Workshop II:
Conducting Discipline-Based Education Research

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Discipline-Based Education Research (DBER)

- Workshop I: Moving from Teaching to Research about Teaching and Learning
- **Workshop II: Conducting Discipline-Based Education Research**
- Workshop III: Instrument Design (3:00 – 5:00 PM)

What Is Discipline-Based Education Research (DBER)?

"DBER is grounded in the science and engineering disciplines and addresses questions of teaching and learning within those disciplines."

"DBER can be defined both by the focus of the research and by the researchers who conduct it"

National Research Council. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.* 2012

DBER practitioners publish to advance their field. (C. Dirks)

What Is the History of DBER?

Late 1800s to early 1900s
Increased interest in the quality of teaching and learning in higher education

1950s-1960s
Sputnik; the need for scientists and engineers for the future of our country

1970s – 1990s
Scholarly research in DBER emerged and the fields gained recognition

National Research Council. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.* 2012

What Is the History of DBER?

Late 1800s: Engineering Education Research (EER)

- **1929-1980 – sporadic EER Ph.D.s awarded**
- **1990 – numerous EER Ph.D.s awarded**

1950s and 1960s: Physics Education Research (PER)

- **Late 1970s – the first PER Ph.D.s**
- **1990s – faculty hired with PER as their area of research**

Note: Astronomy Education Research (AER) is somewhat connected to PER and the field emerged about 20 yrs later

1960s: Chemical Education Research (CER)

- **Late 1990s – the first CER Ph.D.s**
- **1990s – faculty hired with PER as their area of research**

National Research Council. ***Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.*** **2012**

What Is the History of DBER?

2000s: Biology Education Research (BER)

- **1930s – Biologists begin to experiment with new ways of teaching**
- **1980s – 1990s – biologists begin BER(ish) studies**
- **2000s – 83% of BER publications since 1980**
- **2000 – Society for the Advancement of Biology Education Research; Ph.D.s awarded in BER**

2000s: Geochemical Education Research (GER)

- **Late 1950s – 1960s – foundation work in GER**
- **2000s – faculty have achieved tenure based on GER; Ph.D.s awarded in GER**

National Research Council. ***Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering.*** **2012**

A Comparison of Science Research and DBER

Discuss in small groups, what you think are some of the main differences and similarities between science research and DBER.

A Comparison of Science Research and DBER

DIFFERENCES

Quasi-experimental

You typically can’t randomize your subjects like mice!

(Sometimes scientists can’t either!)

Human Subjects

DBER includes the study of attitudes and beliefs

Atoms, lemurs, and circuits don’t talk.

Other?

A Comparison of Science Research and DBER

SIMILARITIES

Methodical approach (the use of systematically collected data)
N matters
Statistical analyses of data (often the same models are used)
Presentation of work (posters, talks, publications)
Funding
Hypothesis driven (but not always!!)
Other?

An Important Aspect of DBER is Asking a Good Question

DBER should . . .

- **be grounded by a theoretical framework/situated in the literature**

- **aim to advance our understanding of the field**

- **reveal underlying mechanisms**

Slater, S. et al. *Discipline-Based Education Research: A Scientists Guide.* 2012

Quantitative and Qualitative Data

Quantitative Data:
Exam scores, students' incoming high school GPAs, learning gains measured by pre- and post-testing, or surveys based on a Likert scale, etc. . .

Useful in determining *what* a student knows, but generally not helpful for understanding *how* or *why* a student knows it.

Qualitative Data:
Interviews, written papers, observations, or audio-visual recordings of student work, etc. . .

Can tell an instructor a great deal about the *how* and *why* of student thinking.

A Few Research Formats/Study Designs

DBER may be hindered by the lack of a true comparison group and randomization.

How can we overcome these obstacles?

A Few Research Formats/Study Designs

Pre- and post-test format: Students are tested at the beginning of a course and then again at the end with differences in performance calculated as learning gains.

Sequential course format: A pre- and post-test measure between different groups of students in subsequent years of a course taught by the same instructor.

