DC05: AAPT Winter 2003 Meeting Austin, TX

Physics Lab Reports and Student Learning In Introductory Physics Classes Any Relationships?

Paul Knutson

Ken Heller, Pat Heller, Vince H. Kuo

www. physics.umn.edu/groups/physed

knut0199@umn.edu

What do students really learn in physics classes?

How do we know what they learn?

Into what aspects of the physics classes should we be putting our time and energy?

How important are the parts of the physics class for student learning? lecture? – recitation? – lab?

Which, if any, of the parts are worth keeping?

Where do we start looking for answers?

A place to start looking for answers is to attempt to measure what students learn. That information can help in the search for answers to the other questions.

Physics teachers are always trying to measure what students learn.

Measuring what students learn is very difficult, but we can probably gain some insight into student knowledge.

There are still questions: What have we really measured? Do we understand the results? Do the results give us insight into what and how we should be teaching?

In measuring student knowledge there is often a large amount of noise. We are interested in reducing that noise.

We are also interested in the relationships among the measures of student knowledge. These relationships can possibly give us some insight into the skills, ideas, and concepts learned by the students and insight into how we can measure different skills and kinds of knowledge.

Outline

The Beginning of a Study

1. **Ways of evaluating student knowledge – looking at traditional measures in an introductory physics class.**

2. **A simple look at initial results and Difficulties with the measurements**

3. **Next steps in the study**

Setting at U of MN

- **Lecture**
  - 3 hours / week
  - ~ 200 students / 1 lecturer
- **Recitation**
  - 15 students / section
  - 1 hour / week
  - Cooperative groups
- **Laboratory**
  - 15 students / section
  - 2 hours / week

Grades: Lab 15%, Quizzes 45 to 60%

Final Exam 25 to 40%

☆ **Note:**

Topics are concurrent in:

Lecture

Lab

Recitation

Similar context rich problems used in lab, recitation, quizzes, and final exams

Some ways of measuring student knowledge:

Qualitative (Conceptual) – Multiple Choice Questions

Quantitative – Problem Solving

Expository – written lab reports

Do these all measure different aspects of student's concepts, understanding, and skills?

Is there data to support our/your position?

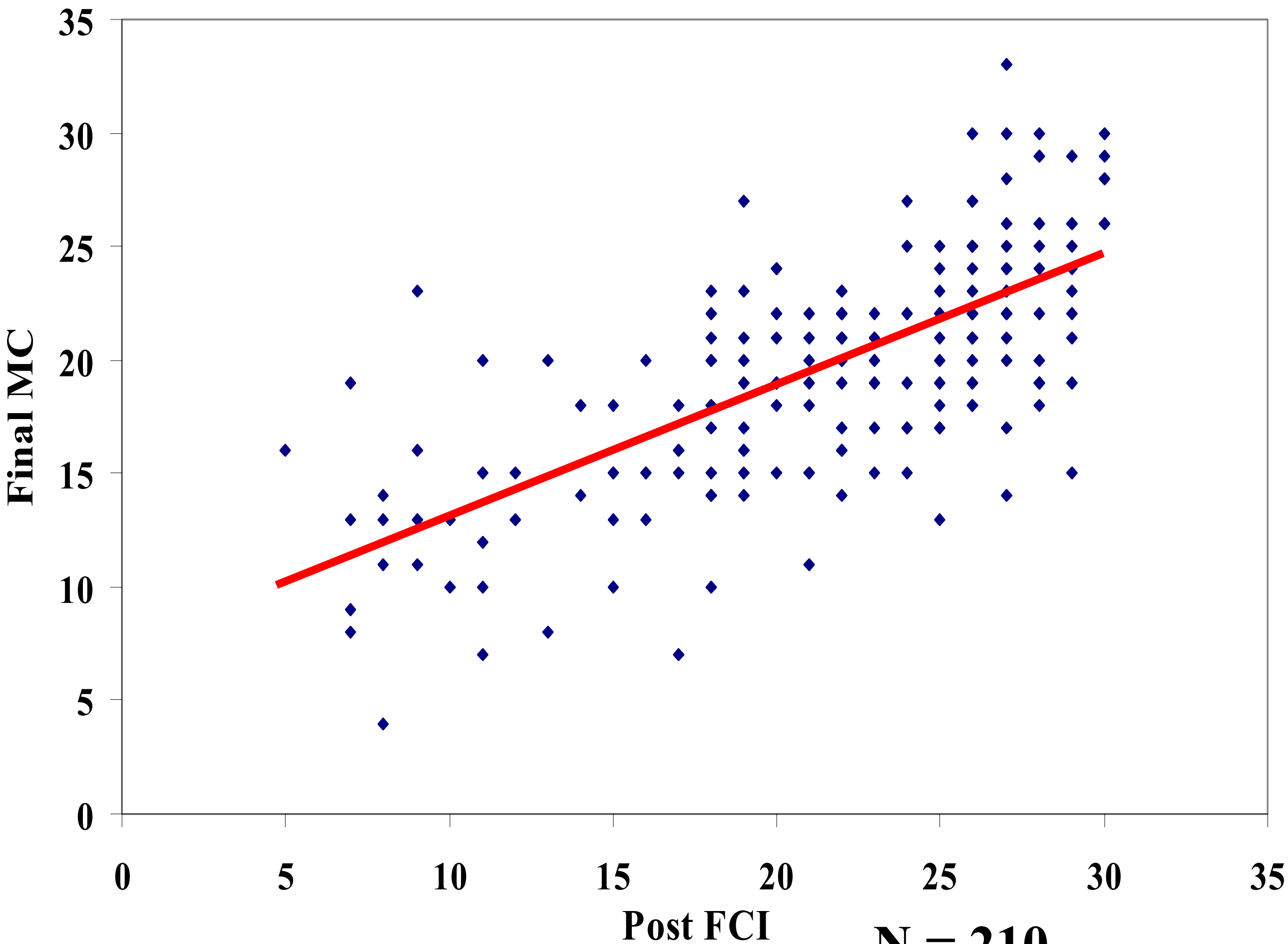
How do results on the multiple choice questions (that include the MBT), given in the final, compare with results on the Post FCI?

