The Role of PER in Introductory Course Reform and Physics Teacher Preparation

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SPIN-UP workshop
June 5th, 2010

Outline

- **What is Physics Education Research (PER)?**
- **What is unique about Rutgers PER?**
- **What does Rutgers PER do?**
- **PER study #1**
- **PER study #2**
- **PER and preparation of Physics Teachers at Rutgers**

What is Physics Education Research?

PER uses the tools and methods of science to study and improve the teaching and learning of physics.

(J. Redish)

What is Physics Education Research?

PER uses the tools and methods of science to study and improve the teaching and learning of physics.

Interdisciplinary:

- **Physics**
- **Education research**
- **Brain research, linguistics, sociology, etc.**

What is unique about Rutgers PER?

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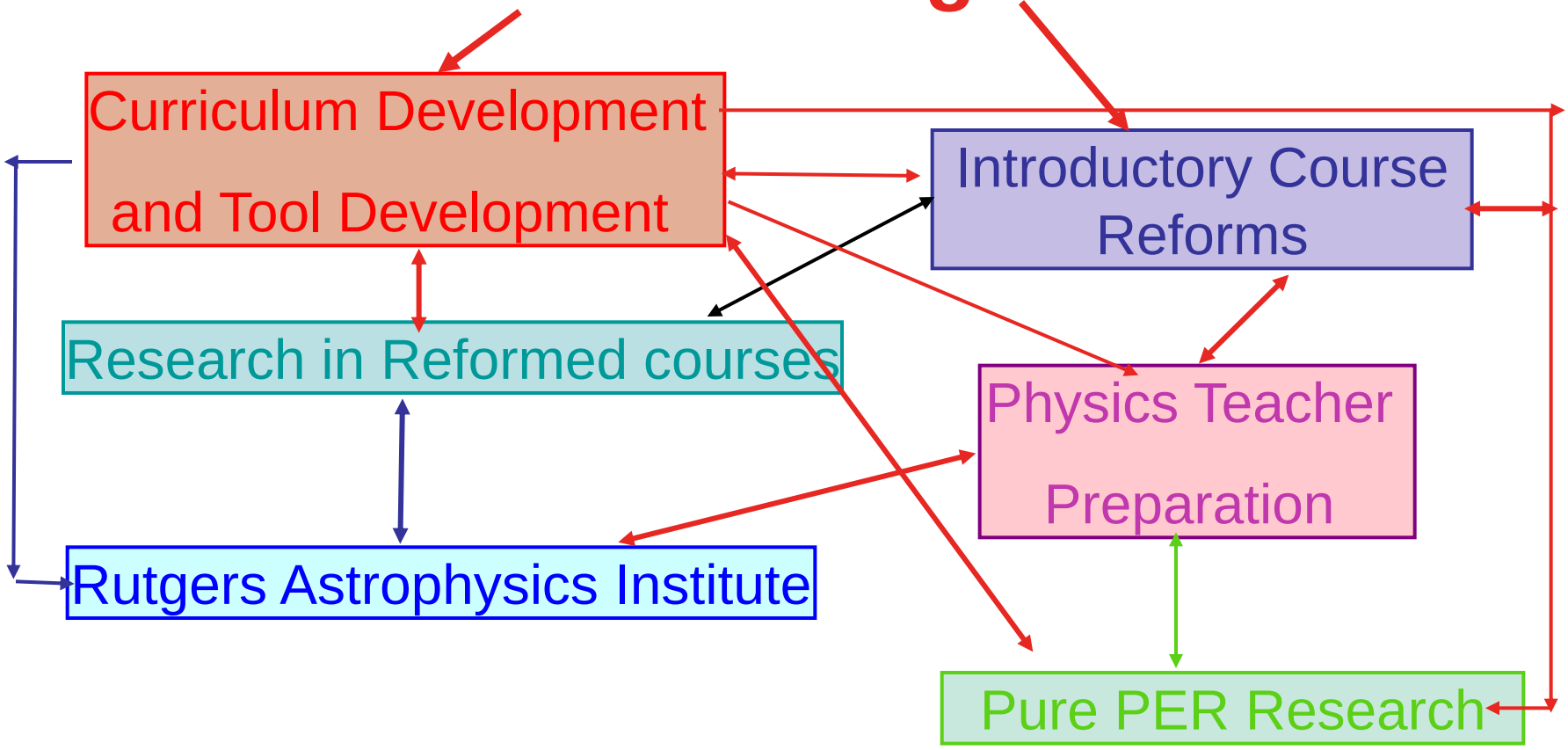
Work of Rutgers PER



Example of Course Reforms (Pioneering work of late G. Horton)

- **Underrepresented students on the path to engineering**

George Horton

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Suzanne Brahmia

Extended Analytical Physics

Extended Analytical Physics EAP

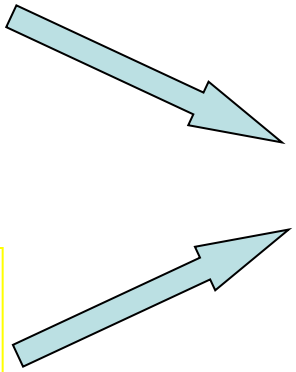
Parallel-path Model

Extended Analytical Physics (EAP I)

3 credits per semester

Analytical Physics (AP I)

