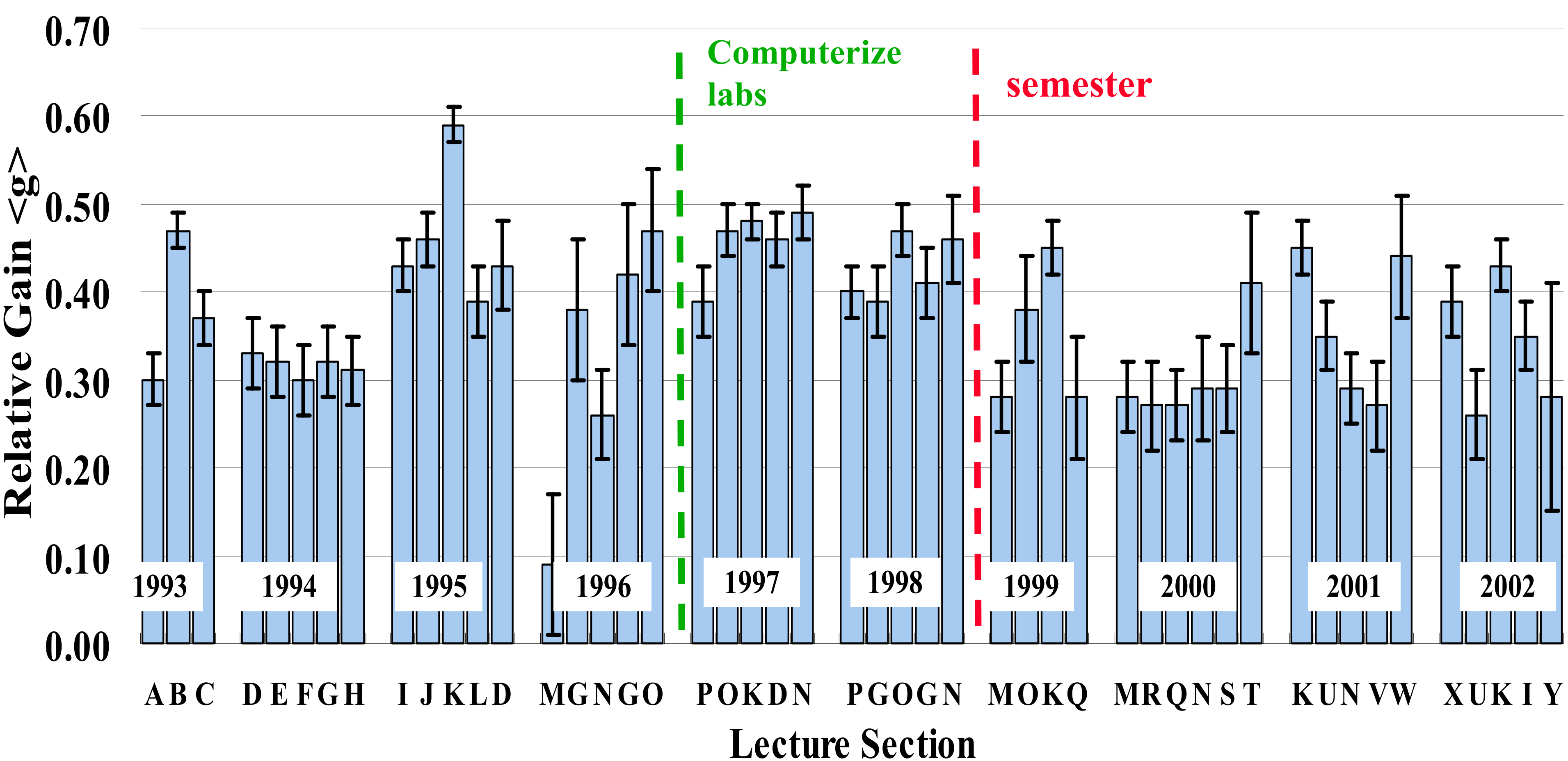


FCI by discussion/lab section



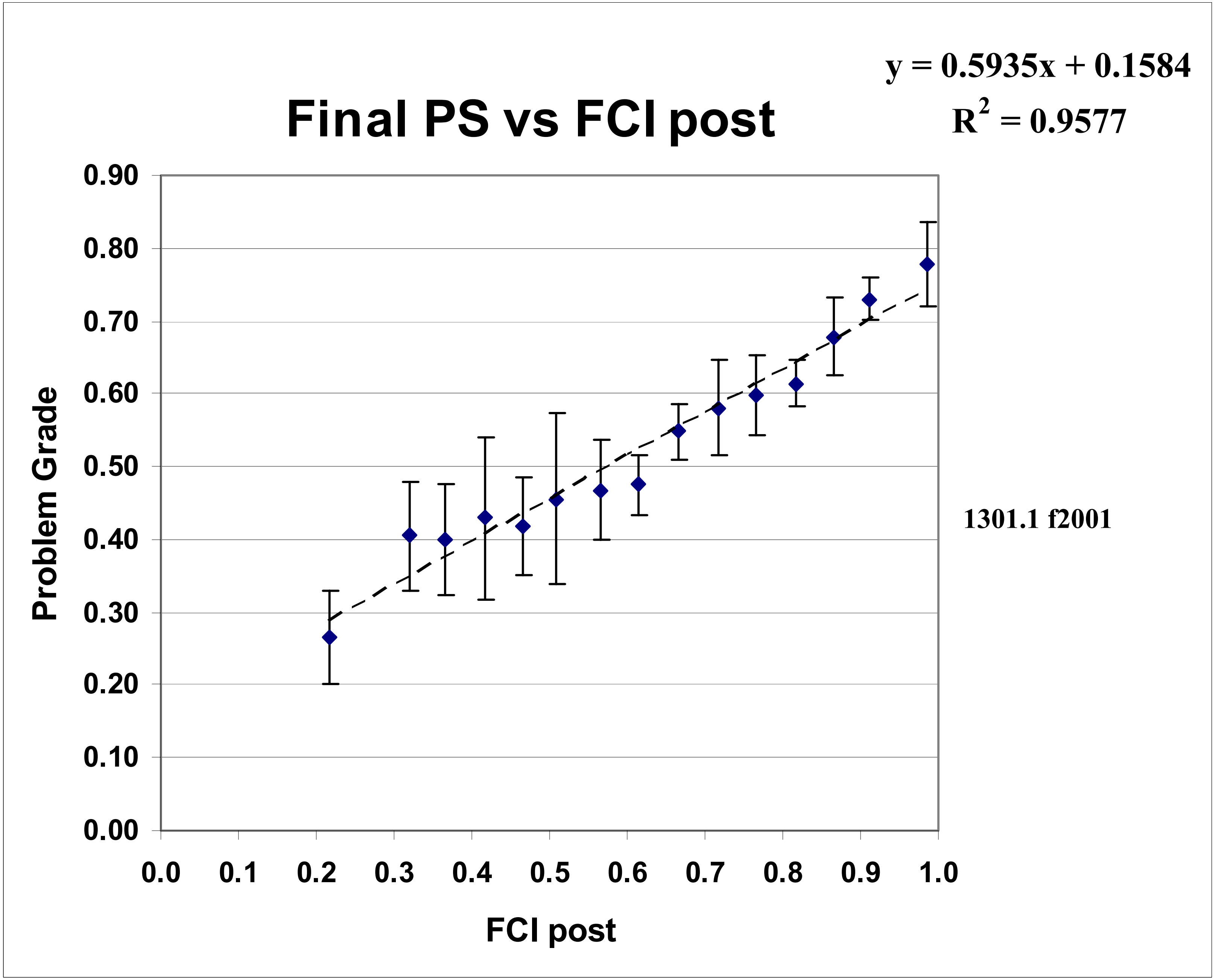
Same symbol (color and shape) is the same TA

FCI Gains
University of Minnesota, 1993-2002
Introductory Calculus-Based Physics (Fall Sections)



each letter represents a different instructor