The FCI measures aspects of a Newtonian understanding of the world.

The MBT measures aspects of a Newtonian understanding of the world plus some kinematics involving graphs. (In addition this mult.choice test includes 7 questions on rotations & oscillations.)

Should we expect students to get similar scores on these two tests?

Sec C Final Mult. Choice vs Post FCI



R = .69

N = 210

(This is a quick reminder from a previous slide)

Some ways of measuring student knowledge:

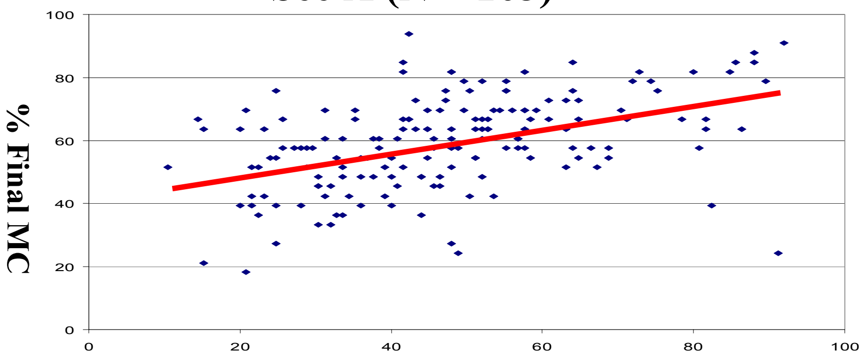
Qualitative (Conceptual) – Multiple Choice Questions

Quantitative – Problem Solving

Expository – written lab reports

Final Multiple Choice vs. Final Problems

Sec A (N = 165)

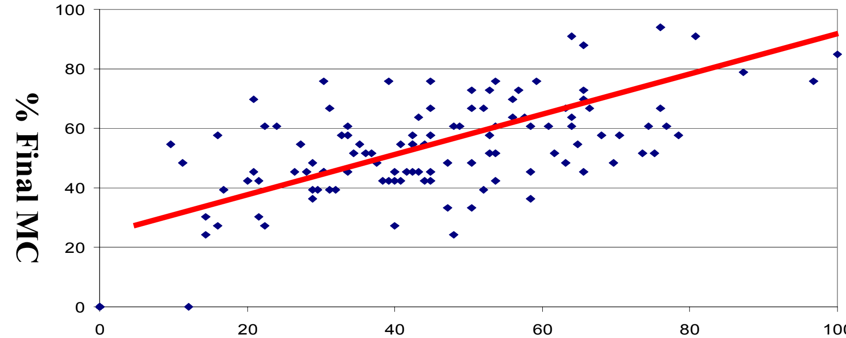


% Final Problems R = 0.45

6 written lab reports **Post FCI = 70%**

Final Probs = 47% MC = 59%

Sec B (N = 124)

