The Influence of PER on Undergraduate Physics Instruction in the United States

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Outline

Focus: Introductory quantitative physics courses at 2- and 4- year colleges/universities

- Faculty knowledge about PER innovations
- Faculty use of PER innovations
- Problems communicating about PER innovations
- Personal and situational variables that correlate with knowledge and use
- Why faculty don't use more PER innovations
- Implications for Committee Charge

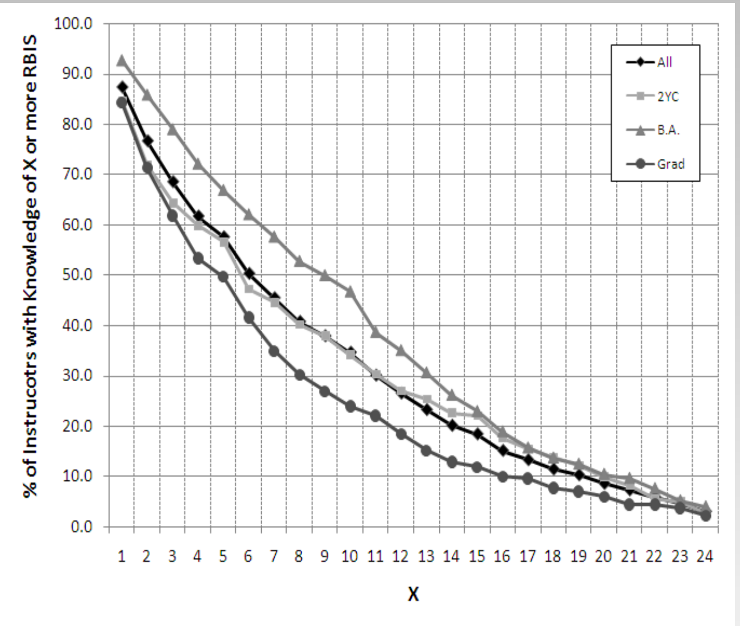
Data Collection

- Web Survey
  - Administered by AIP Statistical Research Center, Fall 2008
  - Random sample:
    - 1) two year colleges
    - 2) four year colleges with a physics B.A.
    - 3) four year colleges with a physics graduate degree
  - 722 useable responses (response rate 50.3%)
- Interviews
  - Semi-structured with N=70 web survey respondents (response rate 72%)
  - Focused on Peer Instruction and Workshop Physics
    - Knowledgeable non-users
    - Former users
    - Current users

- Henderson, C. & Dancy, M. (2009) The Impact of Physics Education Research on the Teaching of Introductory Quantitative Physics in the United States, *Physical Review Special Topics: Physics Education Research,* **5** (2), 020107.
- Dancy, M. & Henderson, C. (2010) Pedagogical Practices and Instructional Change of Physics Faculty, *American Journal of Physics, Physics*, **78** (10), 1056-1063.

Faculty Knowledge about PER

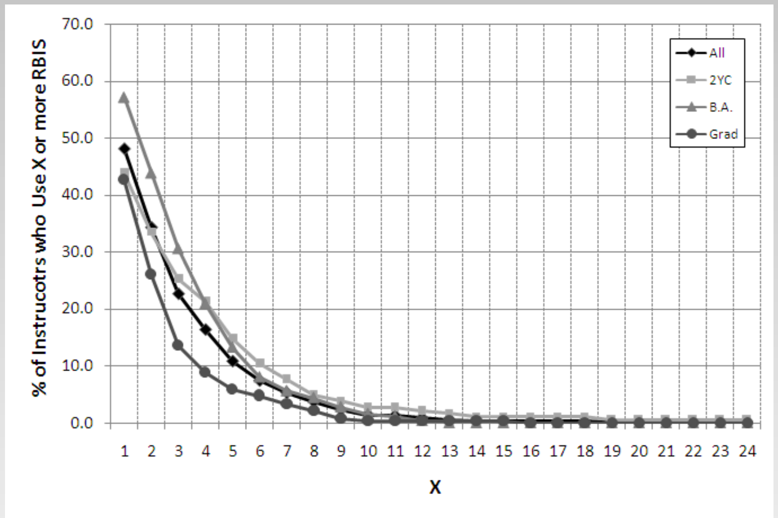
RBIS	Knowledge
Peer Instruction	63.5%
Physlets	56.3
Cooperative Group Problem Solving	49.3
Workshop Physics	48.2
Just in Time Teaching	47.7
Tutorials in Introductory Physics	47.0
Interactive Lecture Demonstrations	45.4
Activity Based Problem Tutorials	43.0
Ranking Tasks	38.7
SCALE-UP	34.5
Active Learning Problem Sheets	34.3
Modeling	32.7
Real Time Physics Labs	32.4
Context Rich Problems	30.4
Overview Case Study Physics	24.7
Open Source Physics	21.8
ISLE	21.1
TIPERS	20.9
Open Source Tutorials	20.8
Video Lab	18.8
Workbook for Introductory Physics	18.5
Experiment Problems	17.3
Socratic Dialog Inducing Labs	16.3
Thinking Problems	15.1



- 87.3% of faculty report that they know about 1 or more RBIS.
- 50.3% know about six or more.
- In general, faculty knowledge at B.A. institutions is higher than that at two year colleges or Grad institutions.