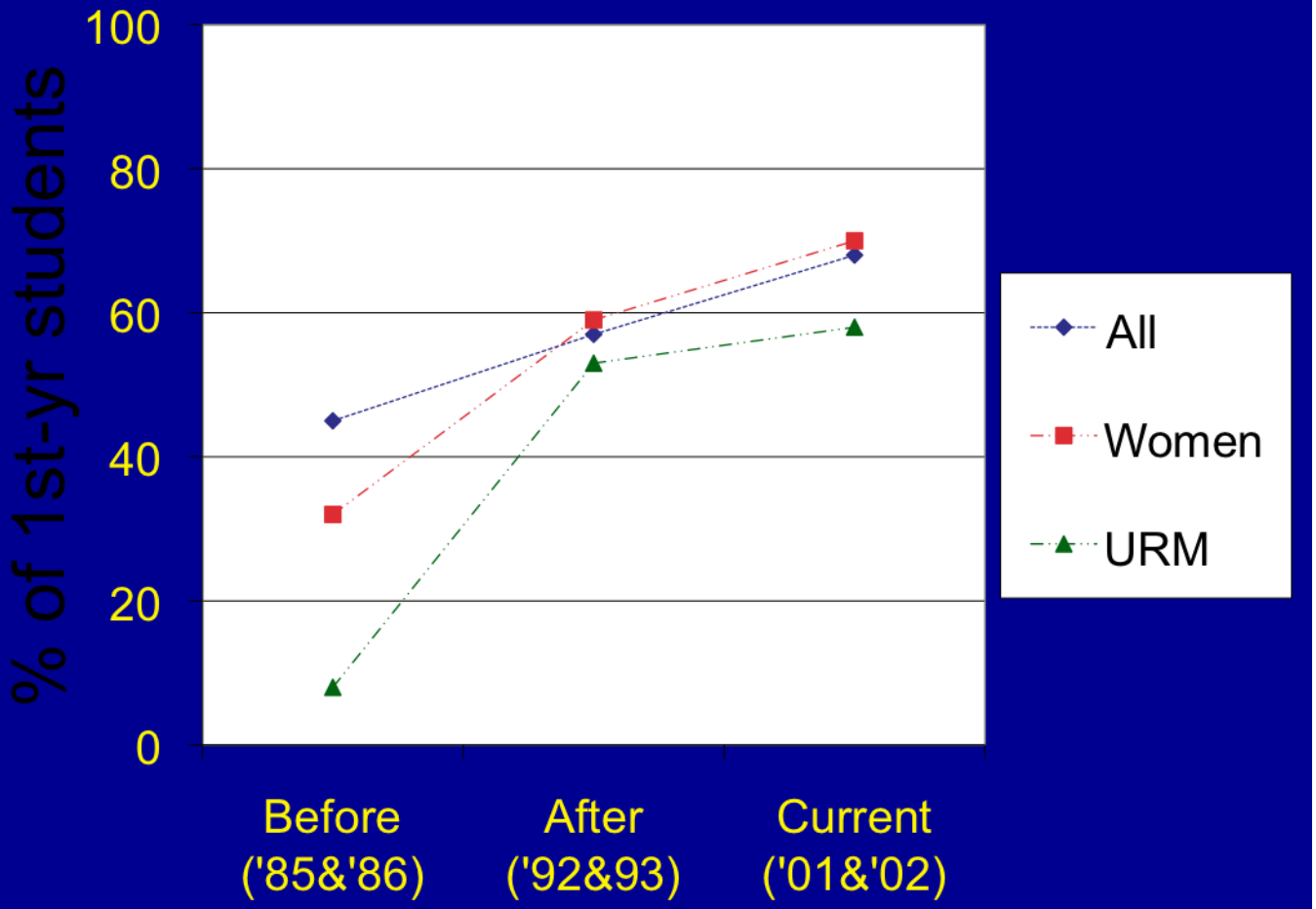
2 credits per semester



Analytical Physics II (AP II)

3 credits per semester

Retention in STEM Majors



Other Course Reforms, Outreach, and Research Combined

- **Thinking like a scientist (both undergrads and high school students including research in X-ray astrophysics!)**

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Reformed courses as PER research laboratory

- **Multiple representations and student problem solving**
- **Development of self-evaluation skills**
- **Ability to solve multiple possibility problems**

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Pure Research

Language and student learning of physics

New paradigms in transfer research

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Research tools that we use

- **Direct observations**
- **Videotaping, transcribing, and coding**
- **Interviewing (think aloud protocols)**
- **Scoring written work using rubrics**
- **Coding exam work**
- **Pre instruction - post instruction testing**
- **Surveying**

What do we do for the physics department?

- Develop curriculum materials
- Push and sustain courses reforms
- Advise grad students who are working on a physics PhD in PER
- Educate TAs
- Take care of graduates
- Run Rutgers Astrophysics Institute
- Help with NSF educational outreach component on proposals

What do we do for the school of education?

Maintain one of the biggest physics teacher preparation programs in the country!

6-8 graduates per year!

Physics for the Sciences (193-194) is our laboratory.

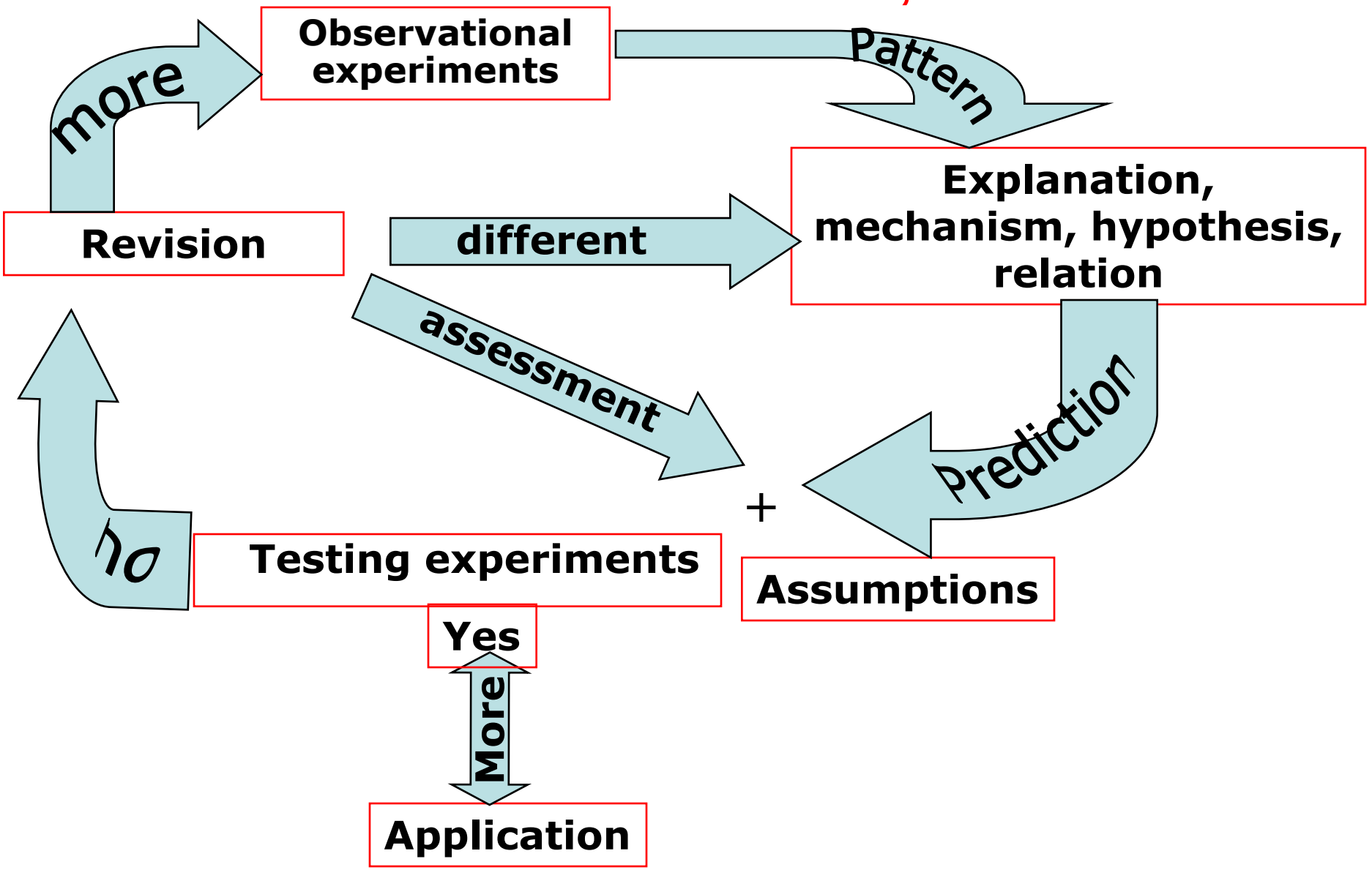
Physics for the Sciences - algebra based (almost no pre-meds) 200/year