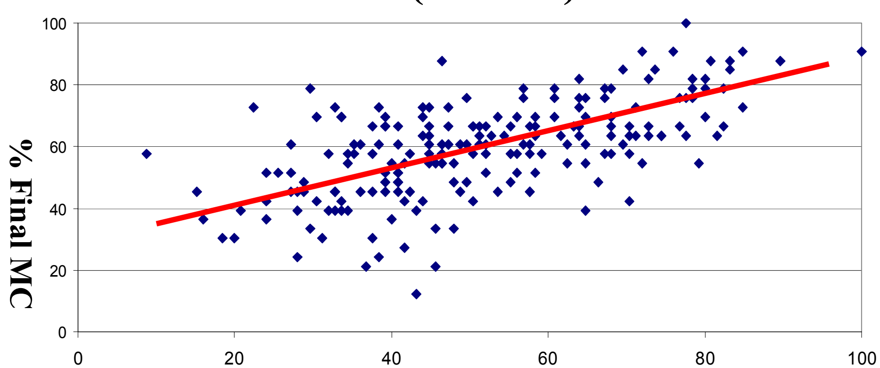


% Final Problems R = 0.56

7 written lab reports **Post FCI = 61%**

Final Probs = 47% MC = 50%

Sec C (N = 201)

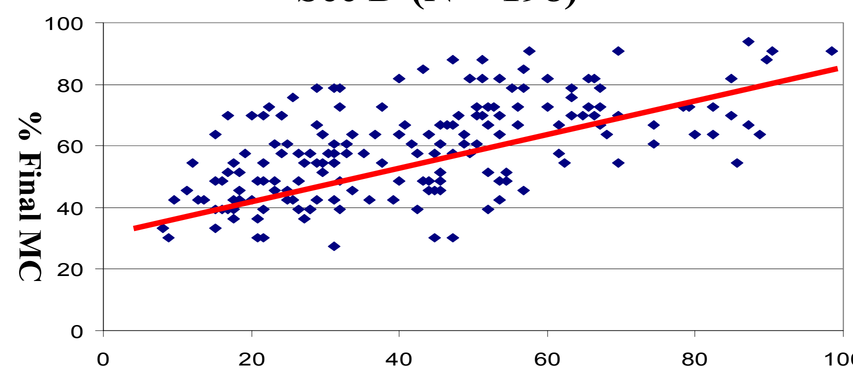


% Final Problems R = 0.61

4 written lab reports **Post FCI = 72 %**

Final Probs = 52 % MC = 59%

Sec D (N = 198)



% Final Problems R = 0.58

8 written lab reports **Post FCI = 71 %**

Final Probs = 42 % MC = 59%

Final Exam Problem

Your have been hired as a technical advisor for the police to help in the scientific investigation of crimes. A shooting happened in an apartment but the people in a neighboring apartment claim that they did not hear a shot. You have been assigned to use the physical evidence to determine if they are telling the truth. You know that if the bullet travels faster than the speed of sound, 330 m/s, most of the noise comes from the sonic boom that no silencer can eliminate. You search the crime scene in the apartment and find that a bullet went through a cookbook and then entered the wall. From the dust patterns on a table, the book was sitting on the edge of the table when the bullet ripped through its center knocking it to the floor. From the entrance and exit hole in the book, the bullet was going horizontally as it passed through it. When you find the bullet hole in the wall, you measure that the bullet dropped by 5.0 mm since passing through the book. You dig the bullet out of the wall and measure its mass as 2.4 grams. You also measure the height of the table above the floor, 1.5 m, the distance of the book on the floor from the table, 0.30 m, the distance from the wall to the table, 5.0 m, and the mass of the book, 1.1 kg. The police want you to tell them the speed of the bullet so that they can tell whether the neighbors are telling the truth.

A bullet went through a cookbook & entered the wall. Find the speed of the bullet.

We know: height of the table,

the bullet went through book horizontally,

the distance the bullet dropped before going into the wall

the distance the book moved after being hit by the bullet,

the masses of the book and the bullet,

not a perfectly inelastic collision.