Formats in which subjects can be randomized.

Two-group comparison: The class is divided into two groups. One group receives treatment A and the other treatment B; both take a pre and post-test.

Cross-over format: The same as two-group comparison but the treatment groups are switched for the second round.

Data Collection: What Instrument Will You Use?

Whatever you use, it should be valid and reliable.

Validated instruments measure what they are supposed to measure, and reliable instruments consistently distinguish between individuals with disparate abilities.

There are many forms of validity and reliability!

Alias, M. Assessment of Learning Outcomes: Validity and Reliability of Classroom Tests. World Transactions on Engineering and Technology Education. Vol 4 No. 2, 2005

Finding an Instrument for Your Needs

I will show you some of them, but if you can't find the one you need then visit these two sites and keep looking:

Field-tested Learning Assessment Guide website (http://www.flaguide.org/)

Mental Measures Yearbook or other resources at the Buros Institute of Mental Measurements (http://www.unl.edu/buros/bimm/index.html).

As a last resort, design your own instrument! (Please attend my workshop at 3:00PM.)

Validated Instruments for Discipline-Based Education Research in Higher Education Science, Technology, Engineering and Math Fields (STEM)

Just a sample. . .

Concept Inventories in Astronomy	
Astronomy Diagnostic Test (ADT)	Hufnagel, 2002
Lunar Phases	Lindell and Olsen, 2002
Light & Spectroscopy Concept Inventory	Bardar, et al., 2007
Concept Inventories in Biology	
Genetics Concept Assessment (GCA)	Smith, et al. 2008.
Genetics Literacy Assessment Instrument 2 (GLAI-2)	Bowling et al., 2008a; 2008b
Conceptual Inventory of Natural Selection (CINS)	Anderson et al., 2002
Biology literacy (http://bioliteracy.net/)	Klymkowsky and Garvin-Doxas, 2008
Diagnostic Question Clusters: Biology	Wilson et al., 2006 D'Avanzo, 2008
Host-Pathogen Interactions (*HPI*)	Marbach-Ad et al., 2009
Introductory Molecular and Cell Biology Assessment (IMCA)	Shi et al., 2010
Concept Inventories in Chemistry	
Chemistry Concept Inventory	Mulford and Robinson, 2002 Krause et al., 2004

Concept Inventories in Engineering	
Engineering Thermodynamics Concept Inventory	Midkiff, et al., 2001
Heat Transfer	Jacobi, et al., 2003
Materials Concept Inventory	Krause, et al., 2003
Signals and Systems Concept Inventory	Wage, et al., 2005
Static Concept Inventory	Steif, et al., 2005
Thermal and Transport Science Concept Inventory (TTCI)	Streveler, et al., 2011
Concept Inventories in Geoscience	
Geoscience Concept Inventory (GCI),	Libarkin and Anderson, 2005; 2006; 2007
Concept Inventories in Math and Statistics	
Statistics Concept Inventory (SCI)	Allen, 2006
Calculus Concept Inventory (CCI)	Epstein, 2005

Concept Inventories in Physics	
Force Concept Inventory (FCI)	Hestenes and Wells, 1992 Hestenes et al., 1992
The Force and Motion Conceptual Evaluation (FMCE)	Thornton and Sokoloff, 1998
Thermal Concept Evaluation	Yeo and Zadnick, 2001
Brief Electricity and Magnetism Assessment (BEMA)	Ding et al., 2006
Conceptual Survey in Electricity and Magnetism (CSEM)	Maloney et al., 2001

Measuring Students’ Science Process and Reasoning Skills	
Rubric for Science Writing	Timmerman and Crotwell, 2010
Student-Achievement and Process-Skills Instrument	Bunce, et al., 2010
Measuring Students’ Attitudes About Science, Research, or Study Methods	
Colorado Learning Attitudes About Science Survey (CLASS)	http://www.colorado.edu/sei/class/
Revised Two-Factor Study Process Questionaire	Biggs, J. et al. 2001
Student Assessment of Their Learning Gains (SALG) Instrument	http://www.salgsite.org/
Survey of Undergraduate Research Experiences	Lopatto, D., 2004
Views About Sciences Survey (VASS)	Halloun, I. and D. Hestenes, 1998