Faculty Use of PER

RBIS	Use
Peer Instruction	29.2%
Ranking Tasks	15.4
Interactive Lecture Demonstrations	13.9
Cooperative Group Problem Solving	13.7
Physlets	13.0
Just in Time Teaching	8.4
Context Rich Problems	8.3
Tutorials in Introductory Physics	7.9
Real Time Physics Labs	7.3
Workshop Physics	6.7
TIPERS	6.6
Activity Based Problem Tutorials	6.0
Active Learning Problem Sheets	5.9
Experiment Problems	4.0
SCALE-UP	3.3
Modeling	3.2
Video Lab	3.1
Open Source Physics	1.9
Socratic Dialog Inducing Labs	1.9
Overview Case Study Physics	1.7
Open Source Tutorials	1.7
ISLE	1.6
Thinking Problems	1.1
Workbook for Introductory Physics	0.9



- **48.1% of faculty say that they use 1 or more RBIS**
- **In general, faculty use at B.A. institutions is higher than that at two year colleges or Grad institutions.**

Problems Talking About PER Innovations

- Names of PER innovations mean very different things to different people
- PER innovations are commonly modified during implementation
  - Between 6% and 47%* of faculty use a PER innovation as described by the developer.
  - In many cases faculty are not aware of these differences.

* Based on Peer Instruction. Range depends on how you define and measure use of an innovation.

From Web Survey – Use of Essential Features of Peer Instruction

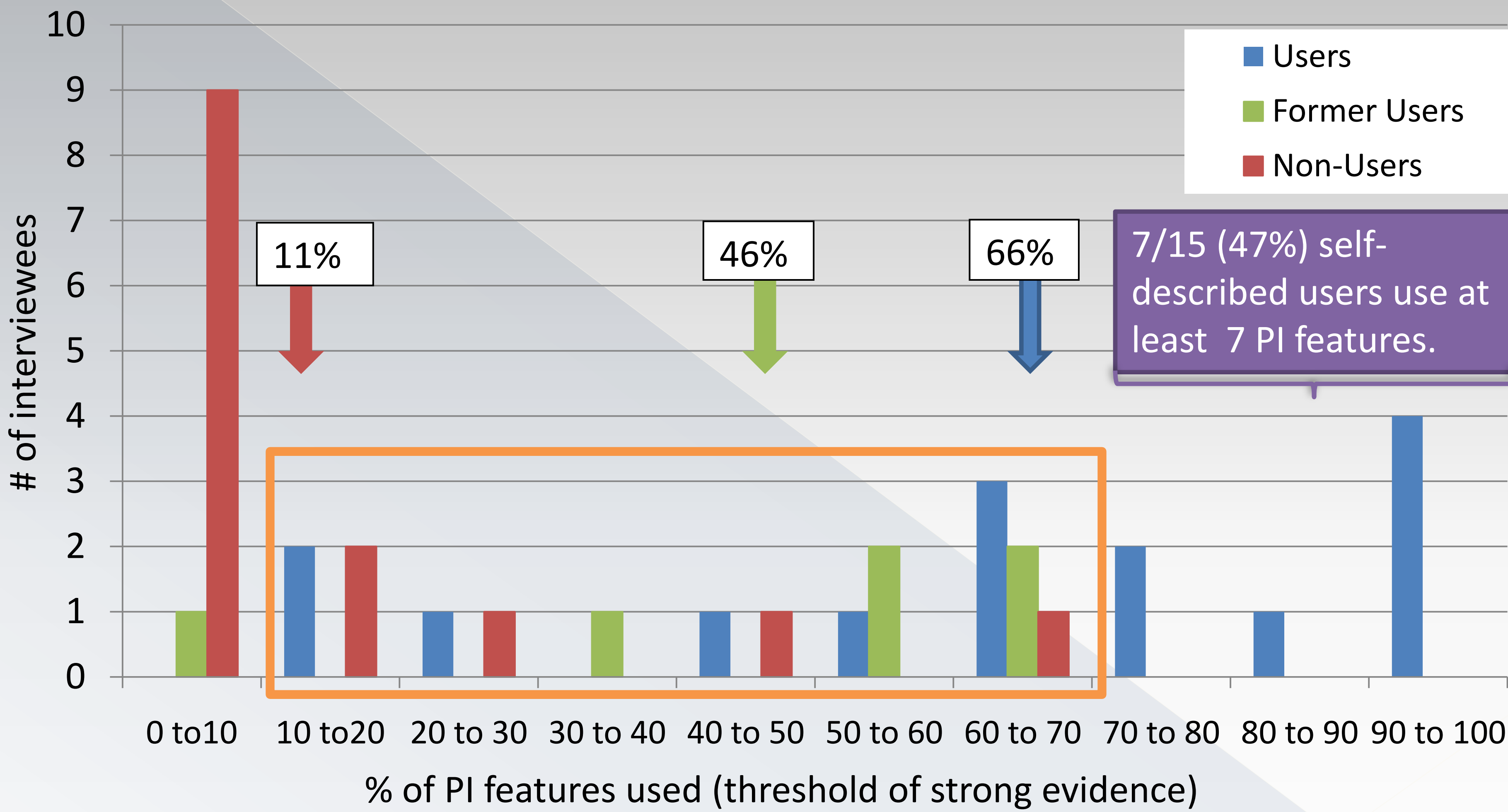
Features of Peer Instruction (measured on survey)	Self-Described Users of Peer Instruction
Traditional Lecture (for nearly every class or multiple times every class)	55%
Students discuss ideas in small groups (multiple times every class)	27%
Students solve/discuss qualitative/conceptual problem (multiple times every class)	27%
Whole class voting (multiple times every class)	38%
Conceptual questions (used on all tests)	64%

Uses all 5 components	6%
Uses 4 of the 5 components	15%
Uses 3 of the 5 components	14%

Use of 'essential features' was even lower for Cooperative Group Problem Solving.

From Telephone Interviews (N=35)

Relationship between self-described user status and Use of Peer Instruction Features



Percentage of 9 Peer Instruction features used by self-described users, former users, and knowledgeable non-users.

