Agency and the Equity of Lab Groups

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Cornell Inter-Disciplinary Education Research

PIs: Natasha G. Holmes & Michelle Smith (EEB)

Postdocs: Emily Smith, Frank Castelli, Claire Meaders

Collaborators: Peter Lepage, Mark Sarvary, Mitra Asgari

Grad students:

Jack Madden

Katherine Quinn

Martin Stein

Ryan Tapping

Cole Walsh

Monica Xu

Undergrad: Zach Whipps

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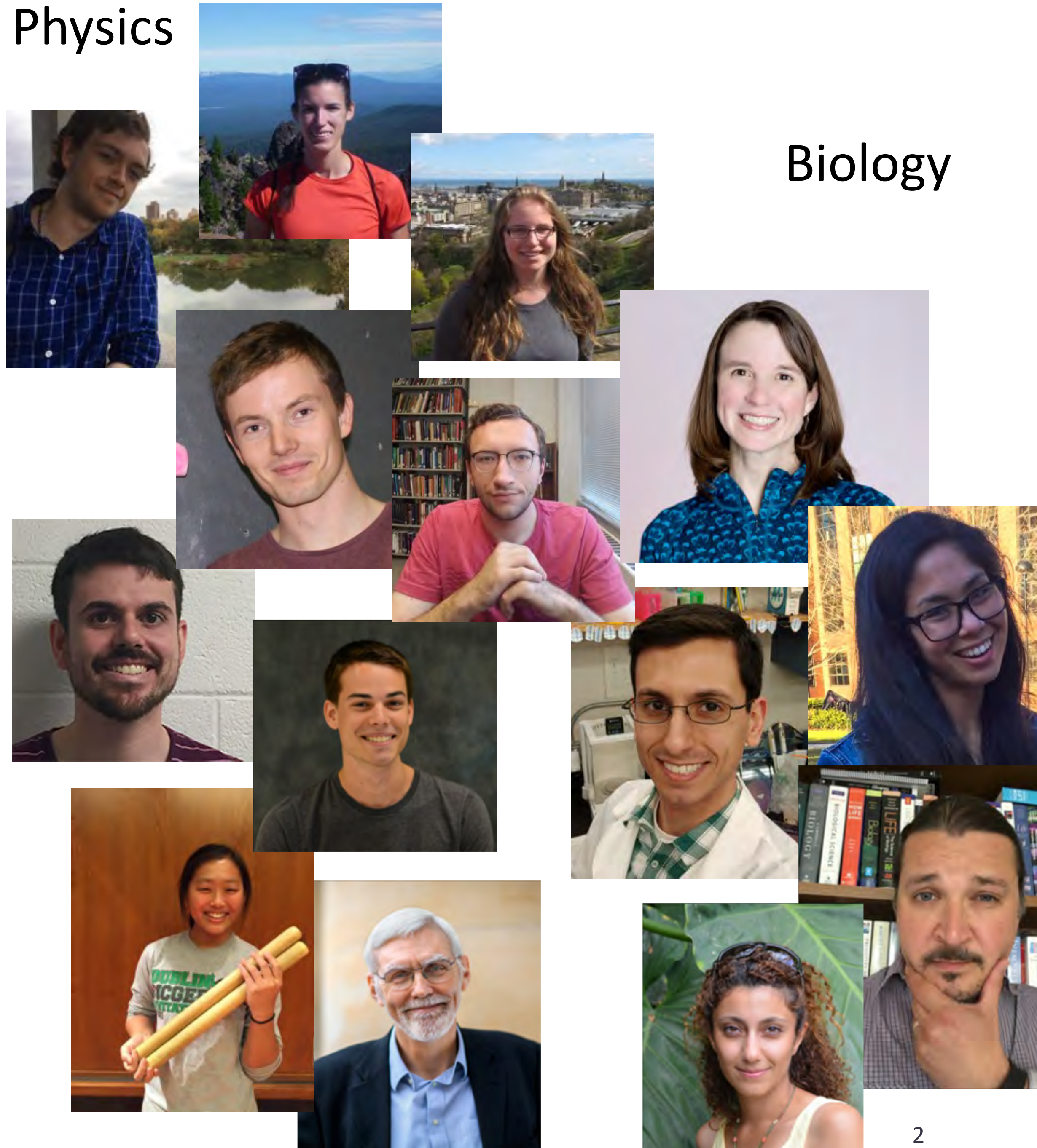
Physics

