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 methods
- **Resources for research-based assessment**
- Video workshops for LAs, TAs, & faculty

PhysPort site content
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

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

Teaching Methods
I want to...
- find a new teaching method
- get implementation help
- learn more about research-based teaching

Assessment
I want to...
- interpret assessment results
- assess the impact of reforms
- assess advanced physics content or skills

Troubleshooting
I need help with...
- covering enough material
- supporting group work
- arguments for skeptical colleagues
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?
**Content**

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

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

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

**Beliefs / Attitudes**

**Colorado Learning Attitudes about Science Survey (CLASS)**
- Beliefs / Attitudes
- All levels
Find an Assessment

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

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

**Research Validation**
- Any
- ▪ Gold Star Validation
  - Validated Level 2
  - Validated Level 1
  - Research-Based

**CI)**
- s, Forces)
  - 30 minutes

**the Force**
- s, Forces)
  - 30 minutes

**hs in**
- s, Graphing)
  - 30 minutes

: about
Find an Assessment

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

Any Subject

Any Level

Any Setting

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
30 minutes

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

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

Beliefs / Attitudes

Colorado Learning Attitudes about Science Survey (CLASS)
Browse Assessments

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

Any Subject ▼  Any Level ▼  Any Setting ▼  Save Course

Assessment Focus
Any

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

Content

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

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

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

Beliefs / Attitudes

- **Colorado Learning Attitudes about Science Survey (CLASS)**
Learn about the Assessment

- Raphael the Motivated Novice
- Diane the Pragmatic Satisficer
- Tim the Seeker

- 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/

- **Format**: Multiple-choice, Pre/post
- **Duration**: 30 minutes
- **Focus**: Mechanics Content Knowledge (Kinematics, Forces)
- **Level**: Introductory

Typical Results

![Histogram of Fraction of Courses](chart.png)
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.
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.
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
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.
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

Studied Using:
- Student interviews
- Expert review

Research Conducted
- At multiple institutions
- By multiple research groups

Statistical analysis
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

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

and even guides to running your own workshop
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

Transformations:
- We report on aggregate data
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

Your Data
- FCI - Physics 100 Fall 2010

Comparison Data
- Students Like Yours
- National

By
- Compare
  Multiple Courses

Normalized Gain
-
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: Peer Instruction, Phet Simulations, Interactive Lecture Demos and Just In Time Teaching.
Your Results Over Time

- How do my results change over time?
Your Results Over Time

Force Concept Inventory

Effect Size

Fall 2010  Fall 2011  Fall 2012

Comparison Data

- Students Like Yours
- National Median
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 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

Force Concept Inventory

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

Your Data
- Split
- FCI - Physics 100 Fall 2010

Comparison Data
- Students Like Yours
- National Median

Percent of Students
- 100%
- 60%
- 40%
- 20%
- 0%

By Question
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

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

Comparison Data

- Students Like Yours
- National Average
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

Comparison Data

- Students Like Yours
- National Average

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

Force Concept Inventory

Effect Size

Instructor A  |  Instructor B
Compare Multiple Courses

Force Concept Inventory

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

Compare Multiple Courses

Your Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Split</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCI - Physics 100 Fall 2010 Add Post Data</td>
<td></td>
</tr>
<tr>
<td>FCI - Physics 100 Fall 2011</td>
<td></td>
</tr>
<tr>
<td>FCI - Physics 100 Fall 2012</td>
<td></td>
</tr>
<tr>
<td>FCI - Physics 101 Fall 2010</td>
<td></td>
</tr>
<tr>
<td>FCI - Physics 101 Fall 2011</td>
<td></td>
</tr>
<tr>
<td>FCI - Physics 101 Fall 2012</td>
<td></td>
</tr>
</tbody>
</table>

Comparison Data

- Students Like Yours
- National Average
Upload Assessment Results

- When will I find the time to analyze my data?
Add Metadata

Physics 101.xml: fall2013 section 2

School
University of Central Flatland

Instructor
Dr. Username

Course
Create a new course

Class
Create a new Class

Assessment
Add an Assessment
Add Metadata
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: ______ minutes
Average student rating for class: ______ out of ______

**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

<table>
<thead>
<tr>
<th>ID Number</th>
<th>Course Grade</th>
<th>Q1</th>
<th>Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td>252654</td>
<td>75</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
## Confirm Auto Guesses in Your File

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student ID</td>
<td><img src="?%E2%9C%85%C3%97" alt="TOEFL Score" /></td>
<td><img src="?%E2%9C%85%C3%97" alt="FCI Q1" /></td>
<td><img src="?%E2%9C%85%C3%97" alt="FCI Q2" /></td>
</tr>
<tr>
<td><strong>ID Number</strong></td>
<td><strong>Course Grade</strong></td>
<td><strong>Q1</strong></td>
<td><strong>Q2</strong></td>
</tr>
<tr>
<td>252654</td>
<td>75</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
Confirm Auto Guesses in Your File

<table>
<thead>
<tr>
<th>ID Number</th>
<th>Course Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>252654</td>
<td>75</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
</tr>
</tbody>
</table>

![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

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student ID</td>
<td>Course Grade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID Number</th>
<th>Course Grade</th>
<th>Q1</th>
<th>Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td>252654</td>
<td>75</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Student ID</td>
<td>Course Grade</td>
<td>FCI Q1</td>
<td></td>
</tr>
<tr>
<td>ID Number</td>
<td>Course Grade</td>
<td>Q1</td>
<td>Q2</td>
</tr>
<tr>
<td>252654</td>
<td>75</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>
Add Metadata
Tell us about the file you uploaded

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student ID</td>
<td>Course Grade</td>
<td>FCI Q1</td>
<td>FCI Q30</td>
</tr>
<tr>
<td>ID Number</td>
<td>Course Grade</td>
<td>Q1</td>
<td>Q2</td>
</tr>
<tr>
<td>252654</td>
<td>75</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>652365</td>
<td>80</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>652365</td>
<td>95</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

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 .15 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 Instruct, Pong Simulations, Interactive Lecture Demos and Just In Time Teaching.
Aug-Sept 2015: Beta Testing for Assessment Data Explorer

Sign-up sheet circulating around room.

Email us to learn more:
smckagan@aapt.org

PhysPort
Supporting physics teaching with research-based resources
(Formerly known as the PER User's Guide)

www.physport.org