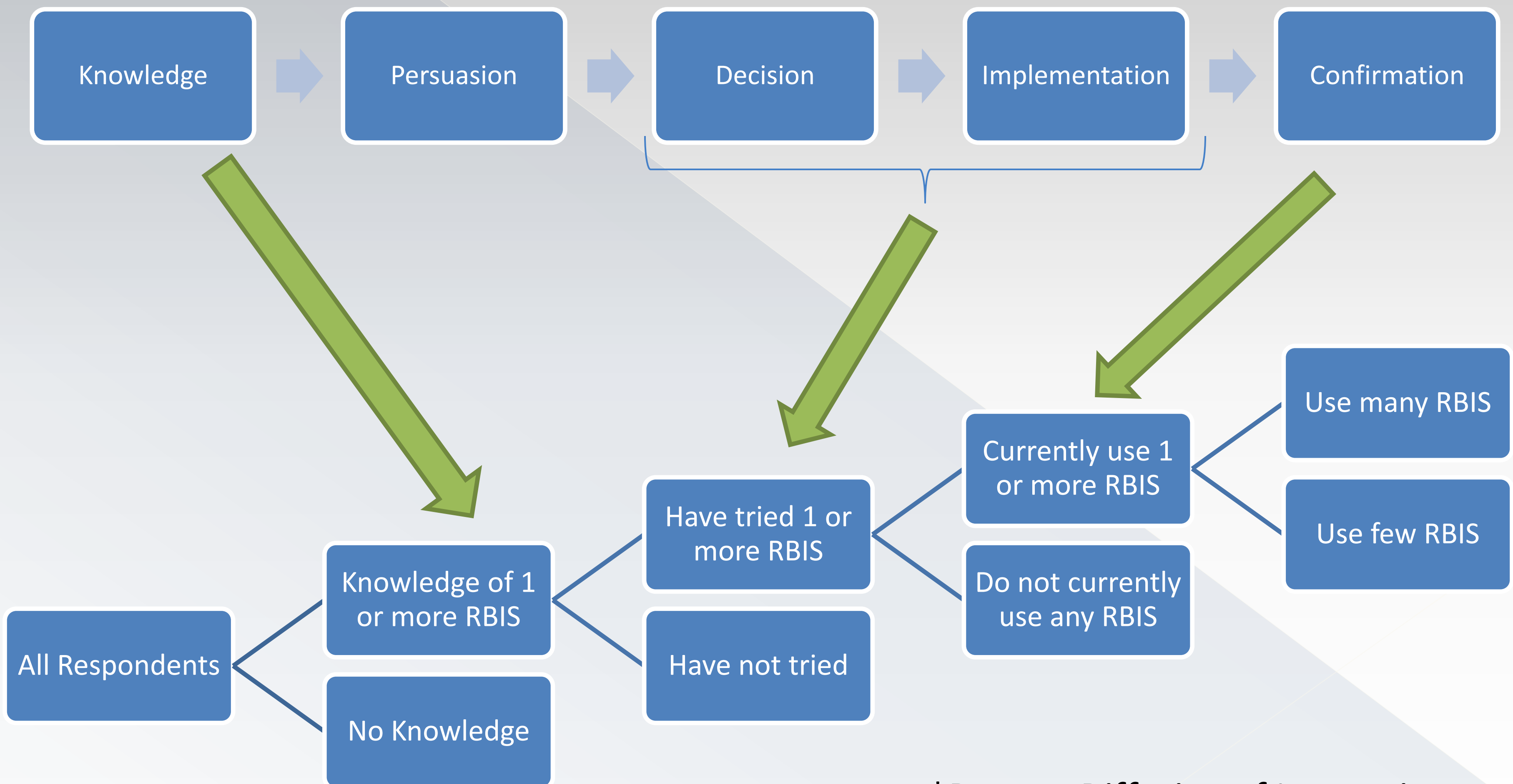
Nine Peer Instruction Features used in Analysis

Adapts: Instructor adapts to student responses to in-class tasks	
Answers not graded: Students are not graded on in-class tasks	
Commit to answer: Individual students have a dedicated time to think about in-class tasks and commit to answers independently	
Conceptual questions: Uses conceptual in-class tasks	
Tasks draw on student ideas: In-class tasks draw on common student prior ideas or common student difficulties	
Multiple choice questions: In-class tasks have discrete answer options	
Questions interspersed: In-class tasks are interspersed throughout class period	
Students discuss: Students discuss their ideas about in-class tasks with their peers	
Vote after discussion: Students commit to an answer after peer discussion	