Biology



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Physics

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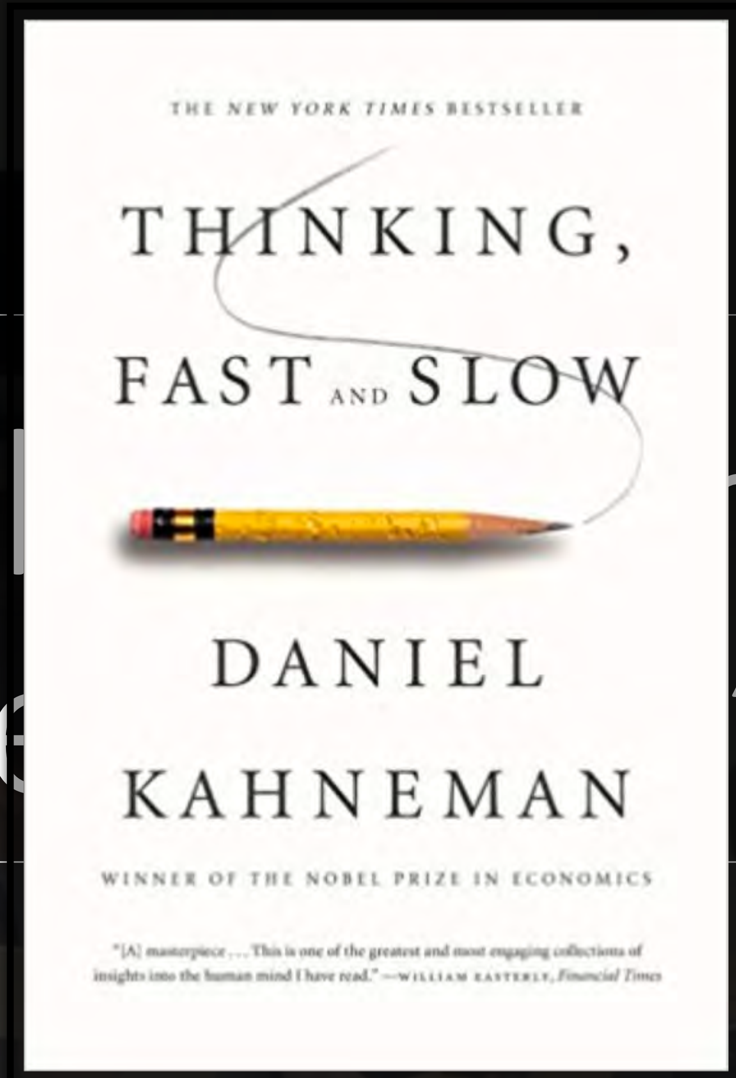

THE NEW YORK TIMES BESTSELLER
THINKING,
FAST AND SLOW
DANIEL
KAHNEMAN
WINNER OF THE NOBEL PRIZE IN ECONOMICS
"[A] masterpiece . . . This is one of the greatest and most engaging collections of insights into the human mind I have read." —WILLIAM EASTERLY, Financial Times


James Day
(UBC)

Ido Roll Doug Bonn
(UBC)

Study 1

HOW DO MALE AND FEMALE STUDENTS USE THE EQUIPMENT IN MIX-GENDER LAB PAIRS?

Proportion of time spent on equipment

Every 2 minutes, identified whose hands were on the equipment (M or F)

$$F_{score} = \frac{\#\ \text{observations female student was using equipment}}{\#\ \text{observations equipment was being used by either student}}$$

$F_{score} = 1$ -> Female handling equipment whole time

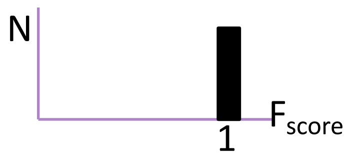
$F_{score} = 0$ -> Female never handled equipment

Proportion of time spent on equipment

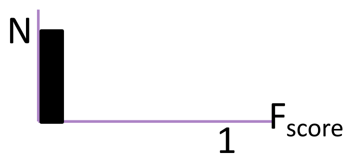
$$F_{score} = \frac{\text{\# observations female student was using equipment}}{\text{\# observations equipment was being used}}$$

Predictions?

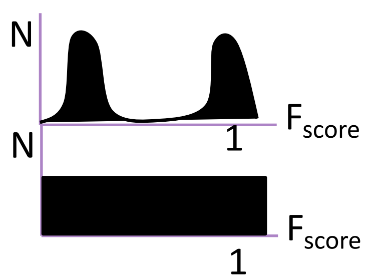
1) $F_{score} = 1$



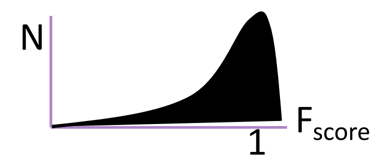
2) $F_{score} = 0$



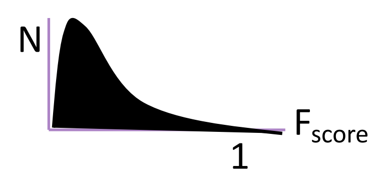
3) $F_{score} = 0.5$ and flat or bi-modal



