Using research-based assessment to improve teaching in your classroom and department:

New resources on PhysPort.org

Sarah B. McKagan
Adrian Madsen
Eleanor C. Sayre
What is PhysPort?
A web resource to support physics professors in using research-based teaching and assessment in their classes

www.physport.org
Motivation

• Physics education researchers have created research results, teaching methods, curricula, and assessments that can dramatically improve physics education.
• Most people who teach physics don’t know about these resources.
• There is a need for a “one-stop shopping” place to find resources for research-based teaching.
The PhysPort Team

Sam McKagan (PI)
Adrian Madsen (co-PI)
Lyle Barbato (development lead)
Matt Riggsbee (visual design)
Brian Danielak (postdoc)

Ellie Sayre (PI)
Bill Hsu (development lead)
Eugene Vasserman (security lead)

Sandy Martinuk (user experience design lead)
Alex Bell (user experience design assistant)
Now available:

• Resources for research-based teaching

• **Resources for research-based assessment**

• Video workshops for LAs, TAs, & faculty:
  • Periscope (this morning): physport.org/periscope
  • Virtual New Faculty Workshop: physport.org/nfw

Coming in Fall 2015:

• Redesign and expansion of teaching methods

• **Assessment Data Explorer**

• Expert Recommendations
Interviewed 24 physics faculty and department chairs about their teaching and assessment (to discover goals, motivations, needs, pain points etc.)
Research and Development Process

Faculty and Department Chair Interviews → Personas of Users → Site that meets real users’ needs

Personas combine characteristics of many different people to represent a coherent set of user needs.
Research and Development Process

Faculty and Department Chair Interviews ➔ Personas of Users ➔ Site that meets real users’ needs

- Paula the Skeptic
- Raphael the Motivated Novice
- Diane the Pragmatic Satisficer
- Tim the Seeker
- Marge the Proto-researcher
Key Personas

Raphael the Motivated Novice

• New to research-based teaching
• Cares about his students’ learning, eager to try new methods
• Needs simple instructions and basic guidance

Diane the Pragmatic Satisficer

• Some experience with research-based teaching
• Wants to use evidence to demonstrate student learning.
• Wants to know what works, how to use it, and what to do if she has trouble.

Tim the Seeker

• Extensive experience with research-based teaching
• Wants to go beyond the basics and address less well-defined aspects of learning, such as problem solving, reasoning skills, and attitudes
Other personas (not used for site design)

Paula the Skeptic

• Not convinced that research-based teaching is effective
• Relies on intuition and experience to guide her teaching

Isn’t going to use our site
(she’ll learn from her colleagues who use the site)

Marge the Proto-researcher

• Extensive experience using and even creating research-based materials and strategies
• Knows where to find most resources she needs

Doesn’t really need our site
Research and Development Process

Faculty and Department Chair Interviews → Personas of Users → Site that meets real users’ needs

Examples from site:

- **Home page**
- Assessment resources
- Assessment data explorer
Start with biggest needs of users

<table>
<thead>
<tr>
<th>Teaching Methods</th>
<th>Assessment</th>
<th>Troubleshooting</th>
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<tbody>
<tr>
<td><strong>I want to...</strong></td>
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<td><strong>I need help with...</strong></td>
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<td>• assess advanced physics content or skills</td>
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Welcome to PhysPort (formerly known as the PER User's Guide), the go-to place for physics faculty to find resources based on physics education research (PER) to support your teaching. Learn more...

Teaching
I want to...
- find a new teaching method
- find questions for my class
- get implementation help
- learn about pros and cons of PER-based teaching
read more on teaching >

Assessment
I want to...
- interpret assessment results
- assess the impact of reforms
- assess for accreditation
- assess advanced physics content or skills
read more on assessment >

Troubleshooting
I need help with...
- covering enough material
- supporting group work
- arguments for skeptical colleagues
- arguments for skeptical students
read more on troubleshooting >

Top ten results of physics education research that every physics instructor should know
by Sarah B. McKagan, Adrian Madsen, and Eleanor C. Sayre

February 1, 2014

The field of physics education research (PER) is widely recognized as a leader in discipline-based science education research. Over the last four decades, researchers in PER have come to understand how students think about physics and have developed teaching methods that vastly improve student learning of physics. This article summarizes the results of PER that are more important for practicing physics educators to know and apply in their classrooms. We explain each result in enough detail that readers can easily understand why we believe each result to be true, and offer...
Research and Development Process

Faculty and Department Chair Interviews ➔ Personas of Users ➔ Site that meets real users’ needs

Examples from site:
• Home page
• Assessment resources
• Assessment data explorer
How do we do assessment in physics?