Where do Faculty Exit

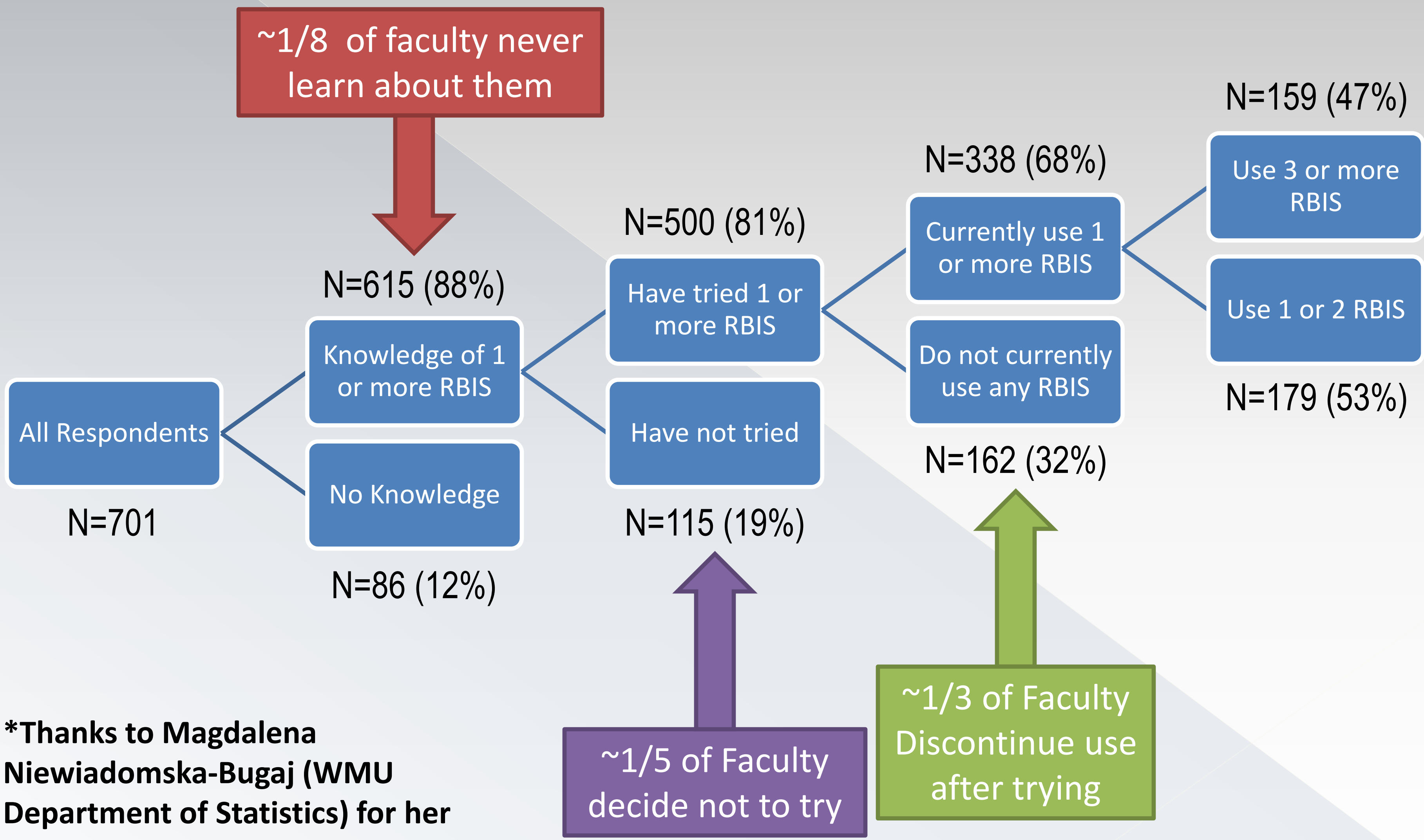
The Innovation Decision Process*

and Why



*Rogers, *Diffusion of Innovations*

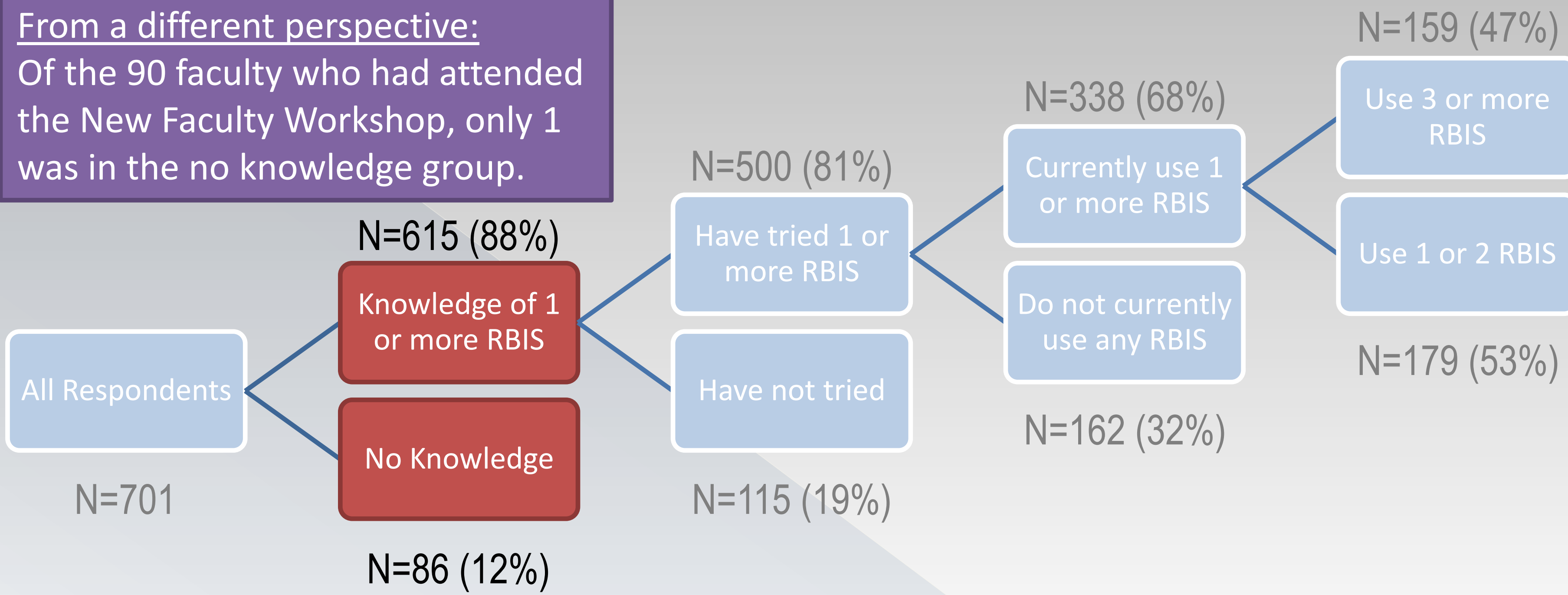
Where Are Faculty Derailed?*



***Thanks to Magdalena Niewiadomska-Bugaj (WMU Department of Statistics) for her work on this analysis.**

What Variables Correlate with Faculty Decisions?