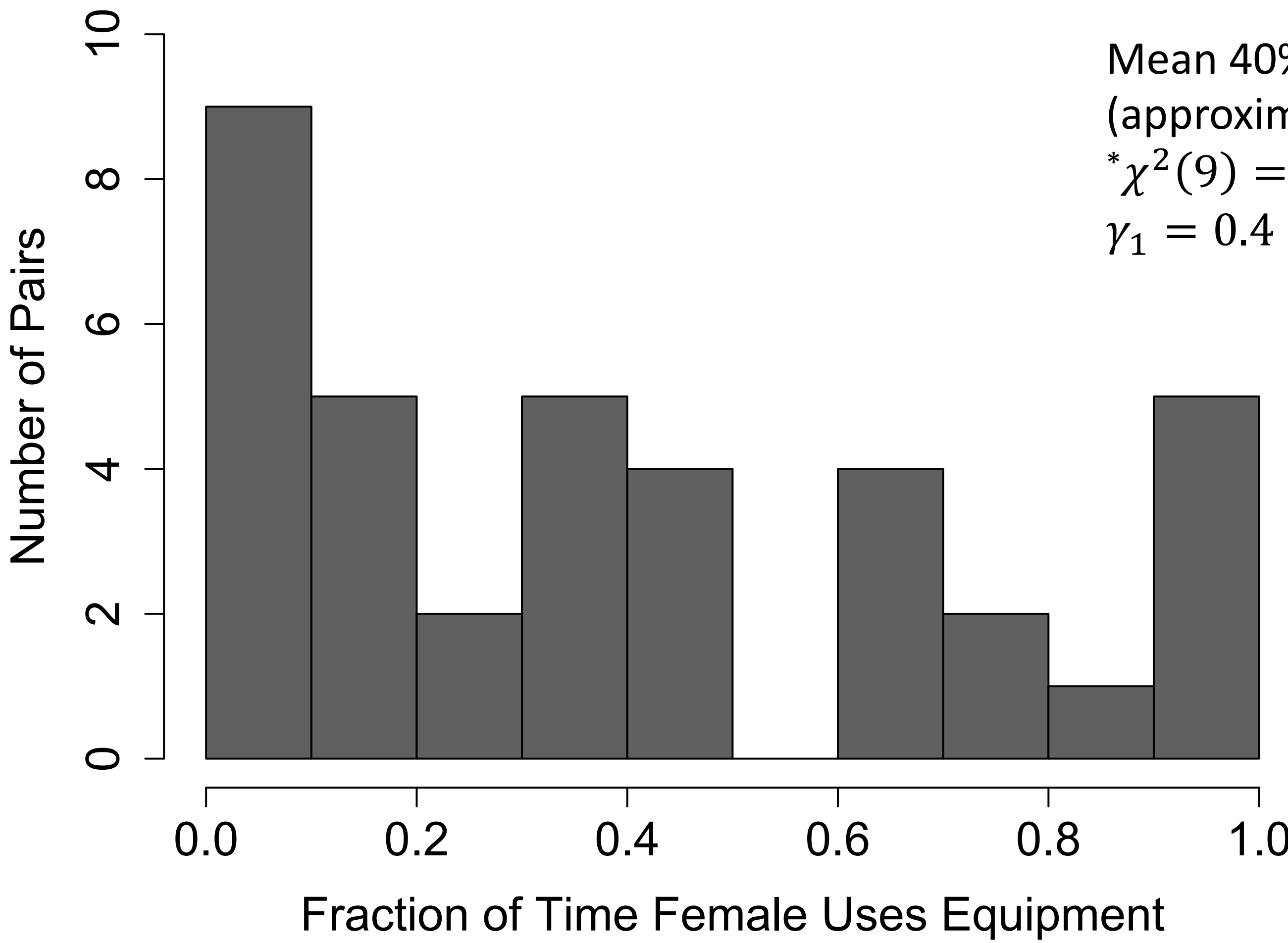
4) $F_{score} = 0.5$ and skewed towards 1



5) $F_{score} = 0.5$ and skewed towards 0



Proportion of time spent on equipment



Mean 40% $\pm$ 6%
(approximately half time)
$^{*}\chi^2(9) = 16.24, p = .06$
$\gamma_1 = 0.4$ (positive skew)

Male student use of equipment seen before in middle-school Jovanovic & King, 1998

*Chi-squared test of independence from a flat distribution

Dhaneesh Kumar Jared Stang Doug Bonn James Day
(UBC)

Study 2

HOW DO MALE AND FEMALE STUDENTS DISTRIBUTE TASKS IN MIX-GENDER LAB PAIRS?