Physics classes:
• Exams
• Homework
• Teaching evaluations
• Assessment surveys

Physics departments:
• Drop-withdraw-fail rates
• Student retention
• Observations
• Assessment surveys

Focus on research-based assessment surveys
What are Research-based Assessment Instruments?

Force Concept Inventory (FCI)
Force Motion Conceptual Evaluation (FMCE)
and 50+ more

These are:
• Generally multiple-choice surveys
• Carefully crafted questions
• Conceptual topics across the physics curriculum
• Additionally: beliefs, problem-solving skills, affect
Find an Assessment

- Which research-based assessment should I use?
- Where do I get the assessment?
- How can I assess non-content skills?
Browse Assessments

Tell us about your course to find assessments relevant to you.

Any Subject  Any Level  Any Setting  Save Course  reset

Assessment Focus
- Content knowledge
- Problem-solving
- Scientific Reasoning
- Lab skills
- Beliefs / Attitudes
- Interactive Teaching

Format
- Multiple-choice
- Multiple-response
- Short answer
- Pre / Post
- Agree / Disagree
- Observational Protocol

Research Validation
- Gold Star Validation
- Validated Level 2
- Validated Level 1
- Research-Based

Content

**Force Concept Inventory (FCI)**
Mechanics Content Knowledge (Kinematics, Forces)
Introductory College
Multiple-choice, Pre/post

**Representational Variant of the Force Concept Inventory (R-FCI)**
Mechanics Content Knowledge (Kinematics, Forces)
Introductory College
Multiple-choice, Pre/post

**Test of Understanding Graphs in Kinematics (TUG-K)**
Mechanics Content Knowledge (Kinematics, Graphing)
Introductory College
Multiple-choice, Pre/post

Beliefs / Attitudes

**Colorado Learning Attitudes about Science Survey (CLASS)**

Beliefs / Attitudes
Learn about the Assessment

- Which assessment should I use?
- Where do I get the assessment?
- How should I administer the assessment?
- How can I assess non-content skills?
Force Concept Inventory (FCI)

developed by David Hestenes, Malcolm Wells, and Gregg Swackhamer
http://modelinginstruction.org/researchers/evaluation-instruments/

Duration
30 minutes

Focus
Mechanics Content Knowledge (Kinematics, Forces)

Level
Introductory

Typical Results

Fraction of Courses
0.08 0.16 0.24 0.32 0.4 0.48 0.56 0.64 0.72

Related Expert Recommendations

Best practices for administering concept inventories

Should I use the FCI or the FMCE?

Why use research-based assessment?

Related Assessments

Mechanics Baseline Test (MBT)

Force and Motion Conceptual Evaluation (FMCE)

Related Teaching Methods

Modeling Instruction
Instruction organized around active student construction of conceptual and mathematical models in an interactive learning community

Research Validation

Gold Star Validation
This is the highest level of research validation. This indicates that the assessment instrument has been thoroughly validated and researched.

Research Validation Summary

Based on Research Into:
☑ Student thinking

Research Conducted
☑ At multiple institutions
☑ By multiple research groups

Examples Resources Research Translations Variations

and even guides to running your own workshop
Example Question 1

A book is at rest on a table top. Which of the following force(s) is(are) acting on the book?

1. A downward force due to gravity
2. The upward force by the table
3. A net downward force due to air pressure
4. A net upward force due to air pressure

(A) 1 only
(B) 1 and 2
(C) 1, 2, and 3
(D) 1, 2, and 4
(E) none of these, since the book is at rest there are no forces acting on it.
FCI Implementation and Troubleshooting Guide

This guide covers all the information teachers would need to implement this assessment in their course. It also includes troubleshooting information and links to additional resources.
Visualize and Analyze Your Assessment Data

Force Concept Inventory

Your Data
- FCI - Physics 100 Fall 2010

Comparison Data
- Students Like Yours
- National

Percent of Students

Normalized Gain

31
Visualize and Analyze Your Assessment Data

- Your identity is protected
- Your students’ identities are protected
- We use one-way, cryptographically-secure transformations
- We report on aggregate data
Visualize and Analyze Your Assessment Data

**Secure**
We use the same security measures used by banks and financial institutions so you can have the utmost confidence that your data is safe.

**Powerful**
With one click, you get a comprehensive analysis of your results, allowing you to compare your data with classes and teachers in similar institutions nationwide.

