Natasha G. Holmes
LASSP, Cornell University

DUE-1611482- 01

Evaluating Scientific Practices in Intro Physics Labs

@ng_Holmes
ngholmes.wordpress.com
ngholmes@cornell.edu

DUE-1611482- 01

Cornell Physics Education Research Lab

Collaborators

N.G. Holmes (PI)

Students & Postdocs

Saaj Chattopadhyay (Undergraduate)
Katherine Quinn (Grad student)
Tim Rehm (Undergraduate)
Emily Smith (Postdoc)
Cole Walsh (Grad student)

Stanford University

Carl Wieman
Isabella Rios
Adam Stanford-Moore
Ruqayya Toorawa

What should labs be doing?

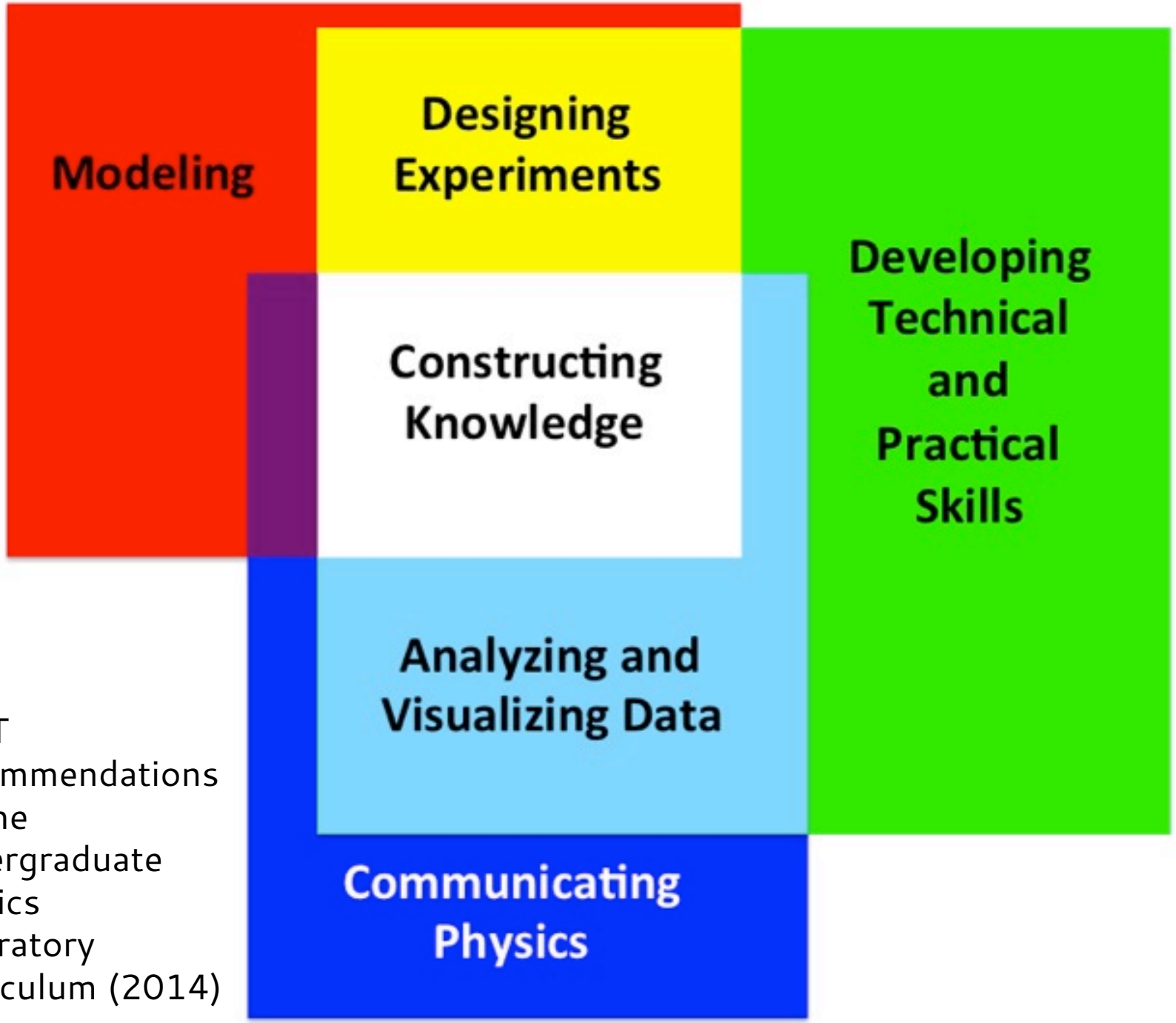
What are labs doing?