<u>From a different perspective:</u>
Of the 90 faculty who had attended the New Faculty Workshop, only 1 was in the no knowledge group.

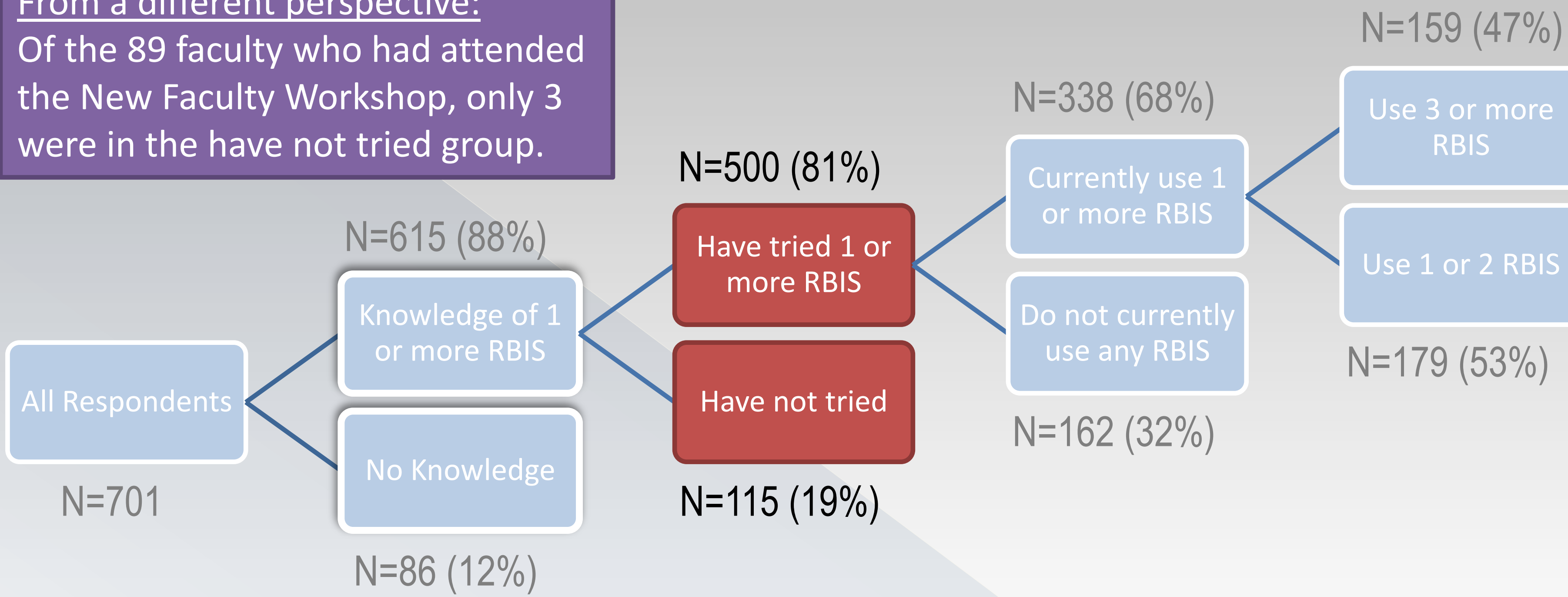


	Knowledge	No Knowledge
Attended talks/workshops related to teaching in last 2 years	75%	37%
Attended New Faculty Workshop	16%	1%
Dissatisfied with meeting instructional goals	13%	31%
Interested in using more RBIS	72%	57%
Part-time, permanent employees	2%	9%
Work at school with physics B.A.	38%	21%

*p<.05 on chi-square test.

What Variables Correlate with Faculty Decisions?

<u>From a different perspective:</u>
Of the 89 faculty who had attended the New Faculty Workshop, only 3 were in the have not tried group.