Use: Projectile motion and conservation of momentum

All the final exam problems were of this nature – involving two or more concepts.

Should we have expected a correlation between this type of question and the multiple choice questions?

This lab problem deals with conservation of momentum in an inelastic collision.

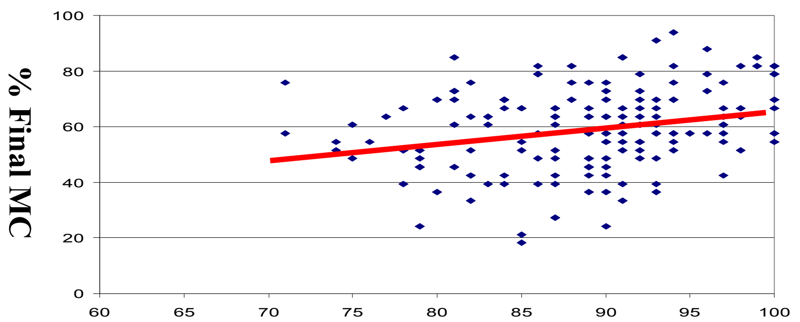
Sample Lab Problem

You have a summer job at NASA with a group designing a docking mechanism that would allow two space shuttles to connect with each other. The mechanism is designed for one shuttle to move carefully into position and dock with a stationary shuttle. Since the shuttles may be carrying different payloads and have consumed different amounts of fuel, their masses may be different when they dock. Your supervisor wants you to calculate the velocity of the docked shuttles as a function of the initial velocity of the moving shuttle and the masses of the shuttles. You decide to calculate the resulting velocity for a system of two objects sticking together after colliding. You then build a laboratory model using carts to check your calculation.

One shuttle is to dock with a stationary shuttle of different mass. Find the velocity of docked shuttles as a function of the initial velocity of moving shuttle and the masses of the shuttles.

Final Multiple Choice vs. Lab

Sec A (N = 186)

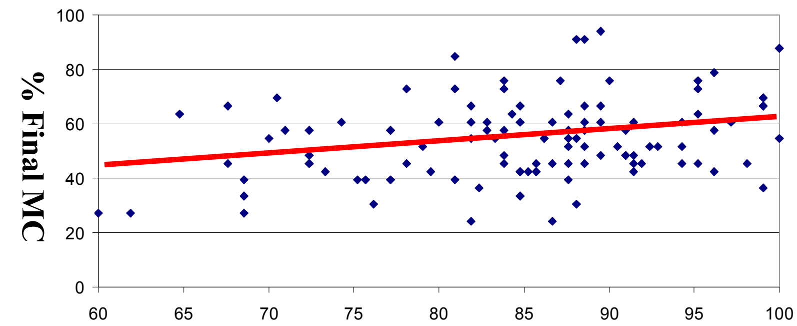


% Lab R = 0.26

6 written lab reports **Post FCI = 70%**

Final Probs = 47% MC = 59%

Sec B (N = 124)

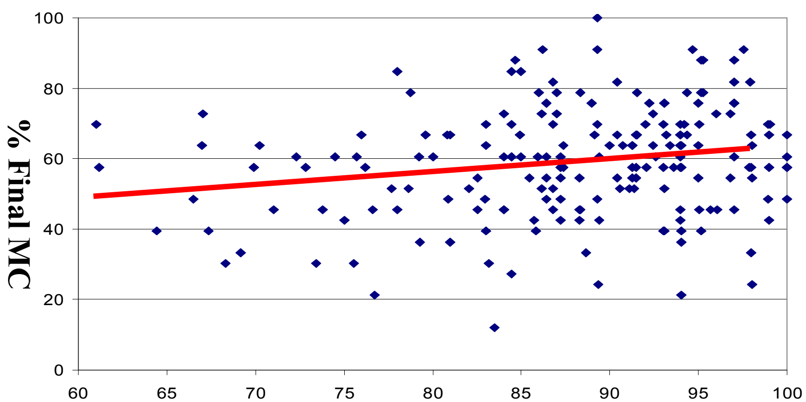


% Lab R = 0.30

7 written lab reports **Post FCI = 61%**

Final Probs = 47% MC = 50%

Sec C (N = 210)