How do we know?

What should labs be doing?

What are labs doing?

How do we know?



AAPT Recommendations for the Undergraduate Physics Laboratory Curriculum (2014)

Where is content?

Where is content?

- Labs found to provide no measurable added-value to reinforcing physics content beyond what is provided by lecture and tutorials

  Wieman & Holmes (2015) *Am J Phys*
  Holmes, Olsen, Thomas, Wieman (2017) Phys. Rev. PER

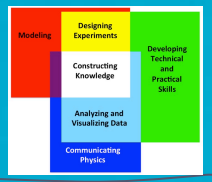
3-institution study

- Labs that aim to reinforce content found to make student attitudes/beliefs about experimental physics more novice-like

  Wilcox & Lewandowski (2017) *Phys Rev Phys Educ Res* 13(1):10108.

- Plus NGSS, AP practice, Phys 21, etc.

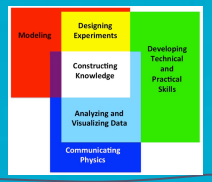
What should labs be doing?



What are labs doing?

How do we know?

What should labs be doing?



What are labs doing?

How do we know?

Physics Lab Inventory of Critical thinking

Physics Lab Inventory of Critical thinking

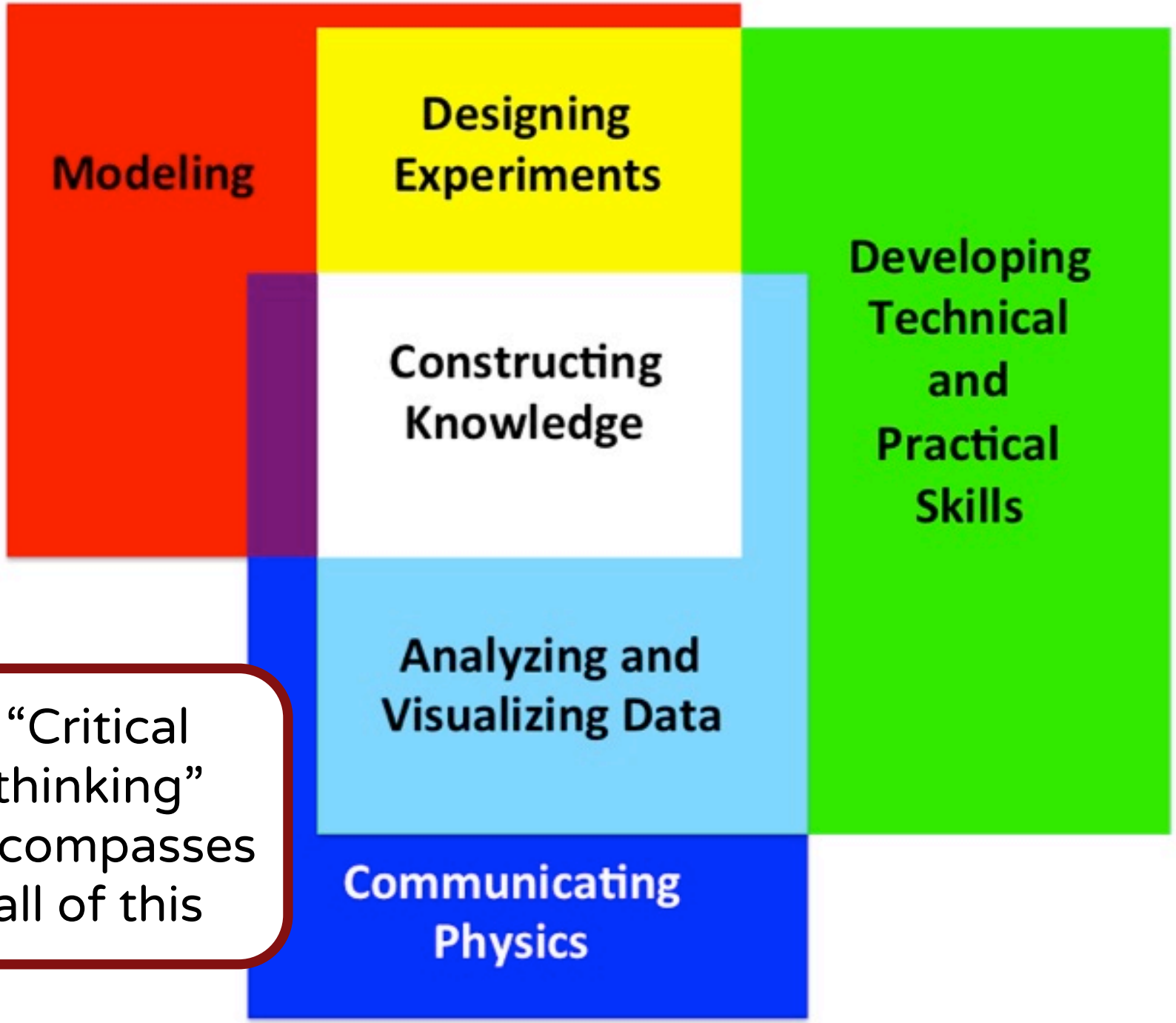
PLIC

What do you mean "critical thinking"?

Quantitative **critical** thinking

The process through which you make **decisions** and decide what to believe

Especially related to “believing” evidence, data, models, etc.