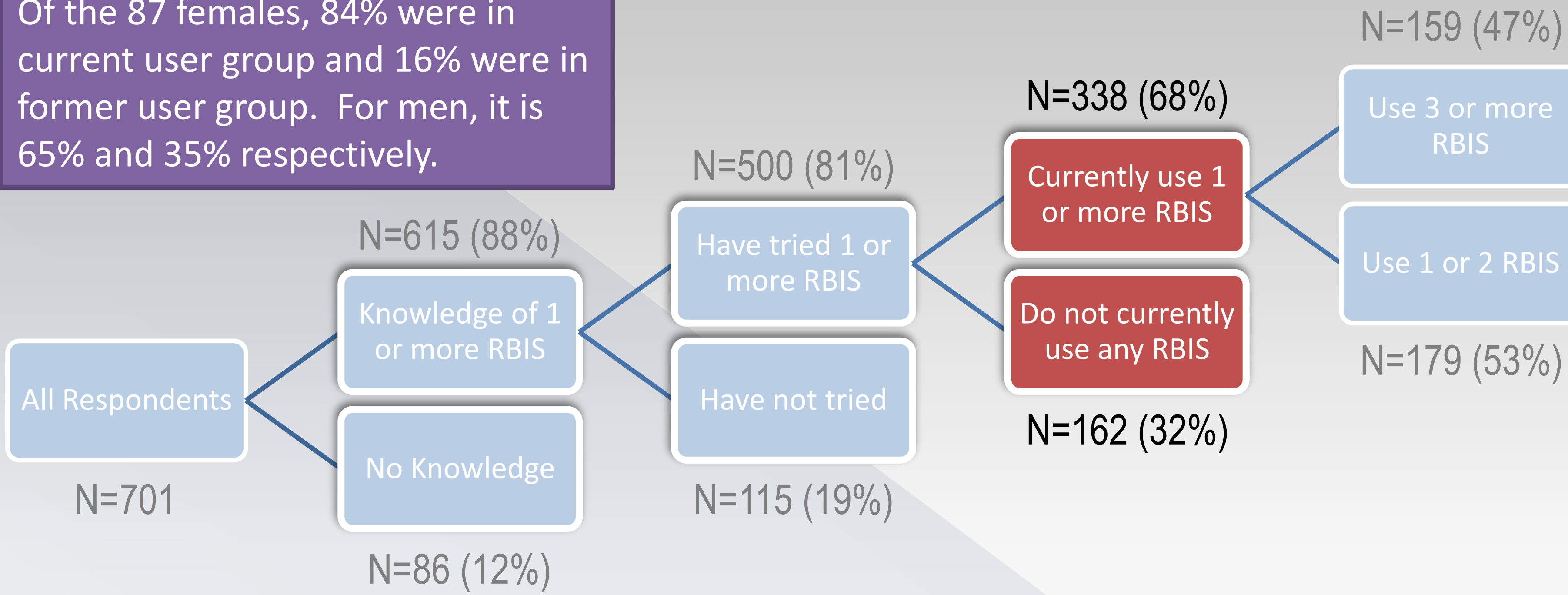


	Have Tried	Have Not Tried
Attended talks/workshops related to teaching in last 2 years	77%	36%
Attended New Faculty Workshop	18%	3%
Interested in using more RBIS	76%	55%

*p<.05 on chi-square test.

What Variables Correlate with Faculty Decisions?

<u>From a different perspective:</u>
Of the 87 females, 84% were in current user group and 16% were in former user group. For men, it is 65% and 35% respectively.

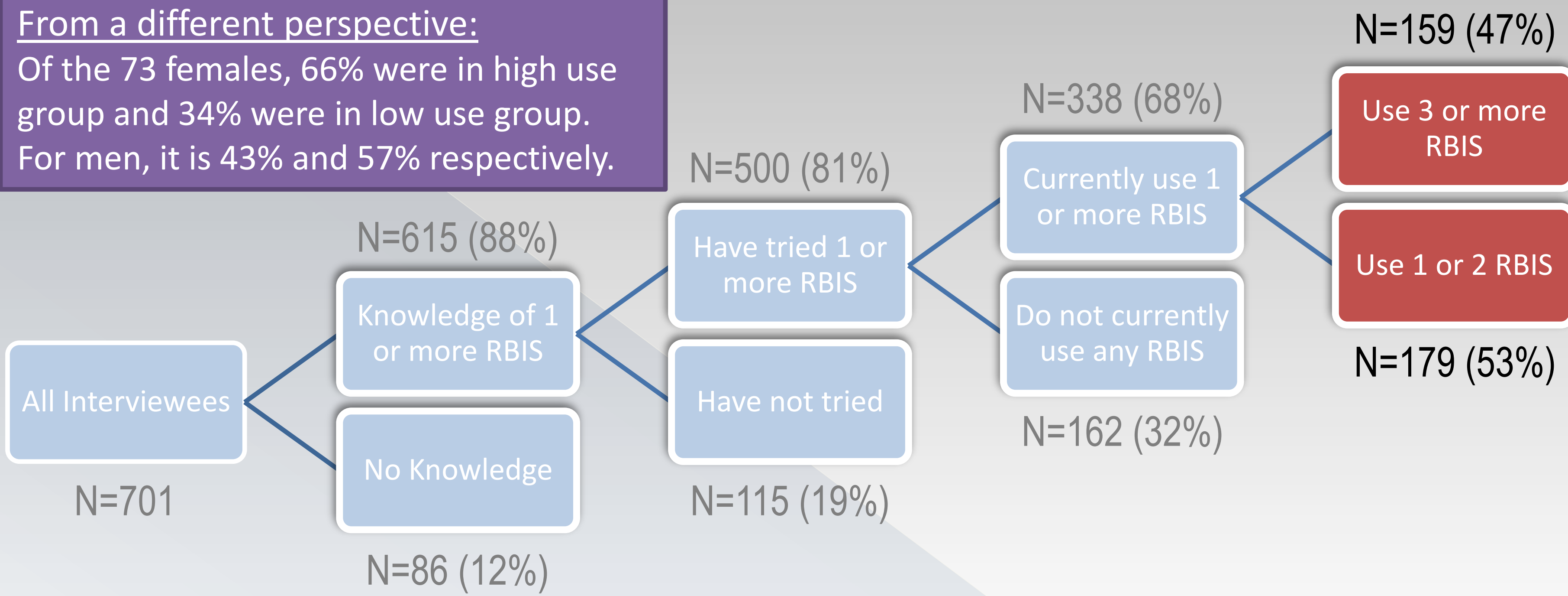


	User	Former User
Attended talks/workshops related to teaching in last 2 years	80%	29%
Female	23%	10%
Interested in using more RBIS	81%	36%
Years of teaching experience (mean)	14.3	16.8

*p<.05 on chi-square or t-test.

What Variables Correlate with Faculty Decisions?

From a different perspective:
Of the 73 females, 66% were in high use group and 34% were in low use group. For men, it is 43% and 57% respectively.