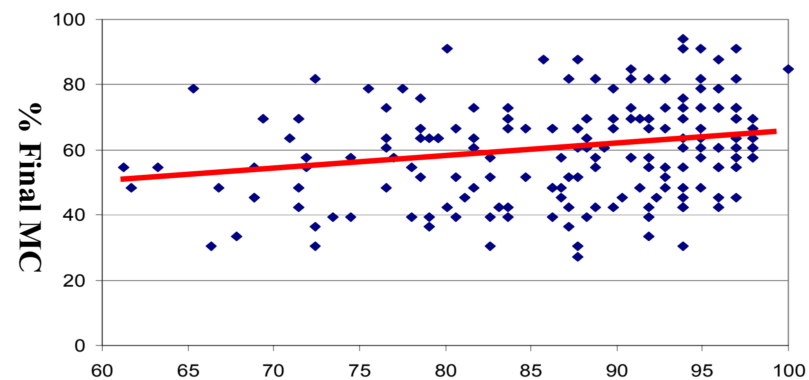


% Lab R = 0.21

4 written lab reports **Post FCI = 72 %**

Final Probs = 52 % MC = 59%

Sec D (N = 180)



% Lab R = 0.28

8 written lab reports **Post FCI = 71 %**

Final Probs = 42 % MC = 59%

What might we expect when comparing final exam problems and written lab reports?

Some of the difficulties that arise:

Grading lab reports and exam problems

generates significant noise.

We try to reduce the noise.

TAs are given significant guidance in grading labs and exams: ~3 hours for each during orientation and the in-service training

TA Guidelines for grading laboratory reports

Problem Report:	**Score**
ORGANIZATION (clear and readable; correct grammar and spelling; section headings provided; **physics stated correctly**)	
DATA AND DATA TABLES (GROUP PREDICTIONS) (clear and readable; units and assigned uncertainties clearly stated)	
RESULTS (results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; **physics stated correctly**)	
CONCLUSIONS (comparison to prediction & theory discussed with **physics stated correctly** ; possible sources of uncertainties identified; attention called to experimental problems)	

TAs come from a variety of backgrounds and countries.

Despite the training

we can expect different criteria.

The TAs that grade the lab reports also

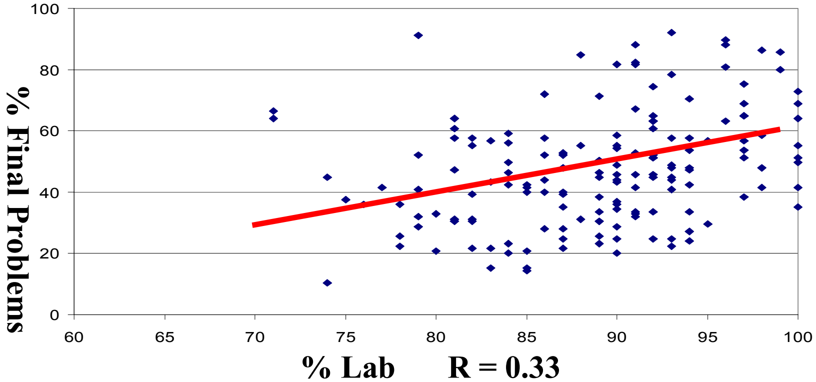
grade the exams – positive effect.

The final exam has 5 problems each problem graded by a different person – noise effect

So – for comparing the generally single concept labs - with final exams, involving two or more concepts, what would we expect?

Final Problems vs. Lab

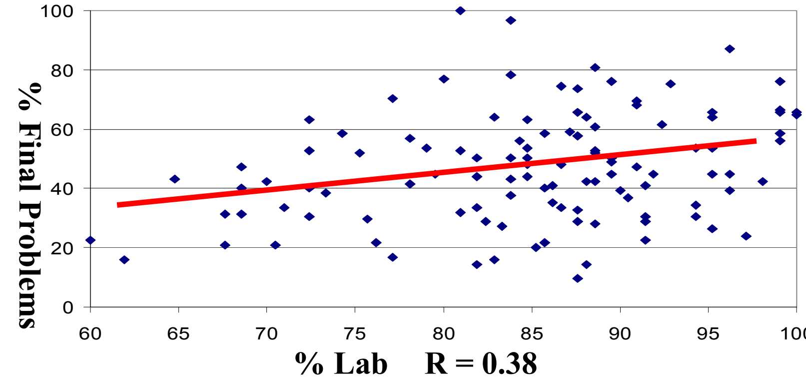
Sec A (N = 170)