Day, Stang, Holmes, Kumar, & Bonn (2016) *Phys. Rev. PER*

Tasks ≈ hands-on

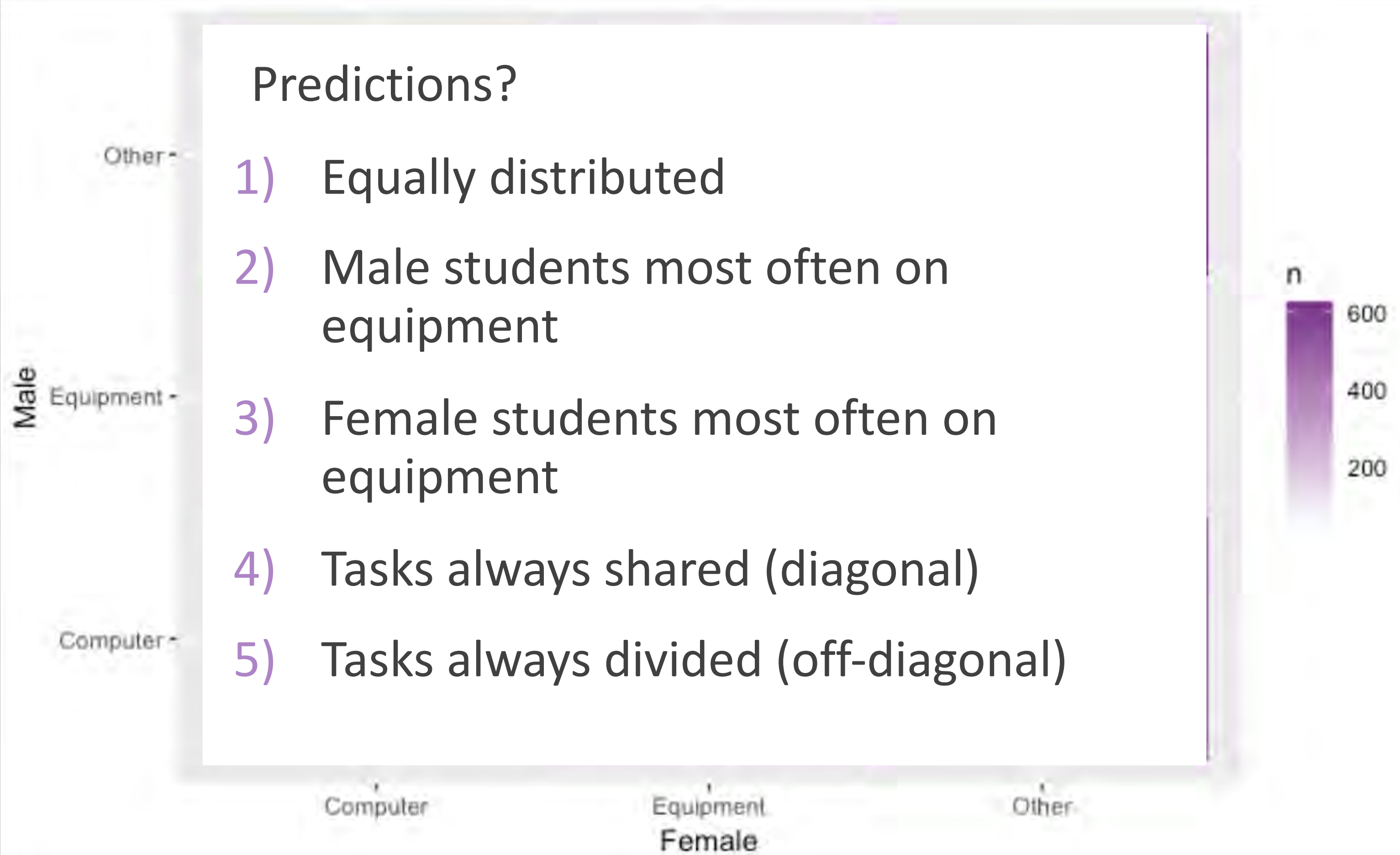
EQUIPMENT

COMPUTER

OTHER

Day, Stang, Holmes, Kumar, & Bonn (2016) *Phys. Rev. PER*

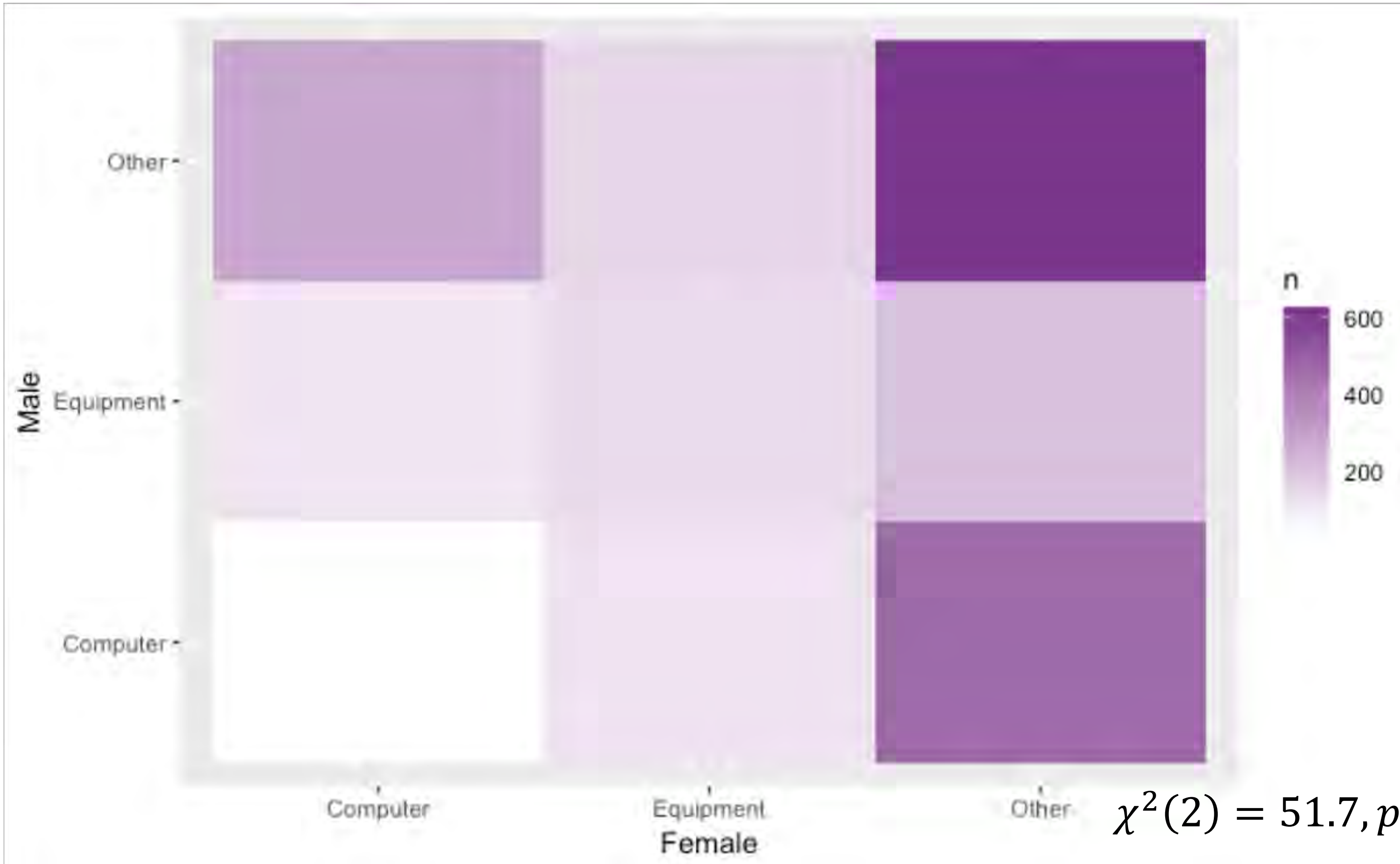
Distributed tasks



Predictions?