Group Work (40 minutes)

In teams of TWO address the following:

1. **Discuss a research idea or question you each have. Determine if the research is situated in the literature, advances the field, and would reveal underlying mechanisms.**

2. **What would be your approach for the investigation? What kind of data would you collect?**

3. **How will you collect your data?**

4. **Do you have any weaknesses in your research design?**

Use a large Post-It and make a poster with your responses.
Be prepared to present to the larger group in 40 min.

POSTER SESSION

One person from each poster circulates for 15 minutes

Then you switch (I will tell you when)

The other person from each poster circulates for 15 minutes

One Example of DBER: Clickers and Peer Interaction

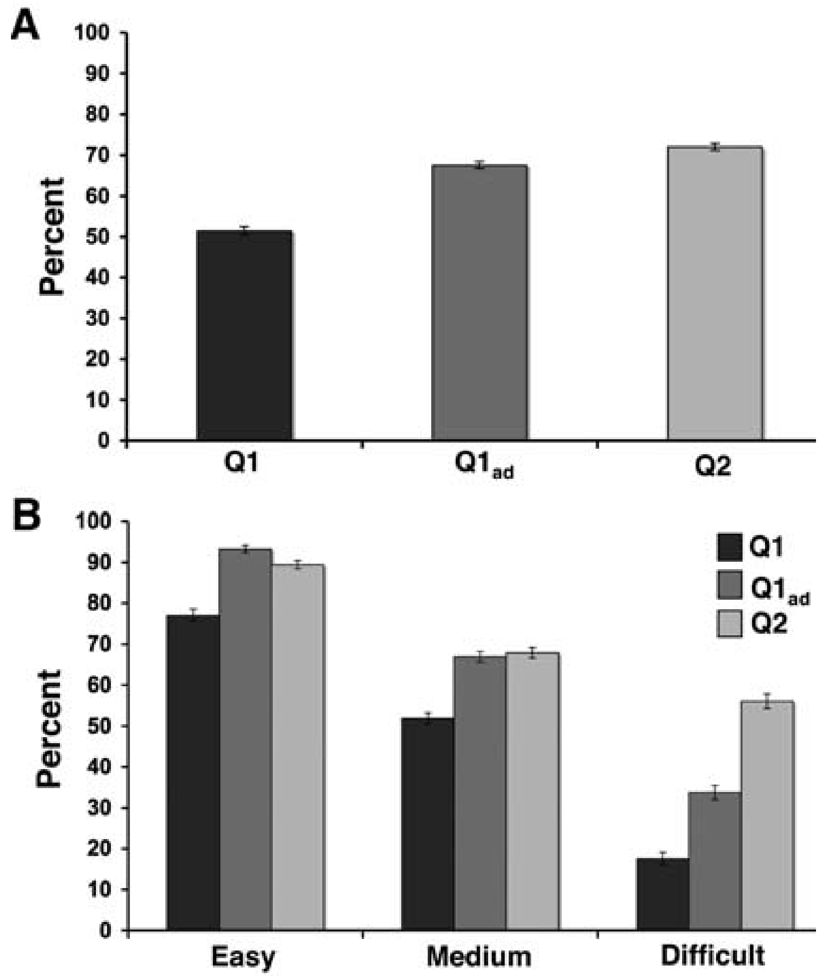
Smith, M. et al. Why Peer Discussion Improves Student Performance on In-Class Concept Questions. Science, 2009 January, 2. Vol. 323

Does active engagement of students during discussion with peers, some of whom know the correct answer, lead to increased conceptual understanding?