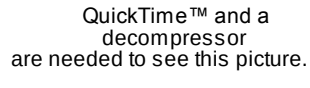
What should their education focus on? (Education is what one remembers when everything is forgotten).

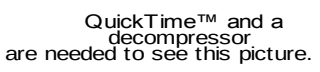
They will encounter most physics content in the course ONCE but if we focus on the process then there are MULTIPLE opportunities to see the same process again and again.

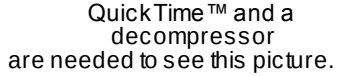
Can we use physics as a context to help students develop "physics habits of mind"?

Investigative Science Learning Environment (ISLE)
Etkina and Van Heuvelen, 2001









ISLE-based courses

Physics for the Sciences 193-194

Extended Analytical Physics 114-115

Total of 350 students/year

- **Some of the main goals of ISLE are to help students understand how knowledge is constructed and develop scientific habits of mind.**

  What are those?

- **We call them SCIENTIFIC ABILITIES**

What are scientific abilities?

9 people + a lot of history

representing physical processes and ideas

designing an experimental investigation

collecting and analyzing data

devising and testing a qualitative explanation or a quantitative relation

modifying an explanation or a relation in light of new data

evaluating

communicating

Rubrics for guidelines, assessment and self-assessment

LEVEL / ABILITY	Missing (0)	Not adequate (1)	Needs improvement (2)	Adequate (3)
To evaluate specifically the ways in which the assumptions might affect the result	No attempt to determine the effects of relevant assumptions.	An attempt is made but effects are described vaguely.	The effects of relevant assumptions are determined correctly but assumptions are not validated.	The effects of relevant assumptions are determined and assumptions are validated.

One approach (we use many more): The lab is completely integrated and basically drives the course.

In the labs students do initial observations to come up with patterns or models, and then they test and apply them after a discussion in a large room meeting. THEY DO NOT READ THE BOOK BEFORE CLASS!

Recitations are dedicated to analyzing processes using multiple representations (problem solving but not traditional)

Students design their own experiments in every lab!

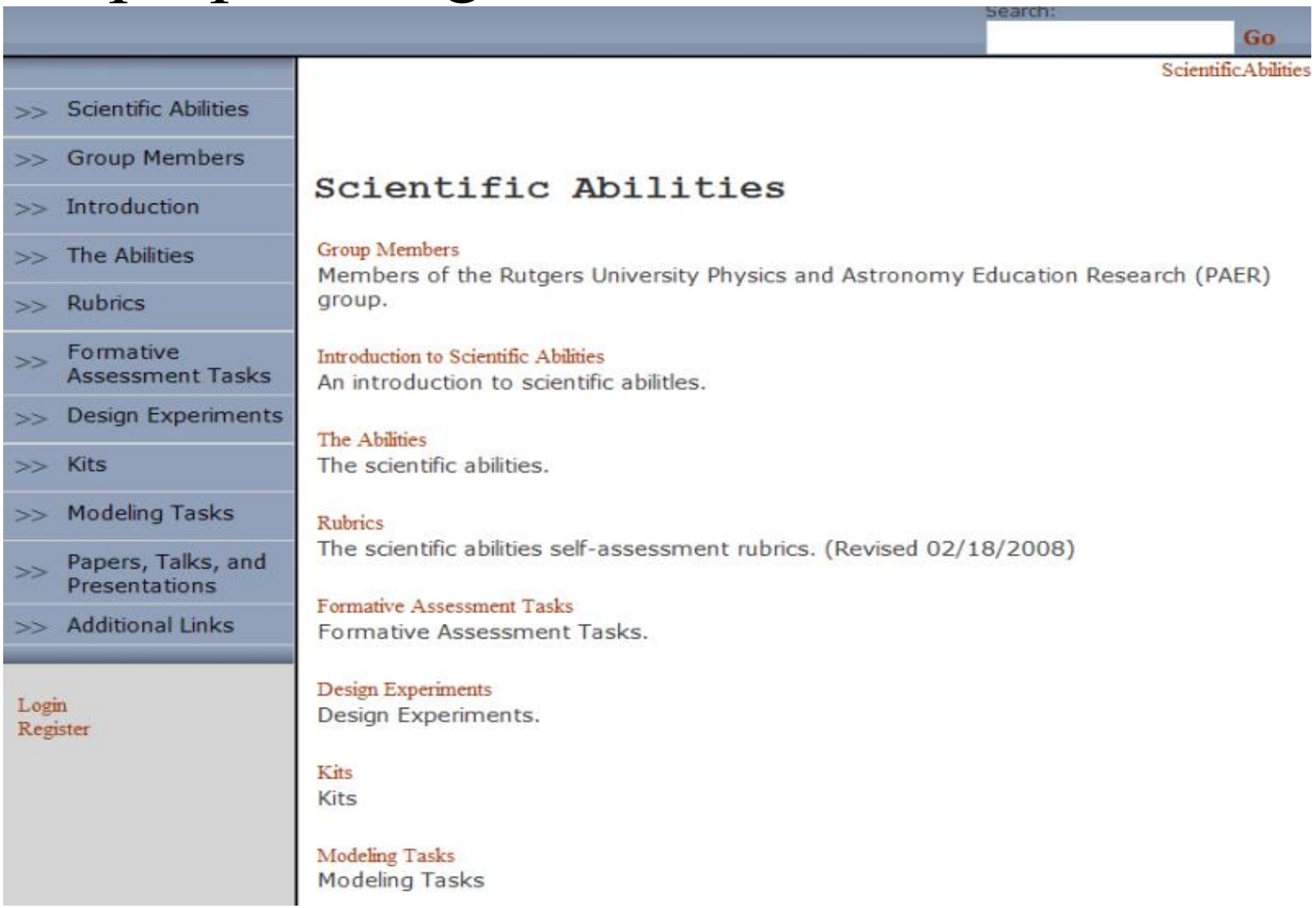
Design an experiment to find a relation between a voltage across and current through a commercial resistor.
Design an experiment to test whether this relation applies to an incandescent light bulb.