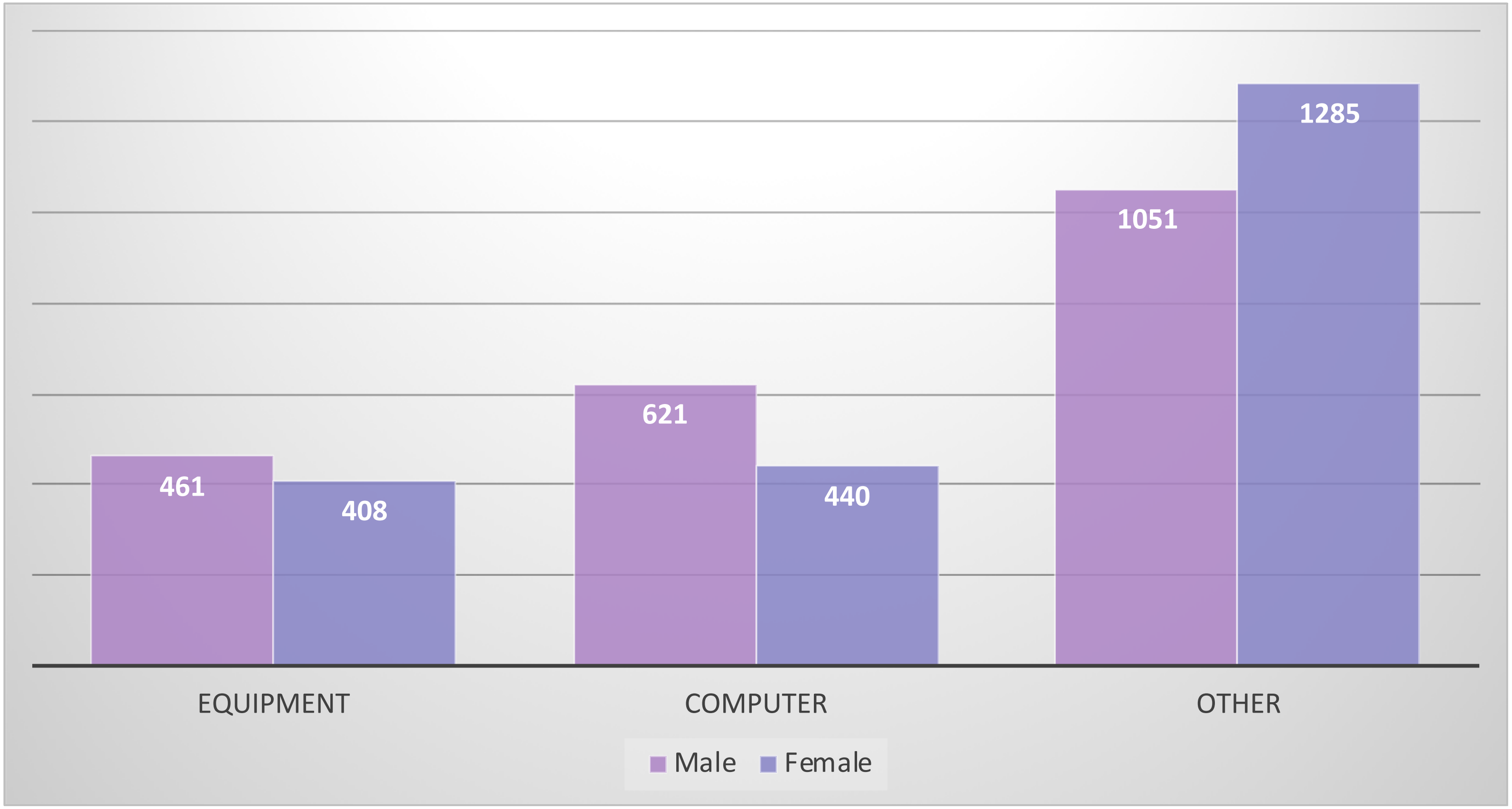
1) Equally distributed
2) Male students most often on equipment
3) Female students most often on equipment
4) Tasks always shared (diagonal)
5) Tasks always divided (off-diagonal)