**Easy**
Our guided process makes it easy to upload your data, and our visualization engine is tailored to assessments, making charting a snap.
Visualize and Analyze Your Results

- How did I do on this assessment?
- How do my assessment results compare to other students like mine?
Visualize and Analyze Your Results

Summary

0.3
Average Gain

Your students' average normalized gain of 0.3 is similar to the national average but statistically lower than "students like mine". This means that students at similar institutions in similar course have higher gains than your students.

Courses taught using interactive engagement techniques have gains in the range from .18 to .66 with an average of .46. Your normalized gain is in the lower end of this range.

Recommendations

Large courses like yours that are taught using interactive engagement techniques tend to have higher normalized gains. The key to these methods is getting students actively engaged in constructing their own understanding and not just passively listening.

This can be accomplished in many ways. Popular methods that you could try include: Peer Instruction, Peer Simulations, interactive Lecture Demos and Just In Time Teaching.
Your Results Over Time

- How do my results change over time?

Diane the Pragmatic Satisficer
Your Results Over Time

Force Concept Inventory

Score

Fall 2010  Fall 2011  Fall 2012
Your Results Over Time

- **Your Data**
  - FCI - Physics 100 Fall 2010
  - FCI - Physics 100 Fall 2011
  - FCI - Physics 100 Fall 2012

- **Comparison Data**
  - Students Like Yours
  - National Median

- **Histogram For Your Class**
- **Your Course Over Time**
- **Breakdown By Question**
- **Compare Multiple Courses**

**Force Concept Inventory**

- **Effect Size**
- Fall 2010
- Fall 2011
- Fall 2012
Question-by-Question Breakdown

• How do my results break down on a question-by-question basis?
• How do I use these results to make improvements in my class and department?
Question-by-Question Breakdown

Histogram For Your Class

Your Course Over Time

Breakdown By Question

Compare Multiple Courses

Force Concept Inventory

Your Data

Split

FCI - Physics 100 Fall 2010

Comparison Data

☑ Students Like Yours

☑ National Median

Percent of Students

0 20% 40% 60% 100%

Q1  Q2  Q3  Q4  Q5  Q6

By Question ▼
Question 2

A book is at rest on a table top. Which of the following force(s) is(are) acting on the book?

1. A downward force due to gravity
2. The upward force by the table
3. A net downward force due to air pressure
4. A net upward force due to air pressure

(A) 1 only 10%
(B) 1 and 2 15%
(C) 1, 2, and 3 40%
(D) 1, 2, and 4 30%
(E) none of these, since the book is at rest 5%

there are no forces acting on it.
Question-by-Question Breakdown
Compare Multiple Courses

- How do the results in my department vary across different courses and instructors?
- Is there a gender gap on these assessments in my class?
Compare Multiple Courses

Histogram For Your Class  |  Your Course Over Time  |  Breakdown By Question

Compare Multiple Courses

Your Data

- FCI - Physics 100 Fall 2010
- FCI - Physics 100 Fall 2011
- FCI - Physics 100 Fall 2012
- FCI - Physics 101 Fall 2010
- FCI - Physics 101 Fall 2011
- FCI - Physics 101 Fall 2012

Force Concept Inventory

Effect Size

0 0.1 0.2 0.3 0.4

Physics 100 Fall 2010  |  Physics 100 Fall 2011  |  Physics 100 Fall 2012  |  Physics 101 Fall 2010  |  Physics 101 Fall 2011  |  Physics 101 Fall 2012

Comparison Data

- Students Like Yours
- National Average
Compare Multiple Courses

Your Data

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Comparison Data

- Students Like Yours
- National Average

Force Concept Inventory

Histogram For Your Class | Your Course Over Time | Breakdown By Question | Compare Multiple Courses

- Instructor A
- Instructor B

Effect Size

0.4
0.3
0.2
0.1
0.0

Instructor A
Instructor B
Compare Multiple Courses

Histogram For Your Class  Your Course Over Time  Breakdown By Question  Compare Multiple Courses

Your Data

- FCI - Physics 100 Fall 2010
- FCI - Physics 100 Fall 2011
- FCI - Physics 100 Fall 2012
- FCI - Physics 101 Fall 2010
- FCI - Physics 101 Fall 2011
- FCI - Physics 101 Fall 2012

Add Post Data

Comparison Data

- Students Like Yours
- National Average

Force Concept Inventory

Effect Size

0.4
0.3
0.2
0.1
0.0

Instructor A - Male  Instructor A - Female  Instructor B - Male  Instructor B - Female
Upload Assessment Results