Design an experiment to test a hypothesis: interaction of electrically charged objects can be explained by magnetism.

Design two independent experiments to determine the specific heat of the given object. The material of the object is not known.

Use the list of available equipment (xx, xx) to pose your own question. Investigate the question and write a report.

http://paer.rutgers.edu/scientificabilities/



http://paer.rutgers.edu/pt3/

Physics Teaching Technology Resource

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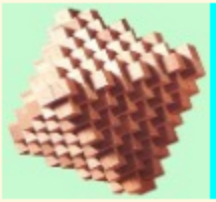
Essential Links
ISLE Physics Network
Scientific Abilities
Compadre

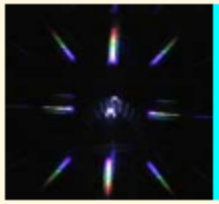
PIRA

Introduction — This is a long introduction for physics teachers and those interested in Prof. Etkina's teaching methods.

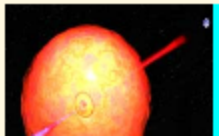


Motion — Learning cycles on the subject of Kinematics.

Newton — Learning cycles on Newton's Laws



Circular and Rotational Motion — Learning cycles on circular and motion and motion with rotation in it



Energy — Learning cycles on work and energy.

Scientific abilities study

Physics for the sciences 193/194 (190 students)