Distributed tasks



$\chi^2(2) = 51.7, p < .001$*

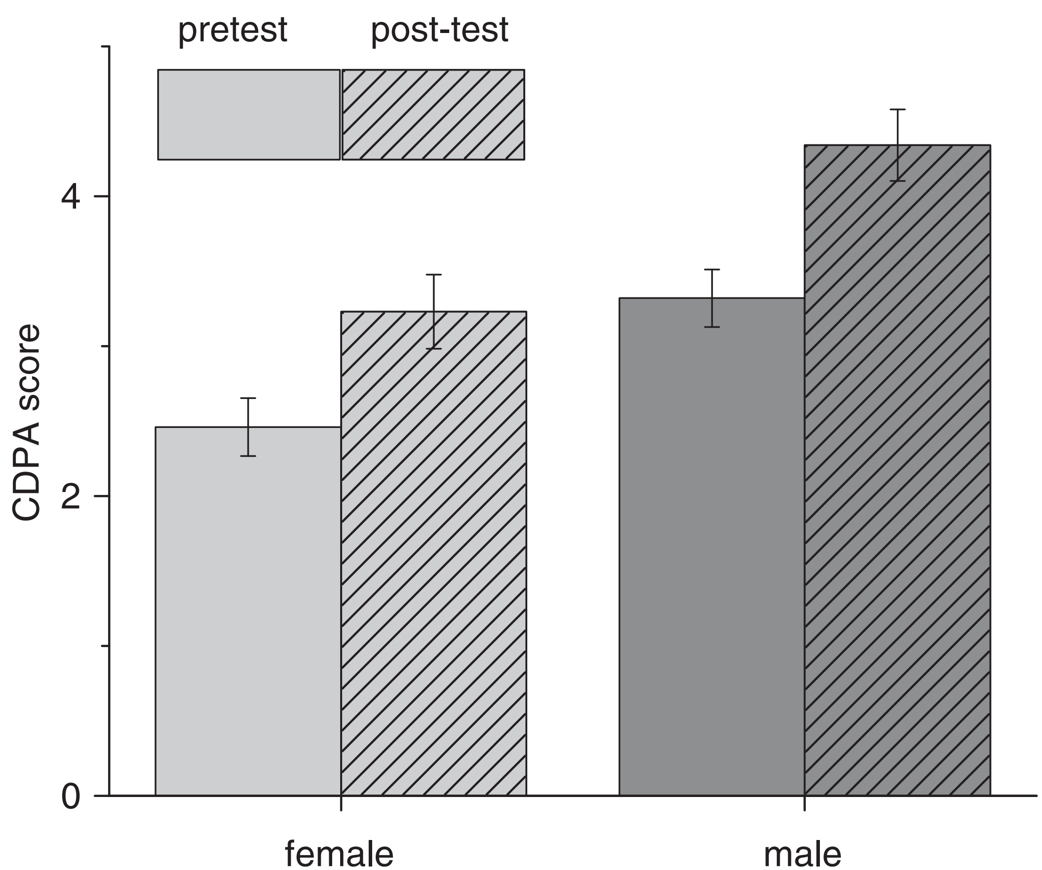
Distributed tasks



Does it matter?

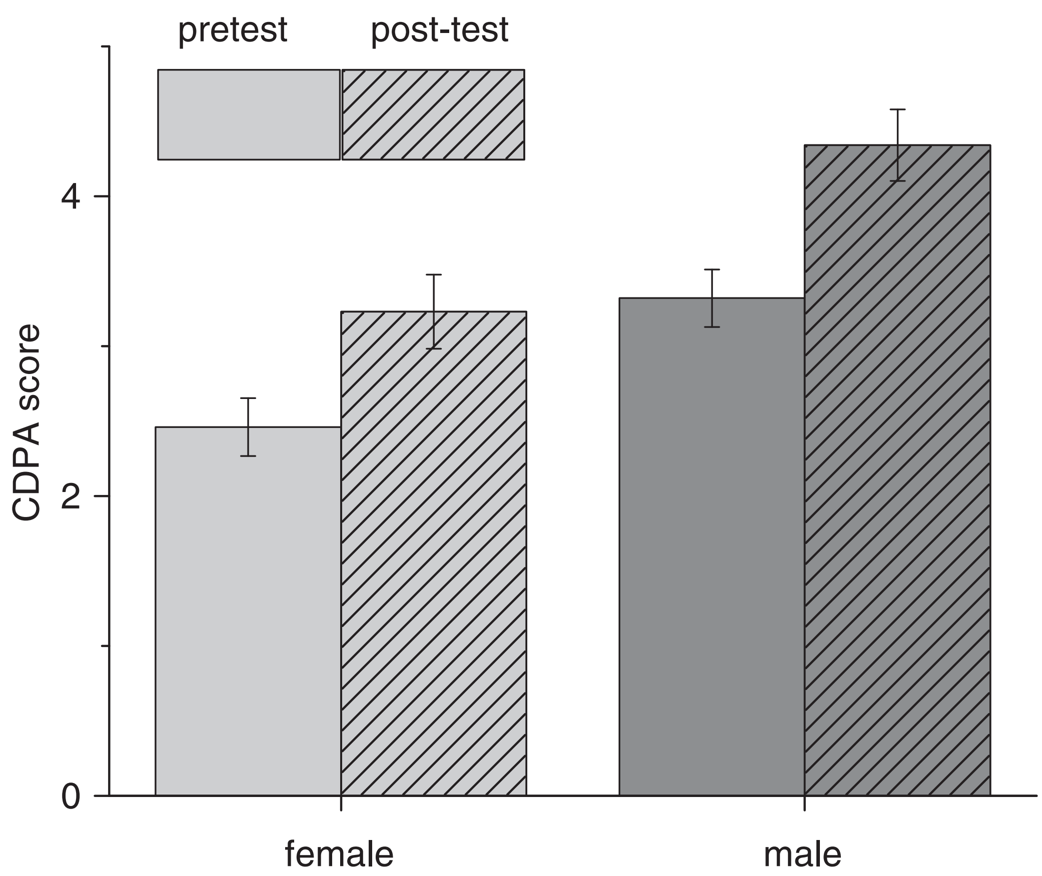
If male students spend more time on computer, do they learn data analysis better?

Tasks ≈ hands-on



Scores on Concise Data Processing Assessment*

$F(1,468) = 16.86^{**}$, $p < .001$, $\eta^2_{partial}$=0.035



BUT no correlation with scores and computer usage

$^{*}r_s = 0.084$, $p = .353$

*Spearman correlation coefficient

Not all labs are created equal?