- When will I find the time to analyze my data?
Upload Assessment Results

Upload your data file

Add metadata to tell us what's in your file

Review and confirm your import

Visualize the results
Physics 101.XML: fall2013 section 2

School

Instructor

Course

Class

Assessment

University of Central Flatland

Dr. Username

Create a new course

Create a new Class

Add an Assessment
Add Metadata

Course Details

Required to visualize your class data

- Course Name (e.g. Physics for Engineers)
- Short Name (e.g. phys123)
- Course Level
- Subject

Analyze and Compare Data with Others Nationwide

- Prerequisite Courses
- Prerequisite Math

Status: Incomplete

OK   Cancel
Add Metadata

Physics 101.xml: fall2013 section 2

- School: University of Central Flatland
- Instructor: Dr. Username
- Course: Phys 100
- Class: Create a new Class
- Assessment: Add an Assessment
Term class was taught: Fall 2014

Course Length: 12 weeks

Section Number: 

Minutes Per Week: 

Average student rating for class: 

In-class activities

Think about a typical day in this class. Which of the following activities do your students engage in for a substantial amount of time?

- Talking to or working with each other in small groups
- Working individually
- Listening to (or taking notes during) lecture
- Presenting to the whole class
- Engaging in whole-class discussion
- Other: 

Out-of-class activities

Which of the following activities are students supposed to spend a substantial amount of time on outside of class?

- Homework problems
- Write up lab reports
- Watch video lectures
- Read textbook; Which one? 
- Investigate simulations
- Work with other students
- Projects
- Other: 

Physics 101.xml: fall2013 section 2

School
University of Central Flatland

Instructor
Dr. Username

Course
Phys 100

Class
Spring 2013

Assessment
FCI Pre and Post
Confirm Auto Guesses in Your File

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**Assessment Data**
- FCI Pre Question 1
- FCI Pre Score
- FCI Pre Other

**Student Data**
- Course Grade
- GPA
- Major
- Gender
- Ethnicity
- SAT score
- ACT score
- Highest level of math
- High School Physics?
- Class Standing
- Expected Graduation Yr.
- TOEFL score

*Do not import*
## Confirm Auto Guesses in Your File

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Add Metadata
Tell us about the file you uploaded

Physics 101.xml: fall2013 section 2

School: University of Central Flatland
Instructor: Dr. Username
Course: Phys 100
Class: Spring 2013
Assessment: FCI Pre and Post

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Done
FCI Results
Dr. Username, University of Central Flatland
Physics 100, Fall 2013

Summary

Your students’ average normalized gain of 0.3 is similar to the national average but statistically lower than “students like mine”. This means that students at similar institutions in similar course have higher gains than your students.

Courses taught using interactive engagement techniques have gains in the range from .18 to .66 with an average of .48. Your normalized gain is in the lower end of this range.

Recommendations

Large courses like yours that are taught using interactive engagement techniques tend to have higher normalized gains. The key to these methods is getting students actively engaged in constructing their own understanding and not just passively listening.

This can be accomplished in many ways. Popular methods that you could try include: First Instruction, Pre Instruction, Simulations, Interactive Lecture Demos and Just In Time Teaching.
Homework

Due before Digital Libraries session
(Wed morning)

• Go to physport.org
• Get verified as an educator:
  • Try to access Periscope: physport.org/periscope
    OR
  • Try to download an assessment: physport.org/assessments

Instantaneous for AAPT members,
may take a while otherwise.
PhysPort site content

**Now available:**

- Resources for research-based teaching
- Resources for research-based assessment
- Video workshops for LAs, TAs, & faculty:
  - Periscope (this morning): [physport.org/periscope](http://physport.org/periscope)
  - Virtual New Faculty Workshop: [physport.org/nfw](http://physport.org/nfw)

**Coming in Fall 2015:**

- Redesign and expansion of teaching methods
- Assessment Data Explorer
- Expert Recommendations
PhysPort site content

**Long-term goals** (not yet funded):

- One-stop shopping
- Community-based database of open-source research-based curricula
- Customized advice: how to interpret your assessment results and/or improve your teaching
- Research on how teaching methods relate to learning gains
Fall 2015: Beta Testing for Assessment Data Explorer

Sign up to be a beta-tester if you have assessment data for: FCI, FMCE, BEMA, CSEM, CLASS, MPEX

Email us to learn more: smckagan@aapt.org

www.physport.org