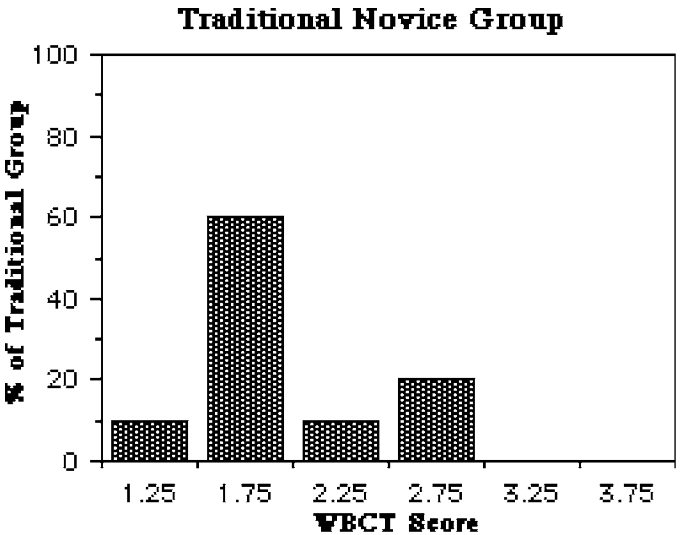
I - Standard Error of the Mean



y = 0.5935x + 0.1584
R2 = 0.9577
Final PS vs FCI post
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Problem Grade
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
FCI post
1301.1 f2001