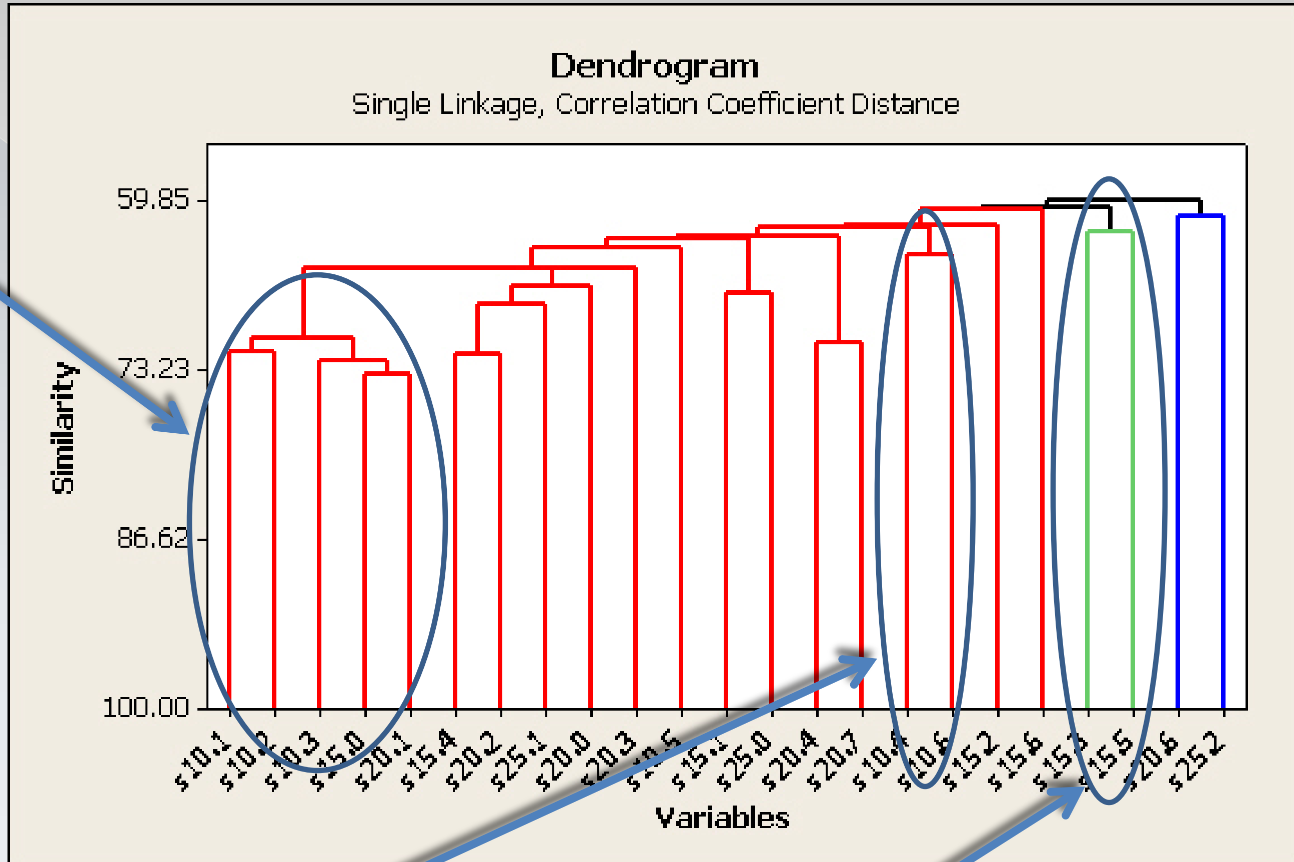


	High User	Low User
Attended talks/workshops related to teaching in last 2 years	91%	70%
Female	31%	15%
Published 4 or more articles in last two years	15%	35%
Work at a school with a physics PhD	23%	44%
Teach larger classes (mean class size)	57	82

*p<.05 on chi-square or t-test.

Future Work – Explore Clustering of Strategies

Clustering of strategies used by High Users



VanHeuvelen Cluster
10.1-ISLE
10.2-Modeling
10.3-Overview, Case Study Physics
15.0-Active Learning Problem Sheets
20.1-Experiment Problems

Studio Physics Cluster
10.4-Scale-Up, Studio Physics
10.6-Workshop Physics

PI & JiTT Cluster
15.3-Just-In-Time Teaching
15.5-Peer Instruction

A Few Preliminary Conclusions

- More support is needed to ensure successful implementations.
  - Faculty are derailed at every point in the innovation-decision process, but largest loss (~1/3) is discontinuation after trying an innovation.
  - New Faculty Workshop is highly successful in developing knowledge and getting faculty to try, but is not correlated with continued use.
- Ongoing Professional Development is important
  - Attendance of talks/workshops related to teaching was significant at each step.
- Female faculty are overrepresented in user and high user groups.
  - Deserves further investigation.
- May be important to think about high vs. low users.
  - They appear to have different needs/interests/instructional situations
  - Commonly assumed barriers (e.g., research productivity, large class size) were not found to be barriers to low use.

Non-Significant Variables

- Importance of instructional goals of problem solving and conceptual understanding.
- Number of research presentations in last 2 years.
- Currently has external funding.
- Frequency of discussions with colleagues about teaching.
- Number of teaching-related journals read.
- Highest degree attained.
- Course taught (calculus- vs. algebra-based).
- Level of departmental encouragement for teaching improvement.
- Teaching as % of job responsibilities.
- Academic rank.

Why Faculty Don't Use More PER Products?

For the 70% of respondents who said they were interested in using more research-based strategies they were asked "What prevents you from using more of these strategies?"