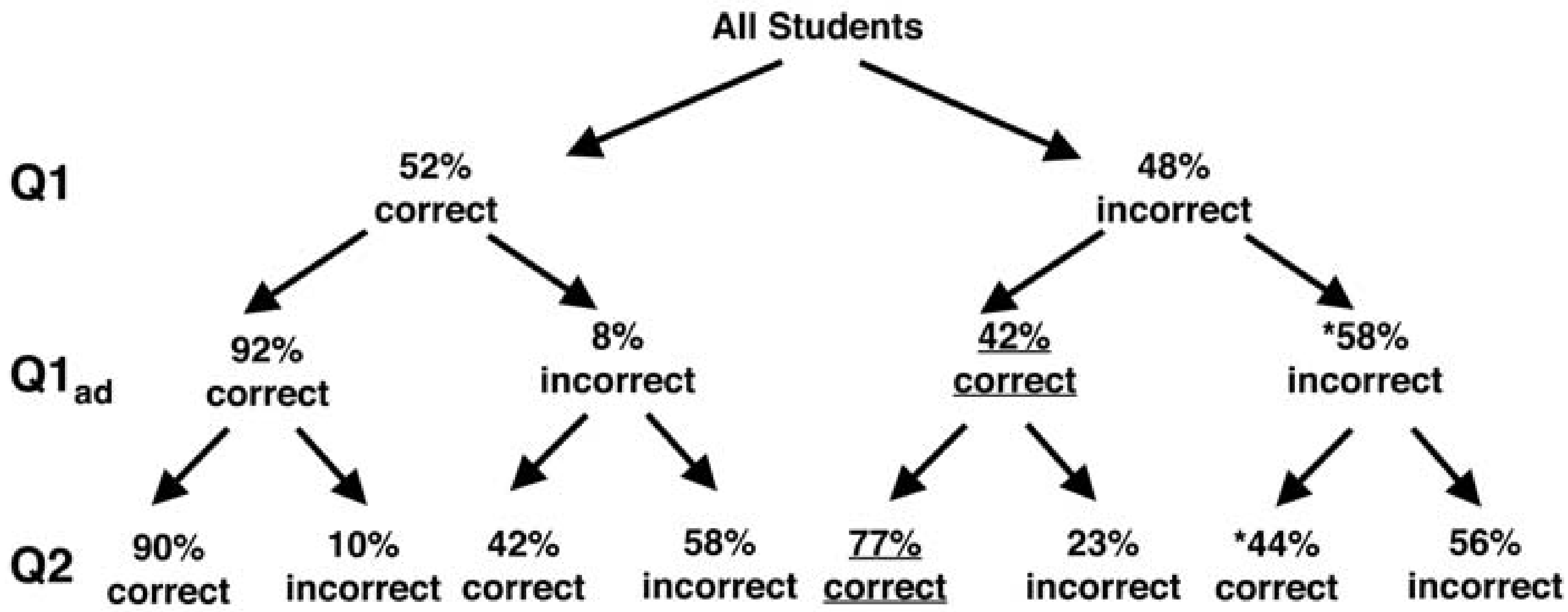
OR

Do students not in fact learn from the discussion, but simply choose the answer most strongly supported by neighbors they perceive to be knowledgeable?

Smith, M. et al. Why Peer Discussion Improves Student Performance on In-Class Concept Questions. Science, 2009 January, 2. Vol. 323



Smith, M. et al. Why Peer Discussion Improves Student Performance on In-Class Concept Questions. Science, 2009 January, 2. Vol. 323