"Doing gender" and "doing physics" in the context of lab work

Men disproportionately spend time on equipment

Study 1
Holmes et al. 2014

Men disproportionately spend time on computers compared with other activities

Study 2
Day et al. 2016

Not related to score differences on CDPA

Summary so far

Enter "Agency"

Agency

AN AGENT IS SOMEONE WHO IS MAKING DECISIONS TO PURSUE A GOAL.

Bandura (1989)

Example: Bouncing ball lab

We should really call this lab "kinematics of a bouncing ball." We'll **use motion detectors** to **measure the position** of a bouncing ball. Although the software can calculate the velocity and acceleration for us automatically, it will be more instructive to export the position data and then play with it.

The first step will be to set up the motion detectors**. Use your hand** as an object to make sure that the motion detector is working correctly. Then **bounce a ball under** the motion detector. If the position of the ball on the graph matches what you would expect, then export the time and position data.

Open Excel and put the position and time information into a table. **Make a graph** of your data, **print** it out, **and tape it** into the data section of your lab notebook. Then **use the position data** to **determine the velocity** from point to point. To do this **calculate** the average velocity: $\Delta x/\Delta t$. Note that the time between data points is not constant and this needs to be taken into account. **Make a velocity vs. time graph**, **pick out a "bounce"** and **determine** the slope by graphing just the data points on that bounce and **using a linear fit**. Since acceleration is the derivative of velocity, the slope of your graph should be the acceleration due to gravity.

Do this four times. **Take the mean and standard error** of your measurements to report a value for g. Go back to your data table **and create a column** for acceleration the same way you did for velocity. **Compare the values** in your acceleration column to the one you've found by curve fitting. **Comment** upon this in your conclusion.

In your conclusion **discuss your results**, paying close attention to sources of error, backing up your reasoning with statements you can quantify as significant (many claim that air resistance is a big factor, if you do this, **sketch** what the velocity graph would look like if there was a very large drag force operating in this problem, and discuss how you would extract g from such a graph). Statements in your conclusion should always be backed up with references to your data. Finally, **suggest ways** that you would improve your measurements.

Learning

Self-efficacy

Motivation

Persistence in STEM

Benefits of agency include

Bandura 1982; 1989; Carlone et al. 2015; Calabrese Barton & Tan 2010; Ko et al. 2014…

***NOT about removing structure.**

	Traditional	Agency
Change goals[1]	Reinforce concepts	Experimentation skills
Turn statements to questions[2]	"Do this four times."	"How many trials will you run?"
	"Take the mean and standard error."	"How will you analyze your data?"

[1]Holmes & Smith, in press with *The Physics Teacher* [2]Holmes, Keep, & Wieman, under review
*Agency labs, see www.PhysPort.org/curricula/thinkingcritically

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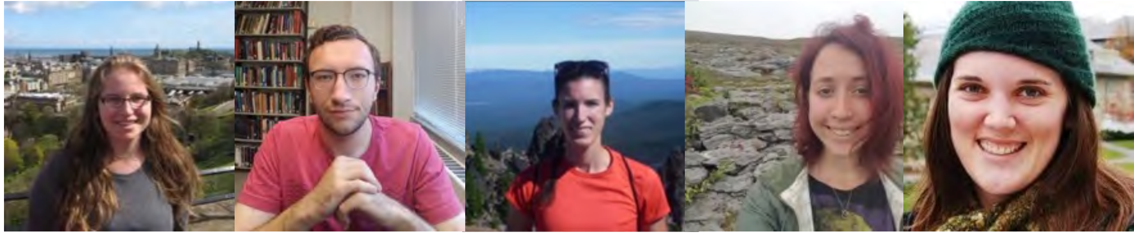


Katherine Quinn	**Zach Whipps**	Emily Smith	Michelle Kelley	Kathryn McGill

Study 3

HOW DO MALE AND FEMALE STUDENTS DISTRIBUTE TASKS IN DIFFERENT LABS?

Tasks ≈ hands-on

EQUIPMENT

COMPUTER

LAPTOP

PAPER

OTHER

Comparing traditional and agency labs

	Control	Agency
Learning objectives	Conceptual physics	Uncertainty and data analysis Critical thinking skills
Student products	Individual Worksheets	Group e-Notebooks
Time per lab	2 hours	
Number of lab sections	3 (1 semester)	6 (2 semesters)
Number of students	58	85

Note: Gender self-identified by students on course surveys with options:
Male, Female, Other (open text), Prefer not to disclose

Quantifying student behaviors

~1~

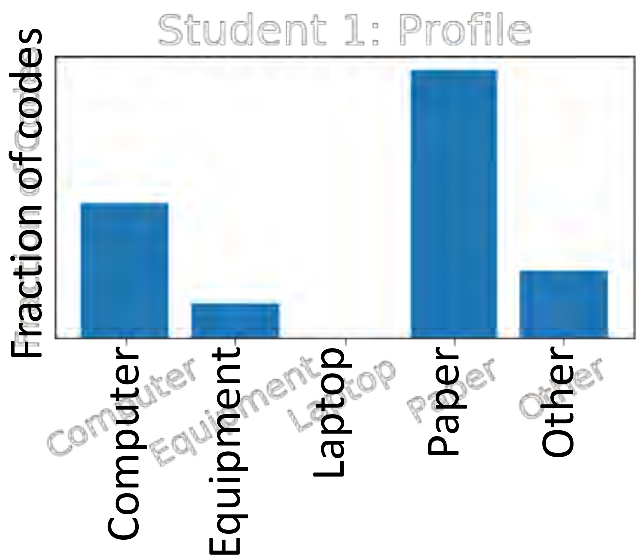
Every 5 minutes, document what every student in the lab is doing

Min	Action
0	Equipment
5	Other
10	Paper
...	...