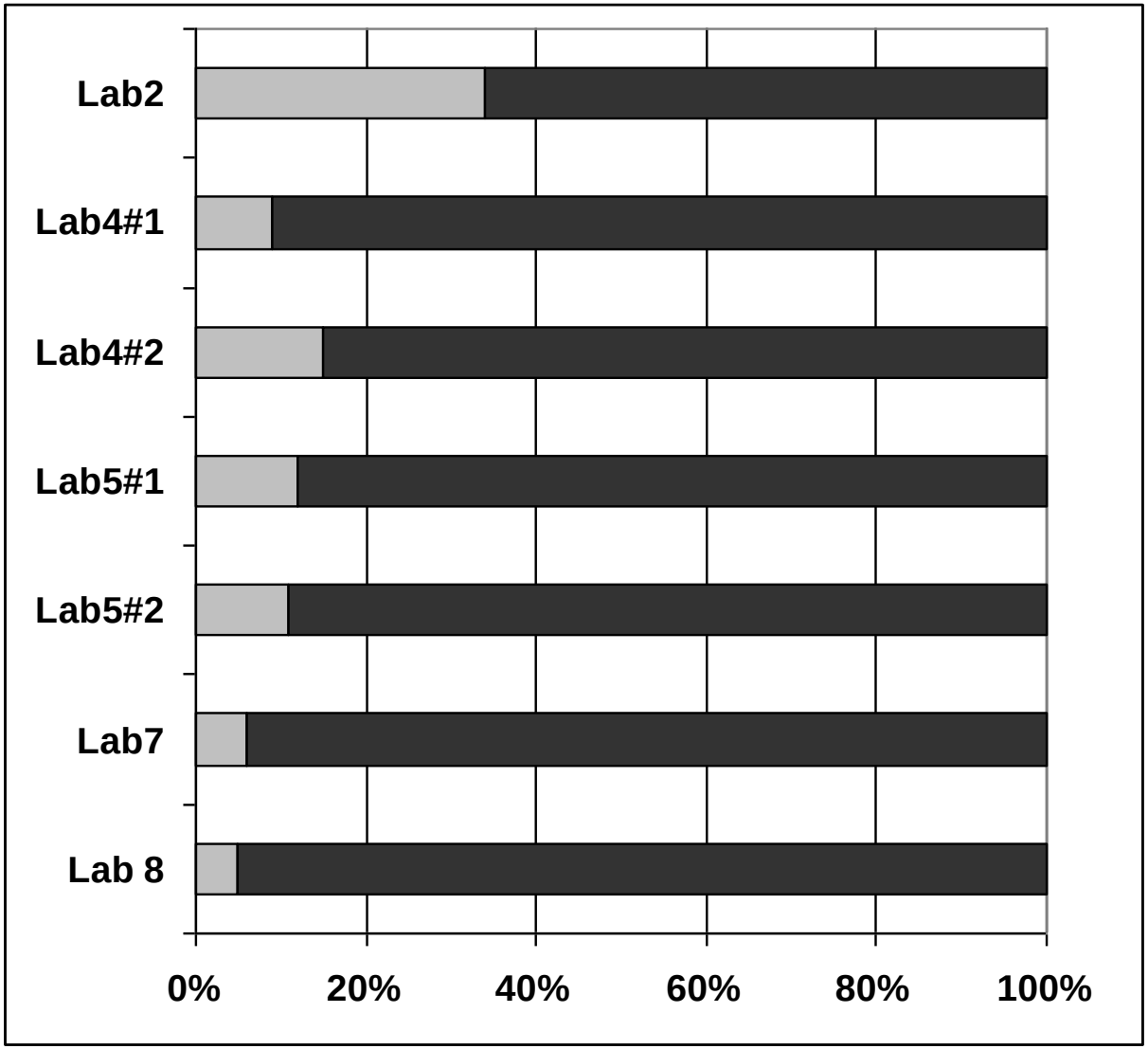
Introduced ISLE and design labs in 2003

Scored lab reports (60 x 14 x 3 x 3) = 8000 pages of student work

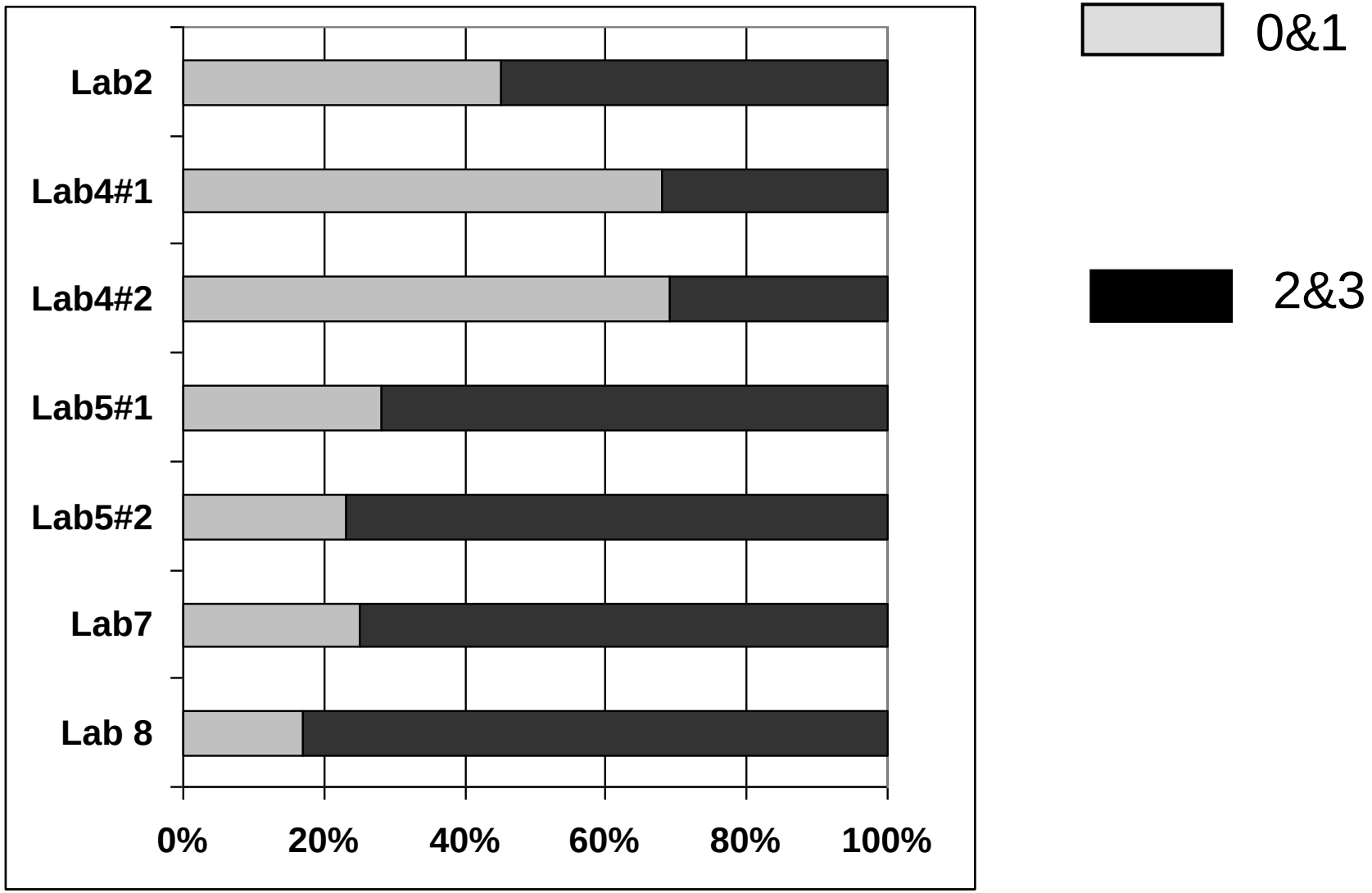
Used rubrics

Reliability > 90%

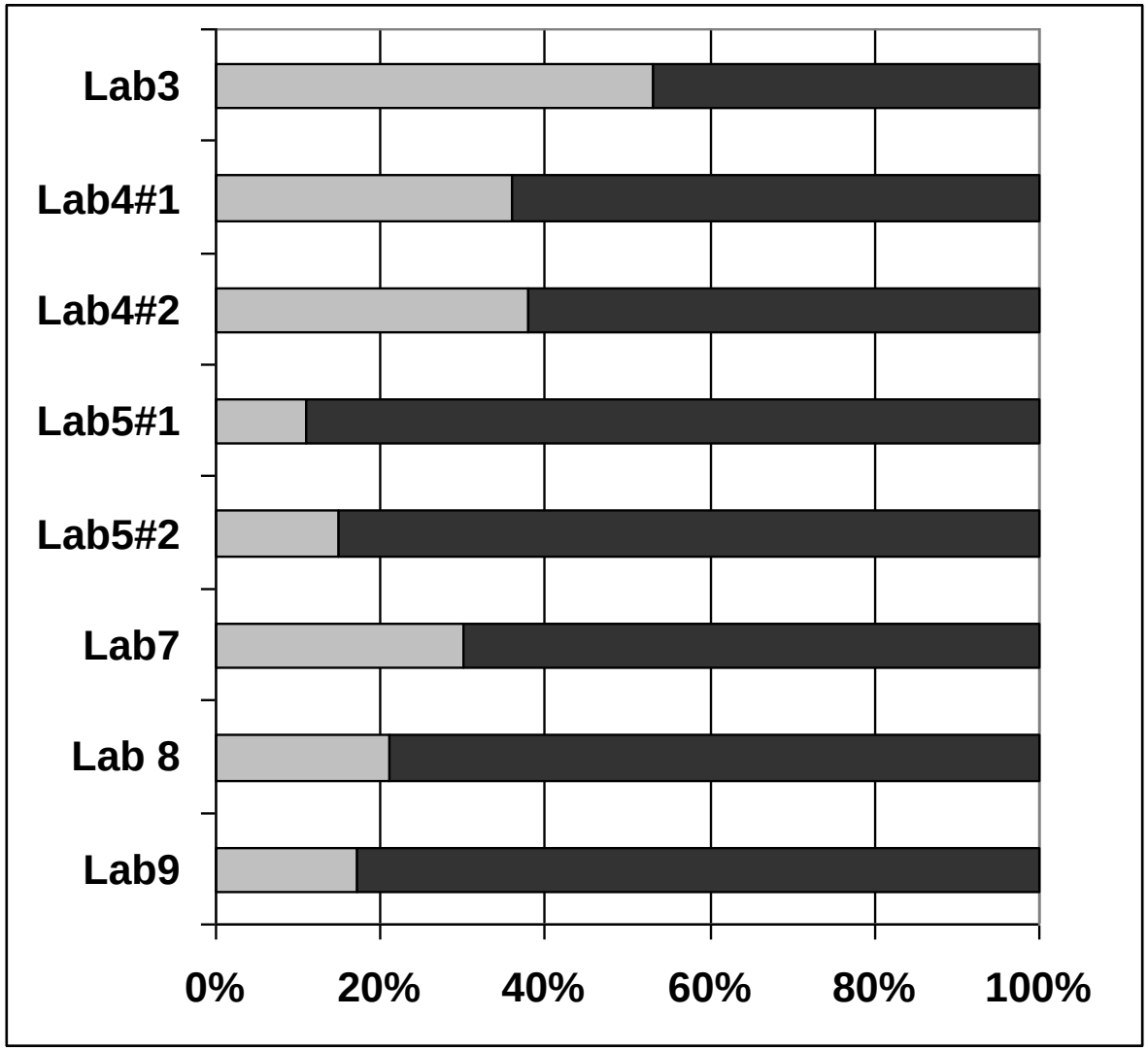
Ability to identify uncertainties



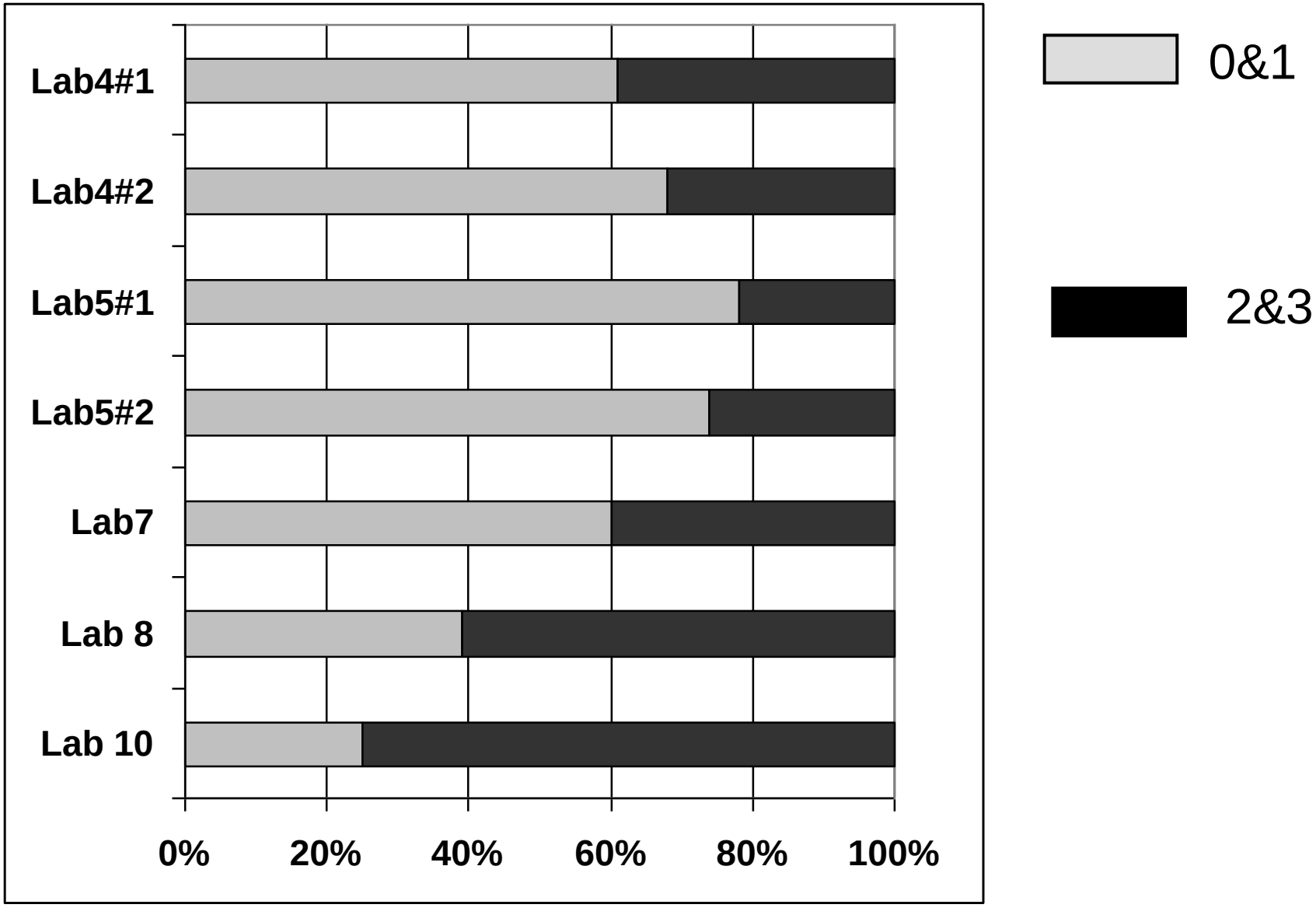
Ability to evaluate uncertainties estimating the largest uncertainty



Ability to identify assumptions



Ability to evaluate assumptions



Research on scientific abilities

200 students in two courses over 3 years

Found

Time dependence

Content dependence (especially the effects of assumptions!)