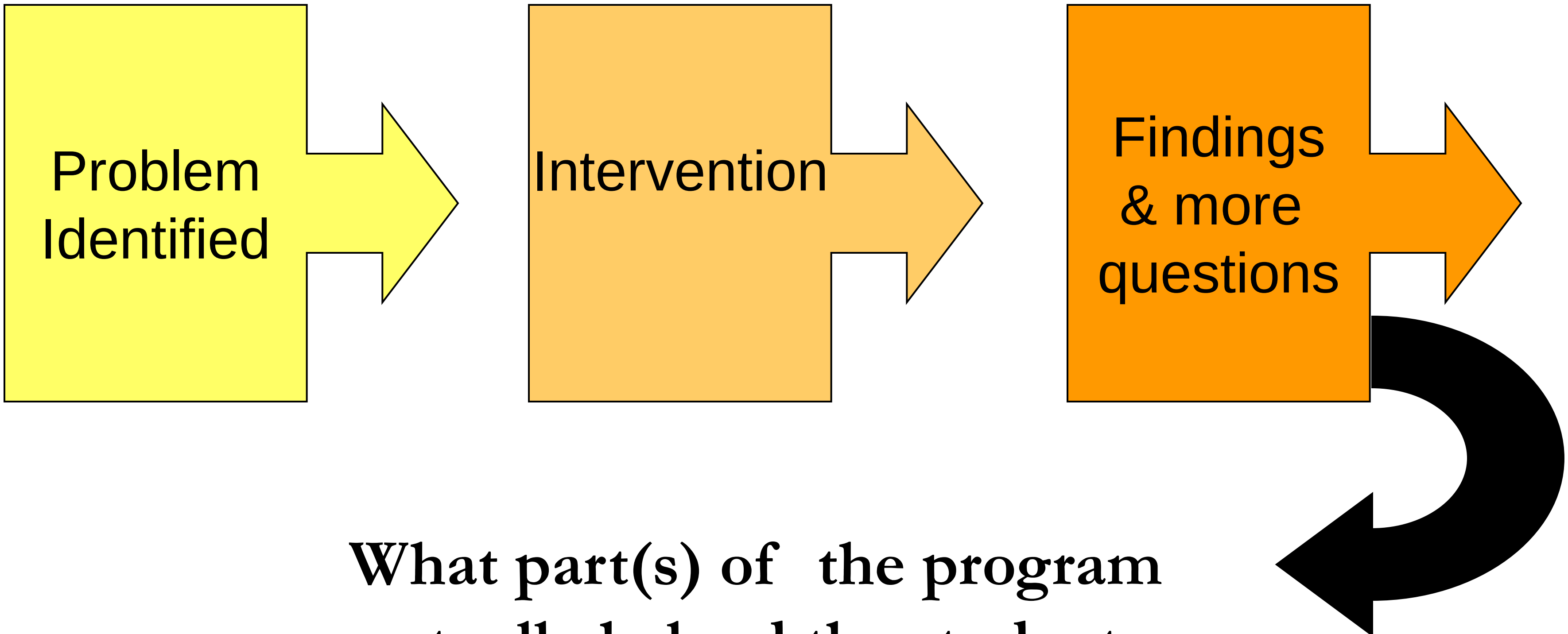


Smith, M. et al. Why Peer Discussion Improves Student Performance on In-Class Concept Questions. Science, 2009 January, 2. Vol. 323