"Critical thinking" encompasses all of this

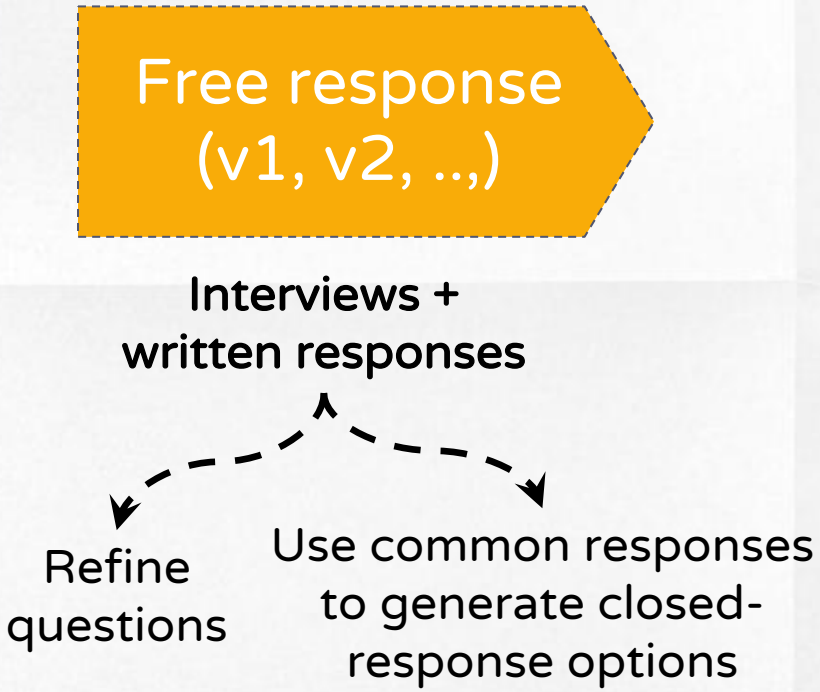
The PLIC: aim

x Assess critical thinking in an efficient, standardized way

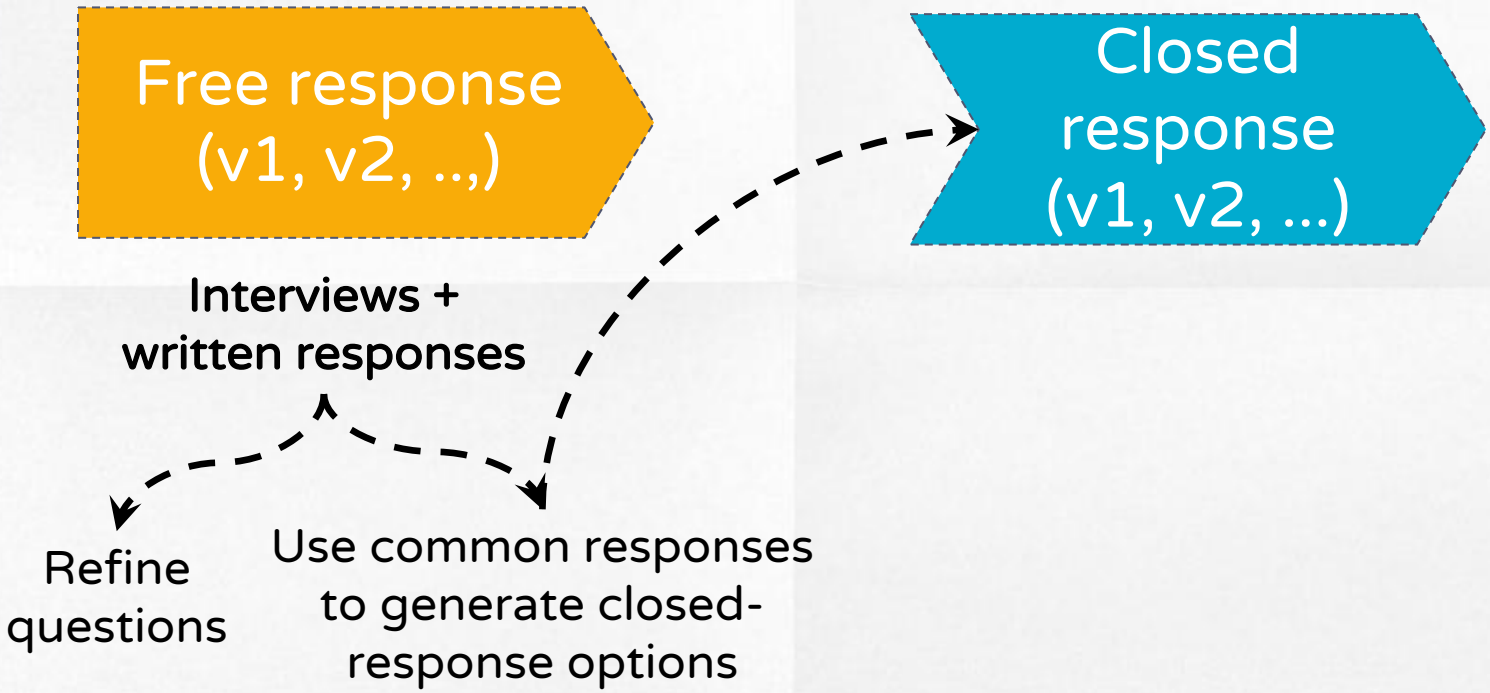
x Useable by instructors in different courses at any institution

[Physics Lab Inventory of Critical thinking]