Significant improvement

Saturation

Transfer project

Experimental and control group
Same course

Experimental group

Design labs+Rubrics

Control group

PER based labs
non-design

Week 1-10

Comparison

Designing a physics experiment

Week 12

Designing a biology experiment

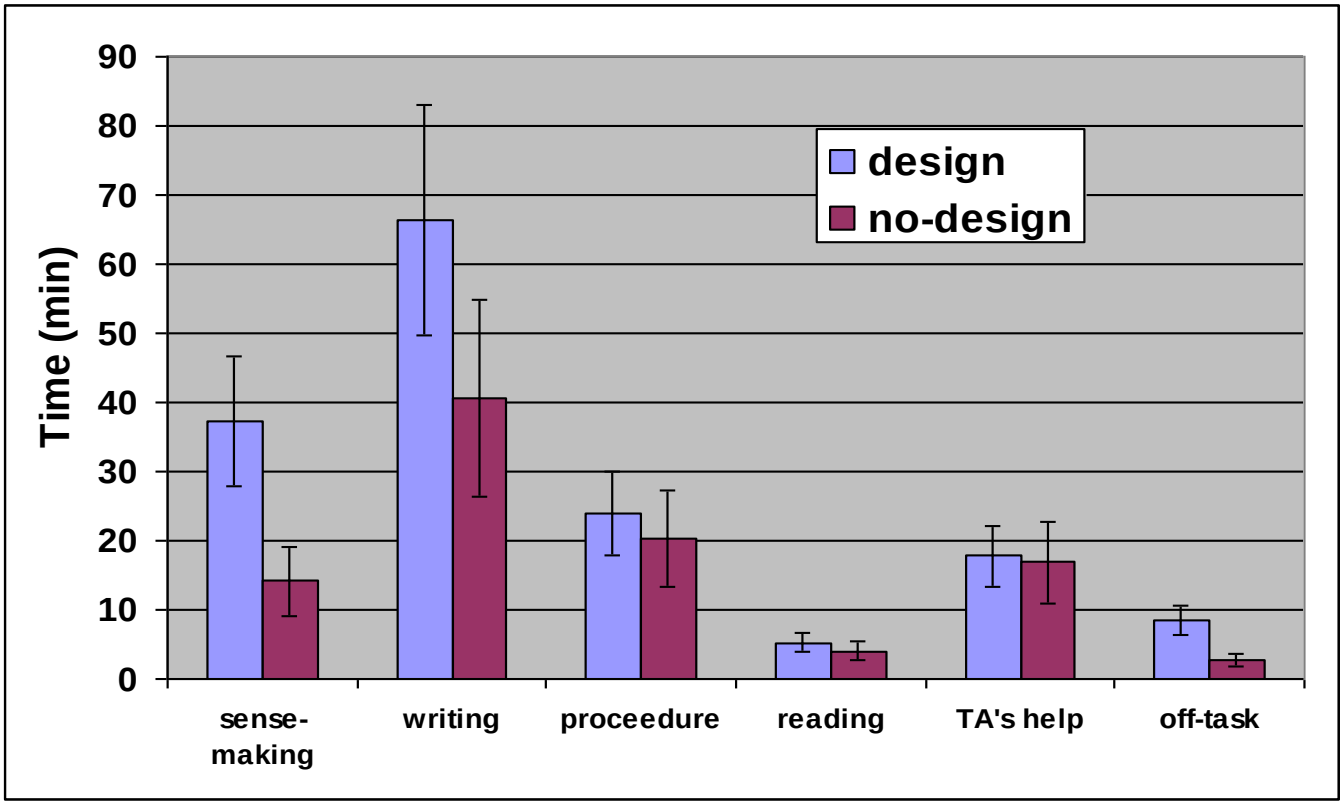
Week 13

Solving regular exam problems

Week 5, 11, 15

Time Spent on the lab activities

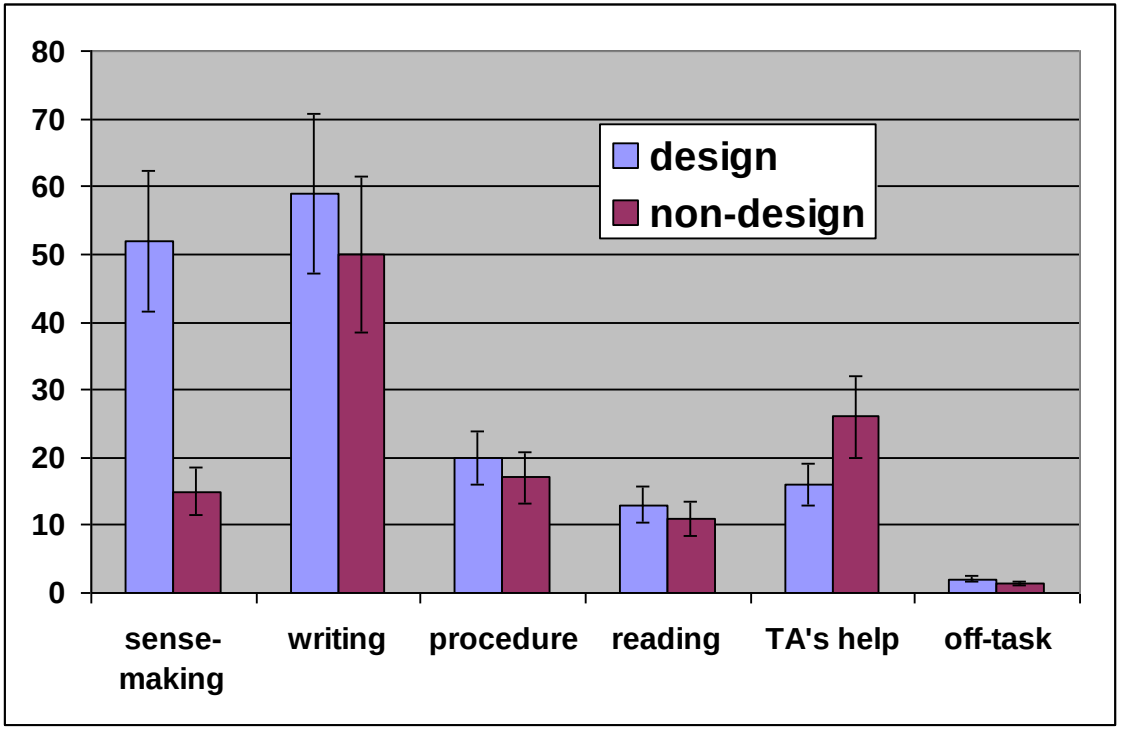
Weeks 1 through 10



Physics transfer task:
Investigation of the behavior of the balloon

Design experiments to determine whether the helium balloon and the air balloon have the same drag coefficients.

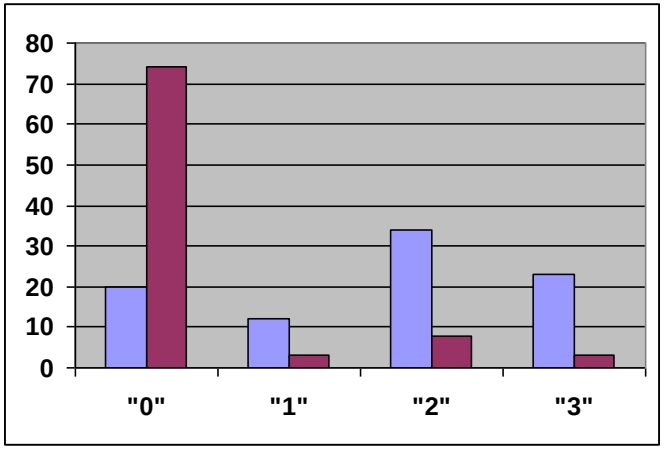
Time spent on lab activities



	Design	Non-design	p - level of significance
Total time	162±17min	120±25min	0.0375
Sense-making	52±10min	15±5min	0.0007

Scientific Abilities

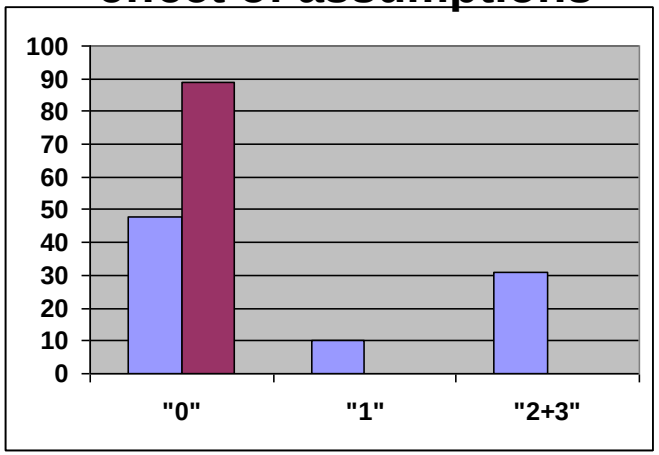
Ability to identify the assumptions



Difference is statistically significant
Chi-square = 67.90, *p* < 0.001

Identified relevant and significant assumptions
64% of design students
13% of non-design students