TIME	**52.7%**
Time to learn about and implement changes	28.6
Time (not elaborated)	24.1
LACK OF KNOWLEDGE ABOUT/ ACCESS TO	**25.5%**
Lack of familiarity with many innovations	22.4
Lack of access to innovations	3.1
WEAKNESSES OF INNOVATIONS	**19.8%**
Difficult to cover material (uses too much class time)	8.0
Not convinced of benefit	6.6
Requires too much instructor time to use	2.4
Student resistance (real or perceived)	2.1
Lack of ready-to-use materials	0.7
LACK OF FIT WITH DEPARTMENT OR INSTITUTION	**16.9%**
Cost to implement (e.g., lab equipment, additional staff)	4.0
Need to coordinate changes with colleagues	3.8
Lack of appropriate classroom space/class scheduling	3.7
Cost (not elaborated)	2.6
Colleagues would not approve	2.1
Cost for students (e.g., books, clickers)	0.7
LACK OF MOTIVATION TO ADOPT (other than TIME)	**9.2%**
I don't follow one method, but adapt pieces of many	6.1
Nothing	1.9
Inertia	1.2
UNCLEAR	**4.7%**

Increasing the Impact of PER: Recommendations from Typical Faculty

themes from interviews with faculty (N=35) who have at least some exposure to PER

- More research on PER methods is needed
  - Stronger evidence about PER pedagogies (i.e., some research not believable).
  - What parts of PER innovations make a difference?
  - Implementing PER in different situations (i.e., types of institutions and students). Much of PER is done at R1 schools.
  - Focus on outcomes beyond conceptual understanding
- PER needs to improve dissemination efforts
  - It is hard to find and sort through available PER products
  - It is important to have ways to learn about PER products in more detail (most dissemination does not really help you learn how to use a new pedagogy)
  - Disseminate to support:
    - Customization (e.g., how do I fit a new strategy to my personality or instructional situation)
    - Gradual changes in practice (models and support for doing this)
  - Higher profile dissemination efforts (e.g., articles in *Physics Today*)
- PER should support work to change department and institutional culture
  - Assessment of faculty teaching not based on measures of student learning
  - Instructional improvement is not valued by departments/institutions

Summary of Research Findings

- Dissemination efforts have impacted the knowledge and practice of many faculty.
  - Most are aware of and value PER innovations.
  - Use lags significantly behind knowledge.
  - Discontinuation is a problem.
  - Most are interested in using more innovations -- ‘time’ is cited as the biggest barrier.
- Innovations are typically modified during implementation. Faculty are often unaware of these modifications.
- Self-described user status is not an accurate measure of innovation features used.
- To encourage adoption along with productive modifications, change agents may need to provide substantial support and guidance during the selection, implementation and customization process.

Relationship to Project Scope

Project Scope: The committee will produce a report that identifies the goals and challenges facing undergraduate physics education and identifies how best practices for undergraduate physics education can be implemented on a widespread and sustained basis. In so doing, the committee will assess the status of physics education research (PER), and will discuss how PER can assist in accomplishing the goal of improving undergraduate physics education best practices and education policy.

Barriers to widespread and sustained implementation of best practices:

- Assessment of teaching
- Development and dissemination change model

Assessment of Teaching is a Barrier to Change

Neither faculty nor their institutions know how to measure teaching effectiveness.

<u>Institutional Evaluation of Teaching</u>

- Problem: Institutional assessments of teaching are made on the basis of student opinion and (sometimes) peer observations. Not on measures of student learning.

- Implications: Faculty are reluctant to try a new instructional style that they believe will improve student learning, but might decrease student satisfaction.

<u>Individual Faculty Self-Improvement</u>

- Problem: Many faculty would like objective measures of their student learning.
    - Currently available conceptual surveys (e.g., FCI, CSEM) can help. But, faculty are often unaware of these and it is hard to find comparison data.
    - Faculty also care about other outcomes (e.g., problem solving).

- Implications: Faculty tend to rely on their intuitions and informal impressions about whether their students are learning.

Assessment of Teaching is a Barrier to Change

Neither faculty nor their institutions know how to measure teaching effectiveness.

Easier (partial) Solution

Better dissemination of existing conceptual surveys and comparison data.
•These surveys can be hard to find (developers are often protective).
•Comparison data is rarely compiled in an accessible way.

Harder Solutions

•Additional measures are needed. (Conceptual understanding at the introductory level is only one outcome that is valued by faculty and their institutions.)
•PER can help faculty develop formative assessment skills.

Opportunity

The current 'culture of assessment' can be leveraged for progress in this area.

Development and Dissemination Change Model is a Barrier to Change

PER needs a larger repertoire of change models that can lead to systemic change.

Development and Dissemination Change Model

- Teaching innovations developed/tested by experts.
- Disseminated mainly by developers via. mass market strategies.
- Secondary implementation seen as non-problematic – fidelity is expected.
- Unit of change is individual faculty.

Strengths

- Has led to creation of innovations.
- Has raised awareness of these innovations and of PER in general.

Weaknesses

- Innovation use lags significantly behind knowledge.
- Innovations are often modified (inappropriately) and/or discontinued.
- Little emphasis on testing in diverse range of students/schools.
- Widespread and sustained implementation requires systemic change.

Development and Dissemination Change Model is a Barrier to Change

PER needs a larger repertoire of change models that can lead to systemic change.

<u>Easier (partial) Solution</u>

Can improve within development and dissemination model
- Need more coordinated testing of innovations in diverse settings.
- Need user-friendly compilations of existing curricula and (modifiable) materials.
- Consultants to help departments identify/implement new practices.

<u>Harder Solution</u>

Need more powerful, research-based change models
- Promising directions include:
  - Community-based models
  - Models that support productive user customization.
  - Departments as the unit of change
- Change models must address situational barriers (e.g., efforts to improve teaching are often not valued) and how to realign these (i.e., systemic change).

Opportunity: RFPs (e.g., NSF) could explicitly solicit proposals in these areas.