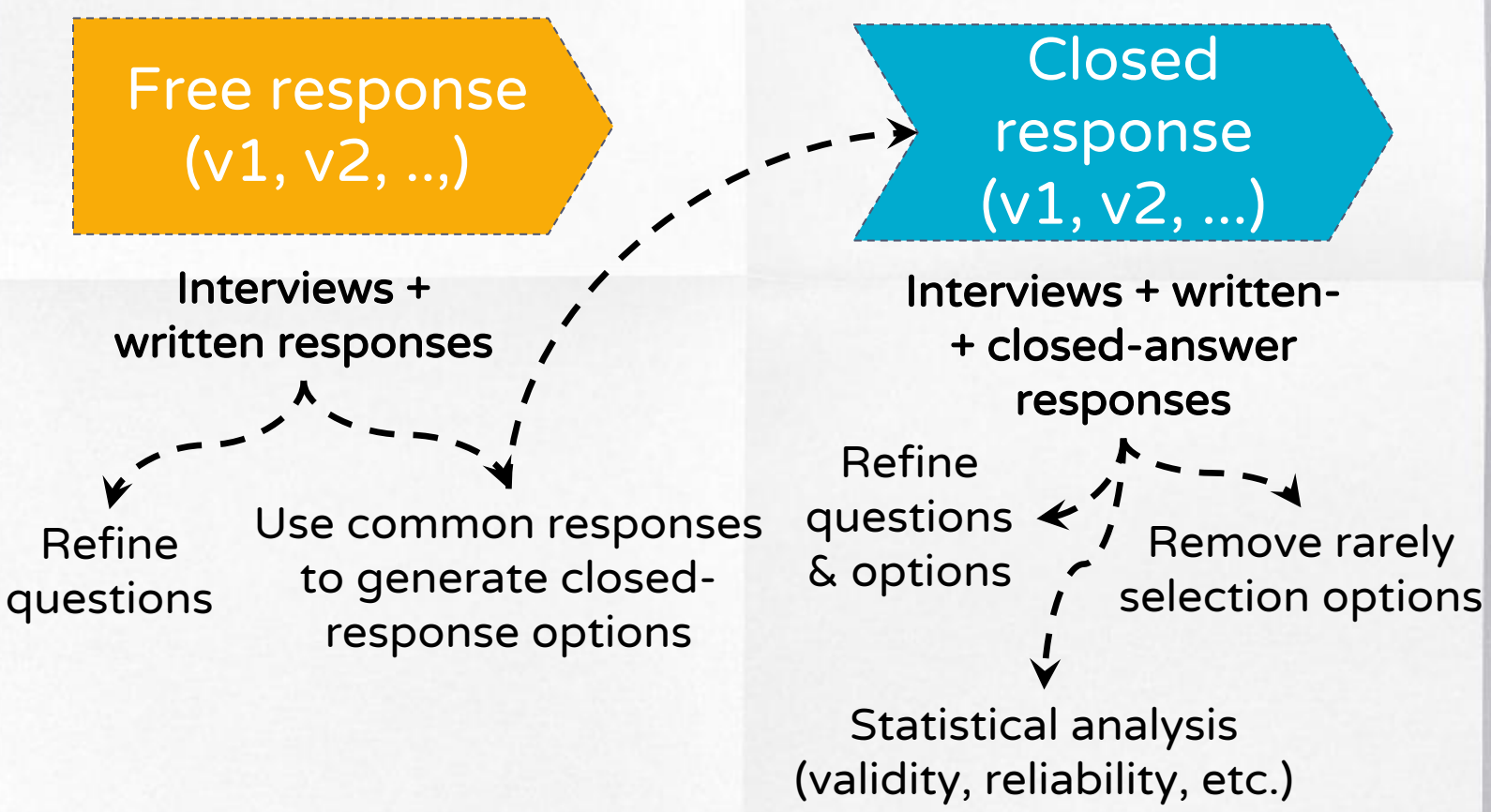
Generating a closed-response survey



Generating a closed-response survey



Generating a closed-response survey



The PLIC: structure

- Case studies of two groups completing a mass on a spring experiment

- Closed response, choose many, Likert-like

[Physics Lab Inventory of Critical thinking]

Two fictional groups

Group 1

- Measure 10 repeated trials
- Measure 5 periods at a time
- Use 2 masses
- Calculate k in each case and compare

Students described "evaluating a model" as finding k

Two fictional groups

Group 1	Group 2
Measure 10 repeated trials	Measure two repeated trials
Measure 5 periods at a time	Measure 5 periods at a time
Use 2 masses	Use 10 different masses
Calculate *k* in each case and compare	Plot, linearize, find k
Students described “evaluating a model” as finding *k*	Residuals graph included – trend motivates need for intercept