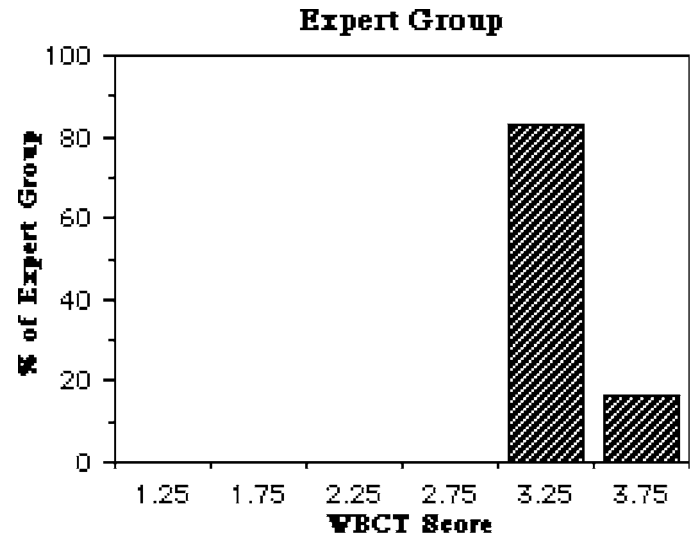
Hierarchical

Surface features

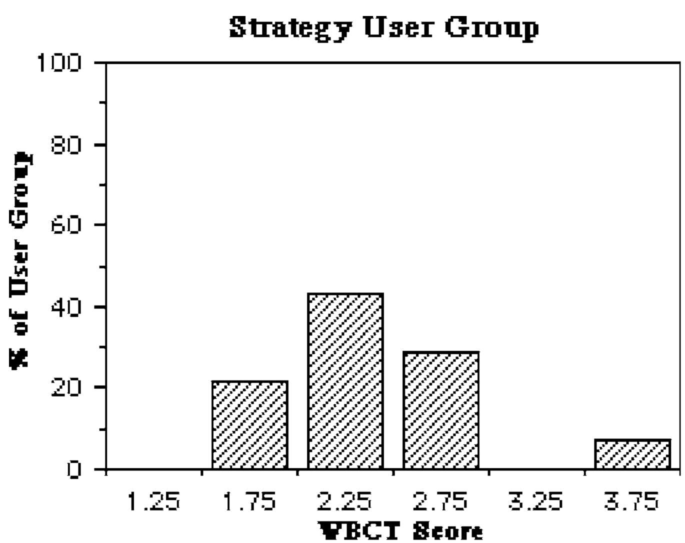


(b)

Physics principles



(a)



(c)

Problem Solving Procedure

	SA	A	N	D	SD
11. The problem-solving procedure taught in class makes sense.	41 *23*	46 *65*	7 *7*	4 *2*	2 *2*
12. The instructor provided adequate examples of how to use the problem solving procedure.	53 *31*	40 *58*	3 *4*	3 *6*	1 *1*
13. Using the suggested problem solving procedure has helped me to solve problems more effectively.	37 *22*	31 *44*	15 *13*	7 *14*	9 *7*
14. The solution sheet format was a useful guide for problem solving	25 21	39 *55*	25 *10*	10 *10*	1 *4*
15. Problems can be solved more effectively in a group than individually.	17 *16*	49 *46*	18 *14*	14 *18*	1 *6*
16. Taking tests as a group helped me to understand the course material.	4 *9*	62 *48*	21 *21*	10 *18*	2 *4*

1991 class (n = 99) 1992 class (n = 135)

Lecture and Recitation

	SA	A	N	D	SD
1. The instructor covered too little material in the course.	4	13	20	45	18
	2	*5*	*24*	*52*	*17*
2. The mixture of presenting new material and solving problems was about right.	17	63	9	10	
	12	*67*	*10*	*11*	*1*
3. Pausing in lecture to allow students to discuss the concepts with others was a good idea.	26	47	21	4	2
	24	*40*	*26*	*9*	*2*
4. The recitations sessions were well coordinated with the lecture.	7	75	11	5	2
	8	*62*	*11*	*12*	*7*
5. The discussion with my group helped me to understand the course material.	13	53	13	17	4
	8	*47*	*9*	*28*	*8*
6. My group worked well together to to complete problem solving activities.	14	59	18	7	2
	4	*53*	*17*	*21*	*5*

* 1991 class (n = 99)   1992 class (n = 135)

The End

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