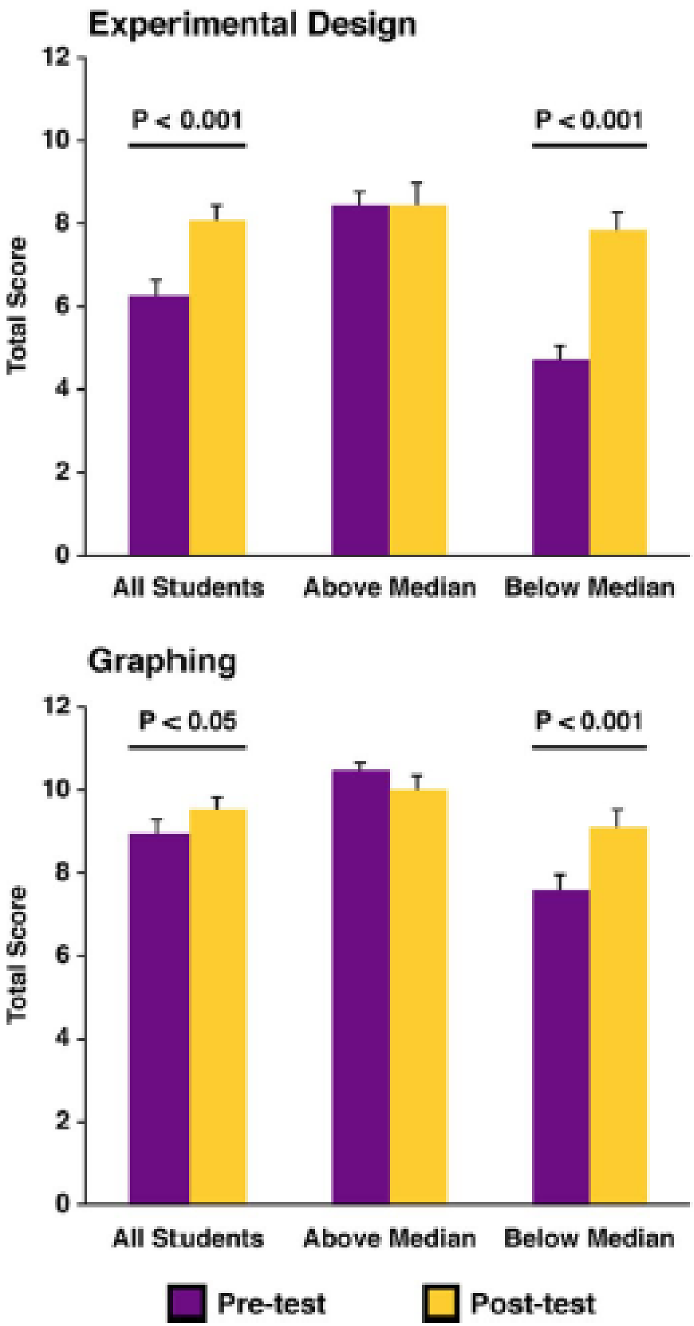
"Our results indicate that peer discussion enhances understanding, even when none of the students in a discussion group originally knows the correct answer."

This study provides support for peer discussion, but more importantly it provides guidance for how faculty should deliver clicker questions!

In the previous workshop I discussed my path to DBER



What part(s) of the program actually helped the students in the Biology Fellows Program?