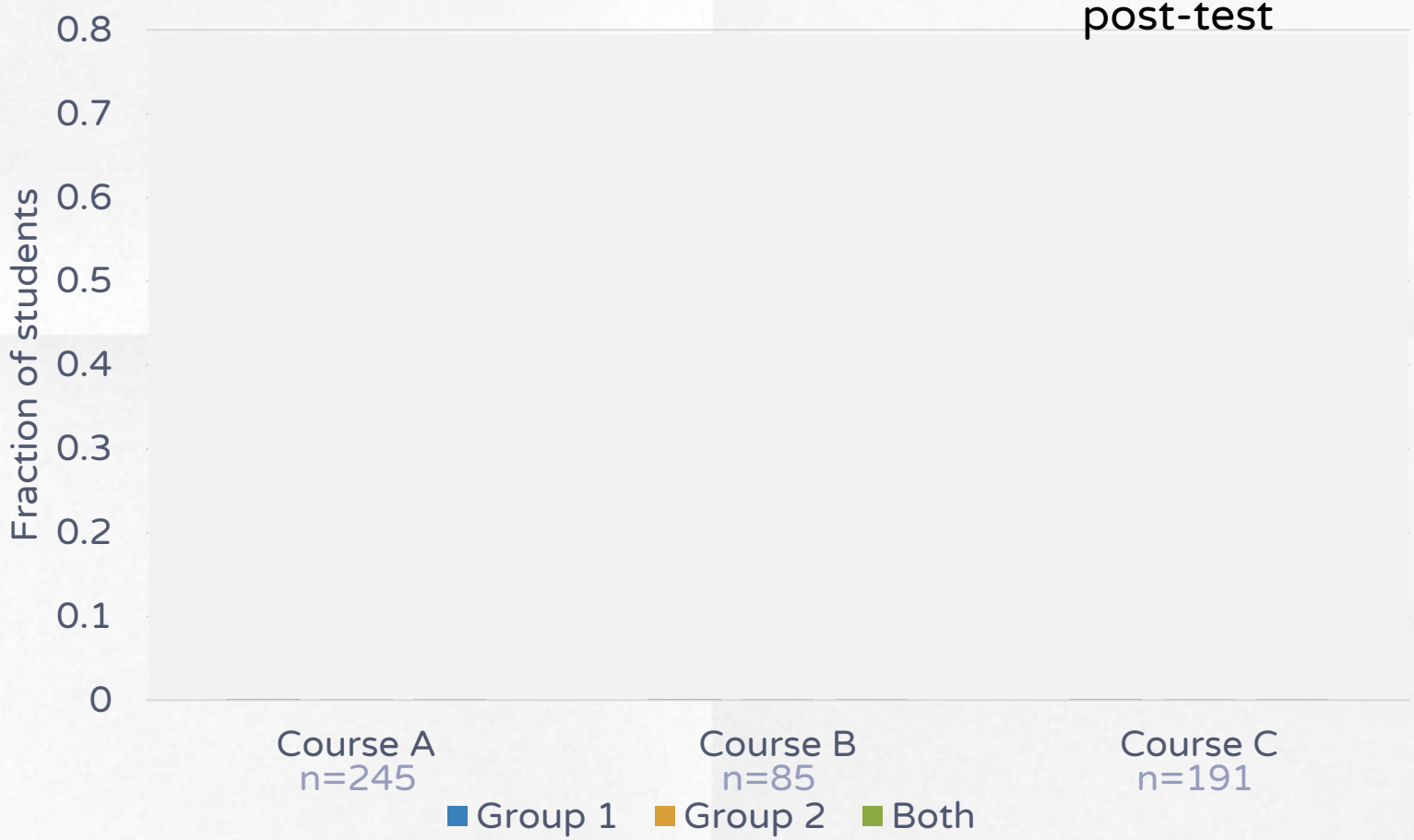
Which group did better?

Experts say Group 2, because:

- Extended limits (More masses)
- Analysis (Fitting, trying different models)