6 written lab reports **Post FCI = 70%**

Final Probs = 47% MC = 59%

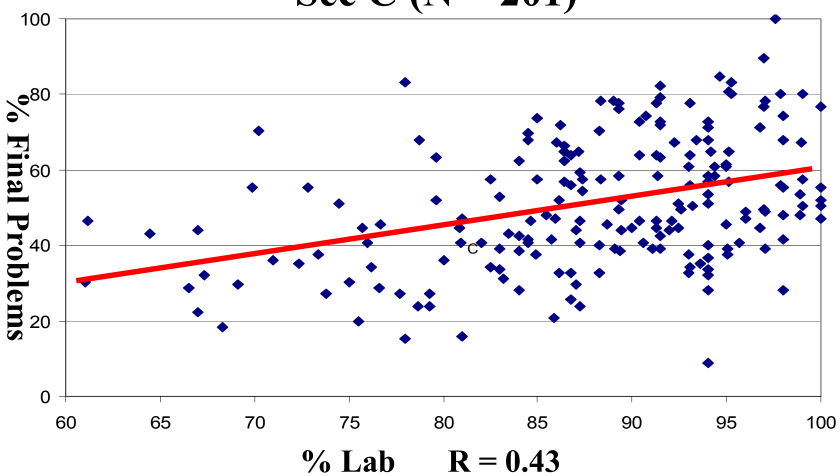
Sec B (N = 124)



7 written lab reports **Post FCI = 61%**

Final Probs = 47% MC = 50%

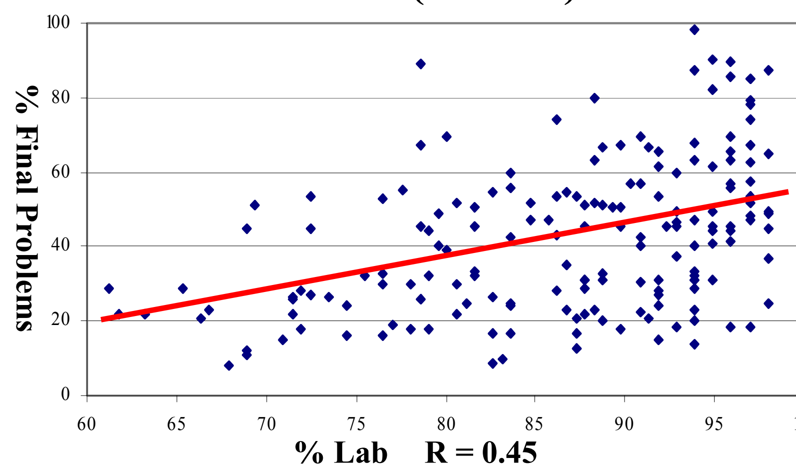
Sec C (N = 201)



4 written lab reports **Post FCI = 72 %**

Final Probs = 52 % MC = 59%

Sec D (N = 198)



8 written lab reports **Post FCI = 71 %**

Final Probs = 42 % MC = 59%

An intermediate conclusion is:

Maybe correlations exist within the measurement instruments we now use

Multiple Choice Questions (qualitative)

Problem Solving (quantitative)

Written Lab Reports (expository)

Next

We need to do a refined analysis, of problems and lab reports, to attempt to reduce the Noise.

A refined analysis could involve one person evaluating the labs and final exam problems using carefully followed criteria - Perhaps using different sets of criteria – for example the rubric used by the TAs and then a set of criteria such as "organization," "support," and "content."

We now have 300 complete sets of written lab reports from introductory physics.

Each set contains from 4 to 8 reports. (depending on the section requirements)

And

A Matching set of 300 (5 problem) Final Exams with 300 sets of Multiple Choice Questions (including the MBT)

Perhaps, after removing some of the difficulties that produce noise, and studying our data, we will gain insight into student knowledge that will help find answers to some of those persistent questions:

What do students really learn in physics classes?

Into what aspects of the physics classes should we be putting our time and energy?

What are the parts of the physics class that should be kept and adjusted?

References: Ron Keith, Dissertation U of MN '93

Tom Foster, Dissertation U of MN '00

Vince H. Kuo, Talk – AAPT, San Diego – winter '01

Paul Knutson, Talk – AAPT, Boise - summer '02

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Paul Knutson

knut0199@umn.edu