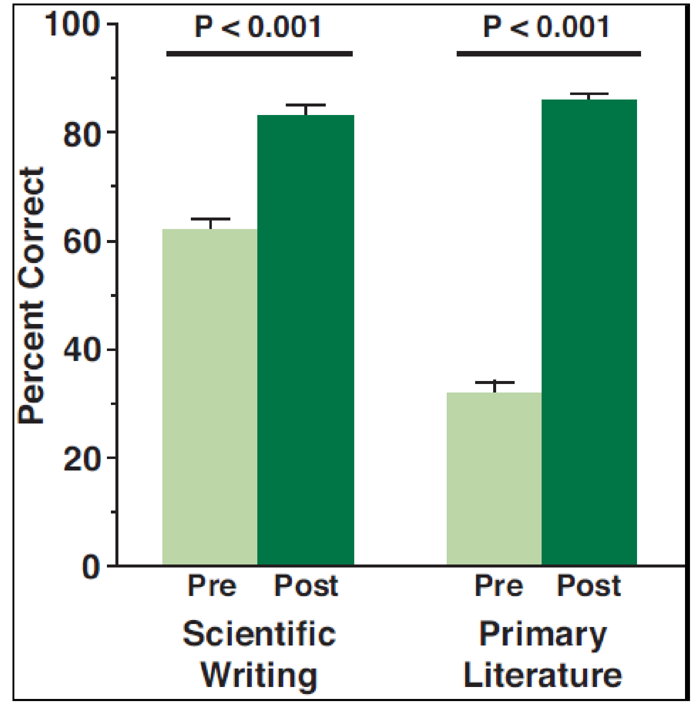
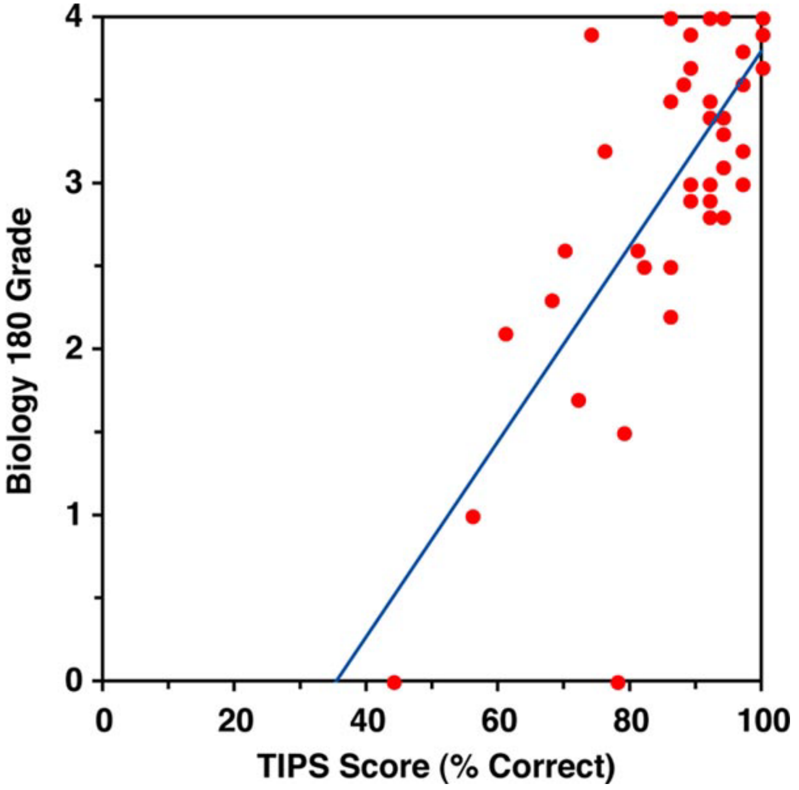
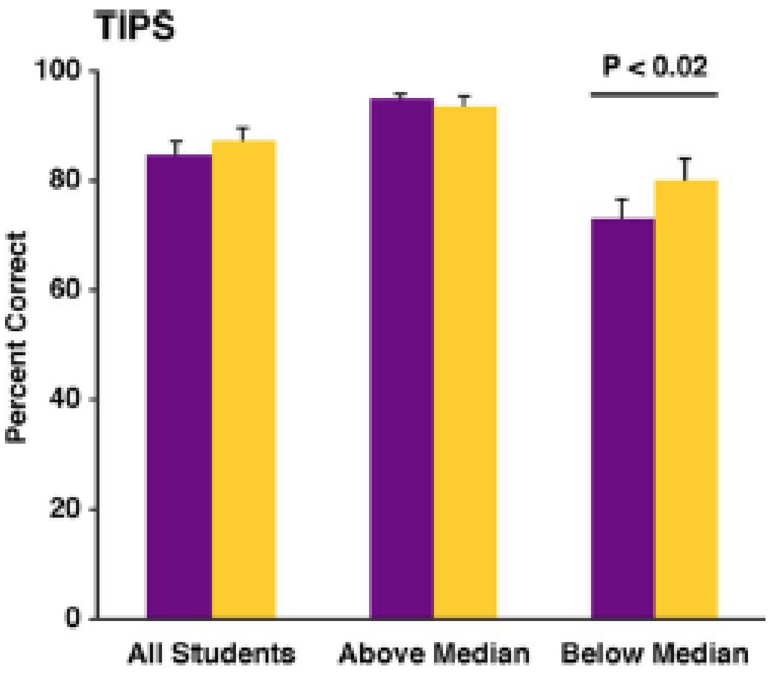


Figure 3. Student Assessment Results. Percent of total points received during either a pre-test (light green bars) or a post-test (dark green bars) on scientific writing (left, N = 44) or primary literature (right, N = 42) for 2006 BFP students.

Test of Integrated Process Skills (TIPS). TIPS was developed first by Dillashaw and Okey (1980) and was designed for high school students





ACK! I needed a better instrument!
I also needed to better understand the problem.