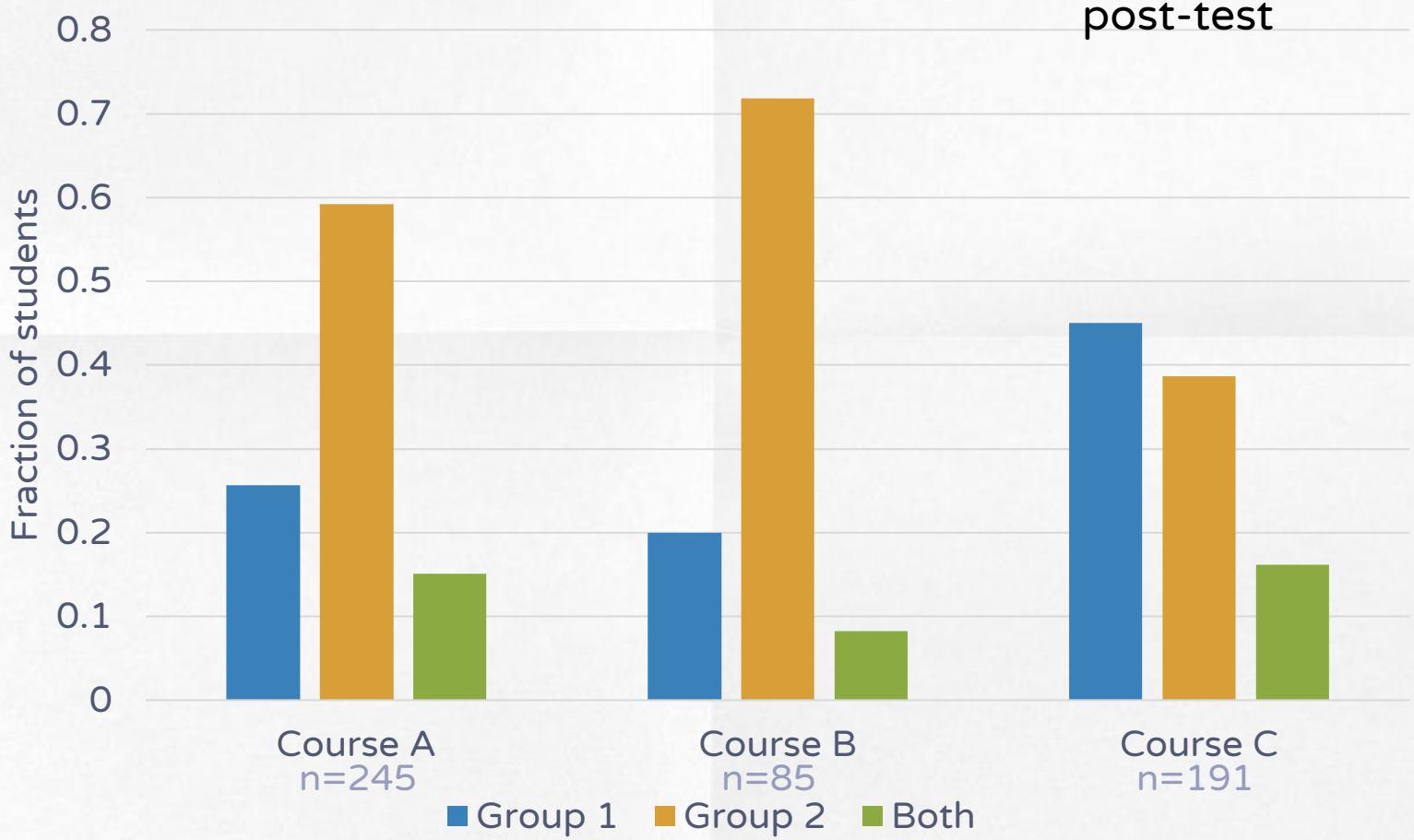
Which group did better?