Ability to evaluate/validate effect of assumptions



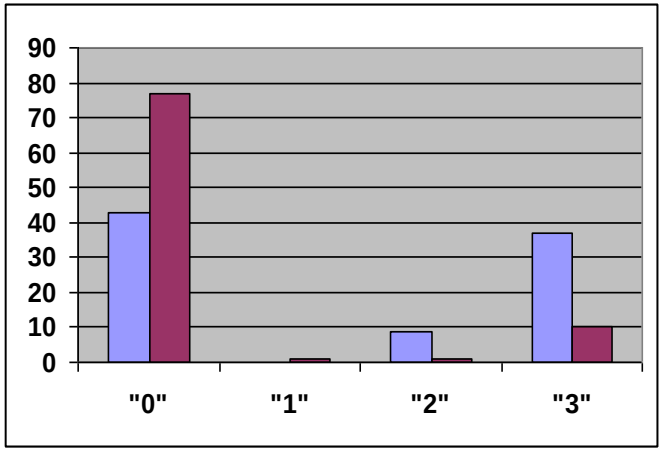
Difference is statistically significant
Chi-square = 53.3 , *p* < 0.001

"0" – missing
"1" – inadequate
"2" – needs some improvement
"3" – adequate

Design
Non-design

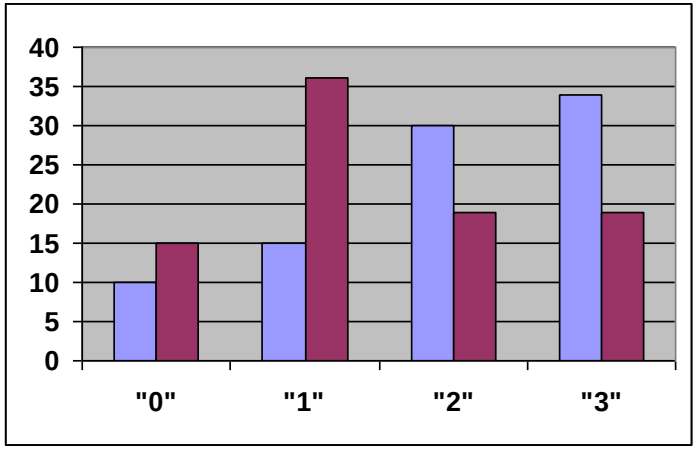
Scientific Abilities

Ability to evaluate the uncertainty



Difference is statistically significant
Chi-square = 30.1167, $p<0.001$

Ability to evaluate the results by independent method



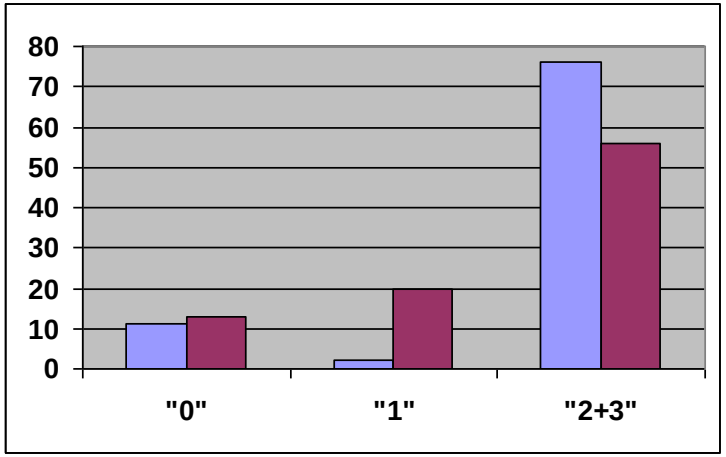
Difference is statistically significant
Chi-square = 16.36, $p < 0.001$

"0" – missing
"1" – inadequate
"2" – needs some improvement
"3" – adequate

Design
Non-design

Physics understanding

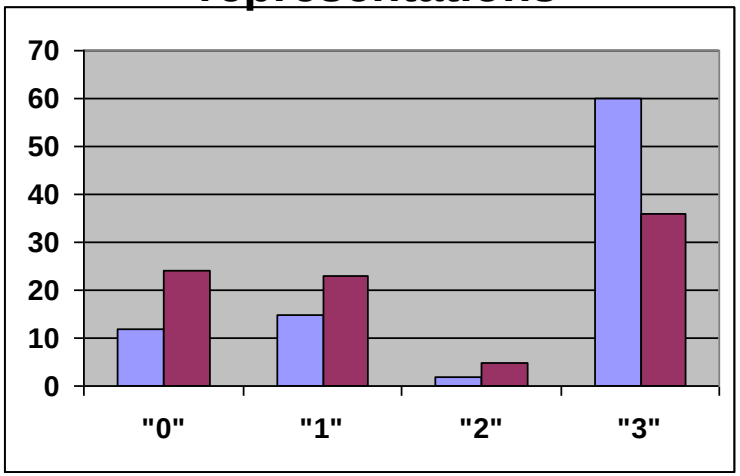
Free Body Diagram



Difference is statistically significant
Chi-square = 17.73, p<0.001

2% of design students
22% of non-design students
have score “1” - draw wrong FBD

Consistency of multiple representations



Difference is statistically significant
Chi-square = 7.838, p<0.025

“0” – missing
“1” – inadequate
“2” – needs some improvement
“3” – adequate

Design
Non-design

Biology transfer task

Conduct two experiments to determine transpiration rate using stem cuttings from a single species of plant.

Summary of findings

Time on sense making

Professionalism in lab reports

Coordinated representations

Recognized assumptions

Evaluated uncertainties

Results, evaluated by an independent method

Preparation of high school physics teachers

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Ed.M. with certification in physical science (5 year program and a post bacc)

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Over 40 graduates in 7 years are now teaching (without a penny of external or internal funding)

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Physics Teacher Preparation is GSE-based

Helps with recruitment

Allows flexibility

Provides with opportunities for teaching in reformed courses

Provides teaching role models

Provides access to equipment and connects to NJAAPT

Department Of Physics and Astronomy

Ed.M. with certification in physical science

FIVE 3-credit courses in how to teach physics

+

Students teach labs and recitations in 193/194 practicing working with students in a new way before they do student teaching in the schools.

This teaching is integrated in their course work in the GSE

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Thank you!