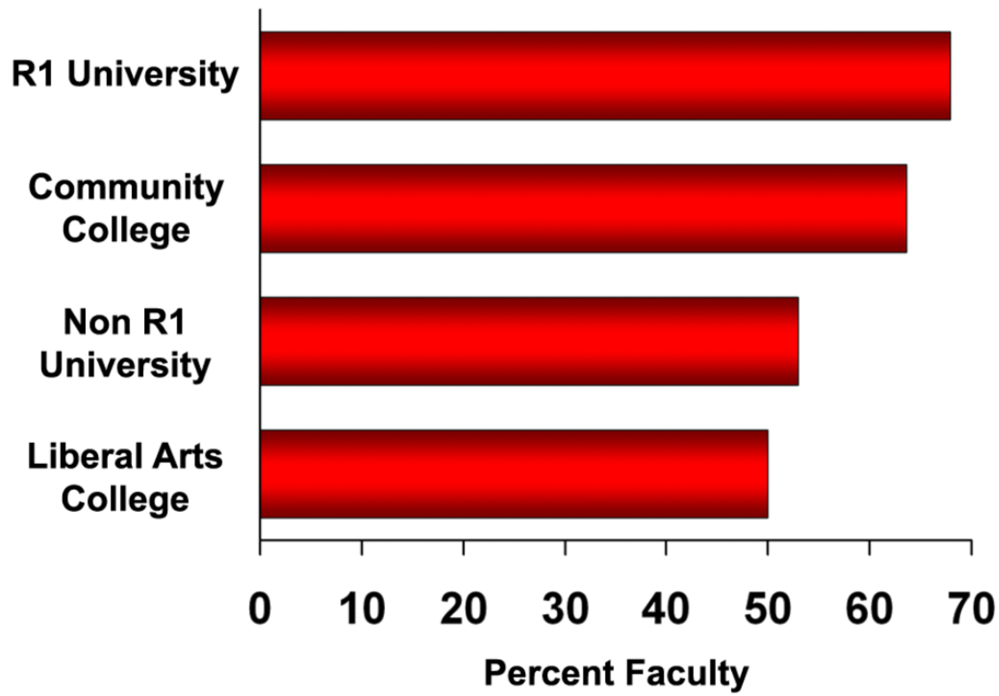


Figure 1. Percent faculty (N=156) at different institutions who felt that the amount of time they spent teaching science process skills was <u>NOT</u> sufficient.

Table 1. Faculty Survey of Undergraduate Acquisition of Science Process Skills	
Science Process Skills	**Average Score of Importance***
Problem solving/Critical thinking	**4.9**
Interpreting data: graphs and tables	**4.9**
Interpreting data: ability to construct an argument from data	**4.8**
Creating the appropriate graph from data	**4.7**
Communicating results: Written	**4.7**
Ability to create a testable hypothesis	**4.7**
Ability to design an experiment: identifying and controlling variables	**4.6**
Ability to design an experiment: development of proper controls	**4.6**
Communicating results: Oral	**4.6**
Knowing when to ask for guidance	**4.6**
Conducting an effective literature search	**4.6**
Reading and evaluating primary literature	**4.5**
Ability to design an experiment: proper alignment of experiment and hypothesis	**4.5**
Understanding basic statistics	**4.5**

Working independently when needed	**4.5**
Working collaboratively to accomplish a task	**4.4**
Being able to infer plausible reasons for failed experiments	**4.4**
Being able to effectively monitor their own learning progress	**4.3**
Creating a bibliography and proper citation of references	**4.2**
Interpreting data: gels, blots, microarrays, etc.	**4.0**
Being an effective peer mentor	**3.6**
Ability to use basic online bioinformatics tools (NCBI databases, BLAST, etc.)	**3.5**
***The average score of importance was determined by converting a verbal Likert scale to a numerical scale (5 = Very Important, 4 = Important, 3 = Moderately Important, 2 = Of Little Importance, 1 = Unimportant), and taking the average.**	

Science Process And Reasoning Skills Test
SPARST

C. Dirks and M.P. Wenderoth

THANK YOU!!!

Instrument Design at 3:00 PM