3 intro physics courses at post-test



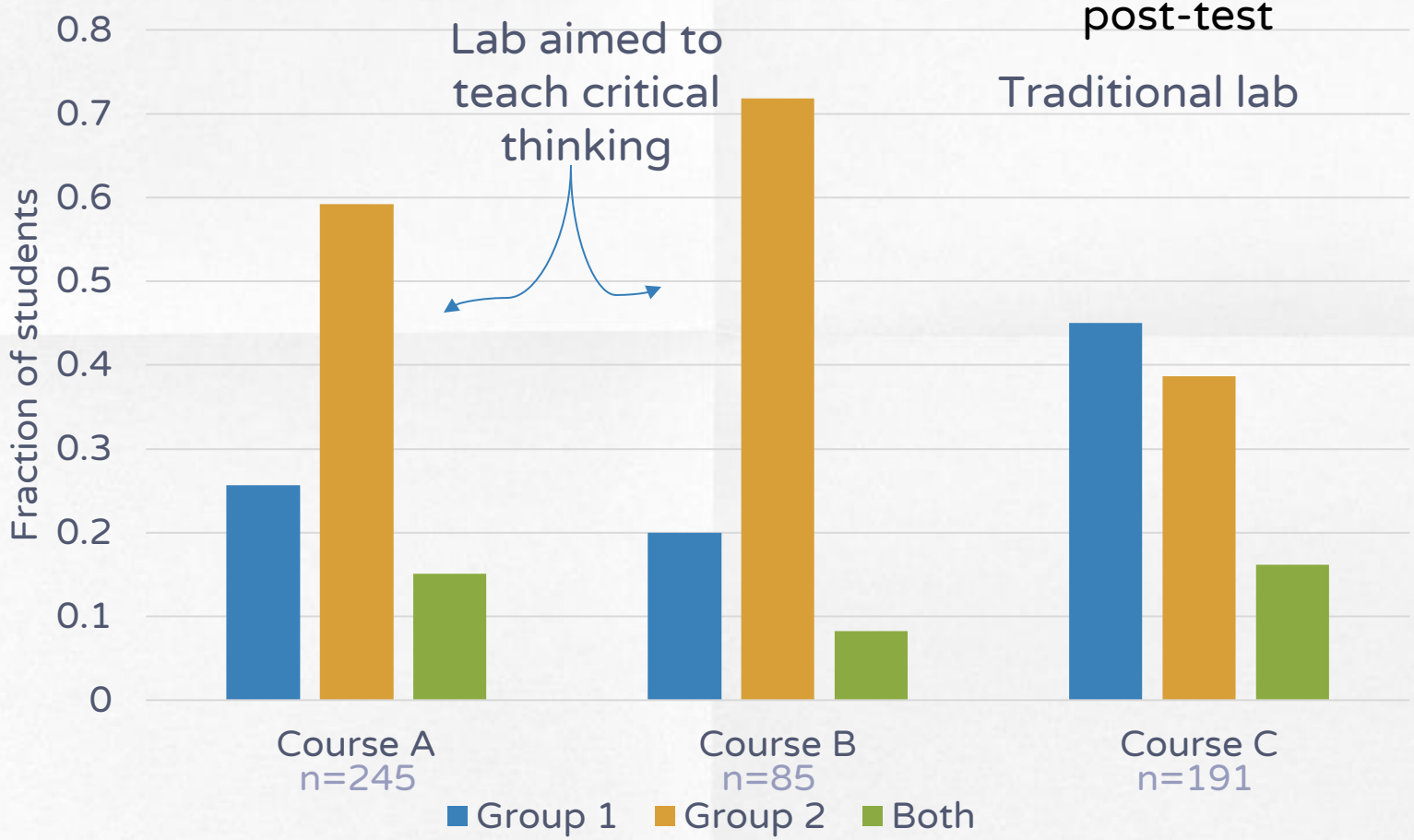
Which group did better?

3 intro physics courses at post-test



Which group did better?

3 intro physics courses at post-test




Why?


Student Reasoning behind "What group do you think did a better job testing the model?"
Group 1 did better
Group 2 did better
Both did equal
Course A
n = 246
Course B
n = 48
Course C
n = 194
Fraction of Students
1.0
0.8
0.6
0.4
0.2
0.0
Tested the limits of the experiment
Collected more data
Collected better quality data
Analyzed data better
Presented their work better
Response Options


Student Reasoning behind "What group do you think did a better job testing the model?"
Group 1 did better
Group 2 did better
Both did equal
Course A
n = 246
Course B
n = 48
Course C
n = 194
Fraction of Students
1.0
0.8
0.6
0.4
0.2
0.0
Tested the limits of the experiment
Collected more data
Collected better quality data
Analyzed data better
Presented their work better
Response Options


Student Reasoning behind "What group do you think did a better job testing the model?"
Group 1 did better
Group 2 did better
Both did equal
Didn't limit # options
Course A
n = 246
Course B
n = 48
Course C
n = 194
Fraction of Students
1.0
0.8
0.6
0.4
0.2
0.0
Tested the limits of the experiment
Collected more data
Collected better quality data
Analyzed data better
Presented their work better
Response Options

- Preferred Group 2 except for amount of data
- Cared about all options

- Preferred Group 1
- Cared most about data quality & amount

What does this tell us?

- Traditional lab instruction aligns with Group 1 methods
  - Focus on data quality and quantity:
    - Comparing parameter to "true" value and taking lots of trials
- Critical thinking instruction aligns with Group 2 methods
  - Focus on range of investigation and quality of analysis
    - **Need to limit number of options to differentiate ideas**
    - **(all options are reasonable, some more expert than others)**
- …


Interested in using the PLIC? Contact me!
ngholmes@cornell.edu
We're also looking for more expert responses!
Poster session: PST2D36
Tues 5:45-6:30pm
The Physics Lab Inventory of Critical Thinking (K.N. Quinn)
Thank you!


CORNELL UNIVERSITY
FOUNDED A.D. 1865