143 Students

~2~

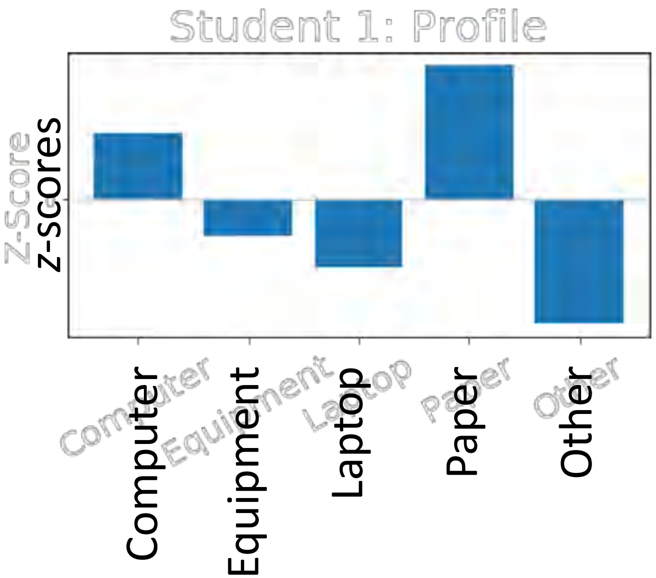
Generate *Student Profiles*

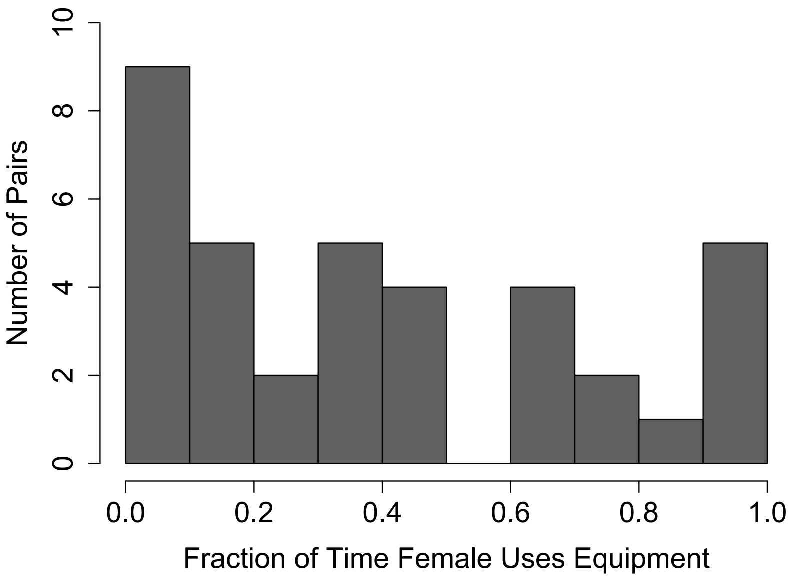


522 Profiles

~3~

Turn each profile into *z*-Scores



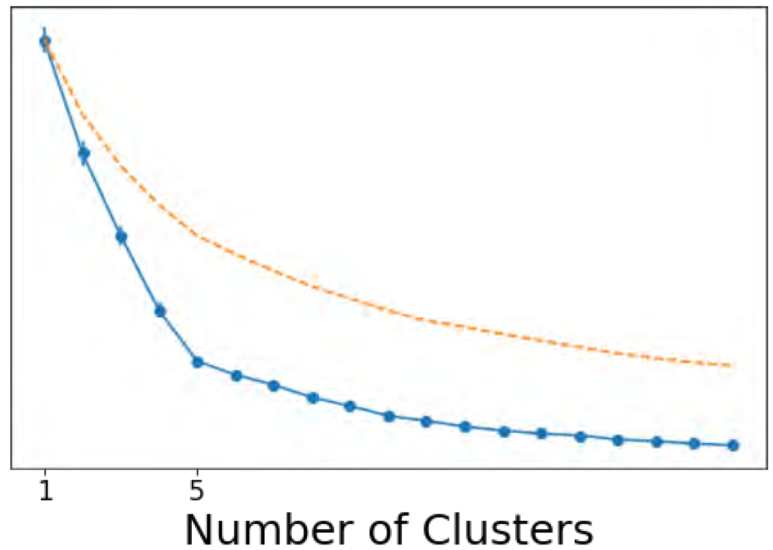


Why z-scores and cluster analysis?

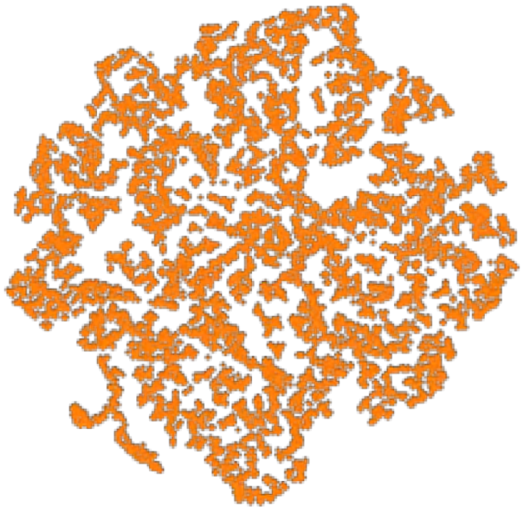
Cluster analysis

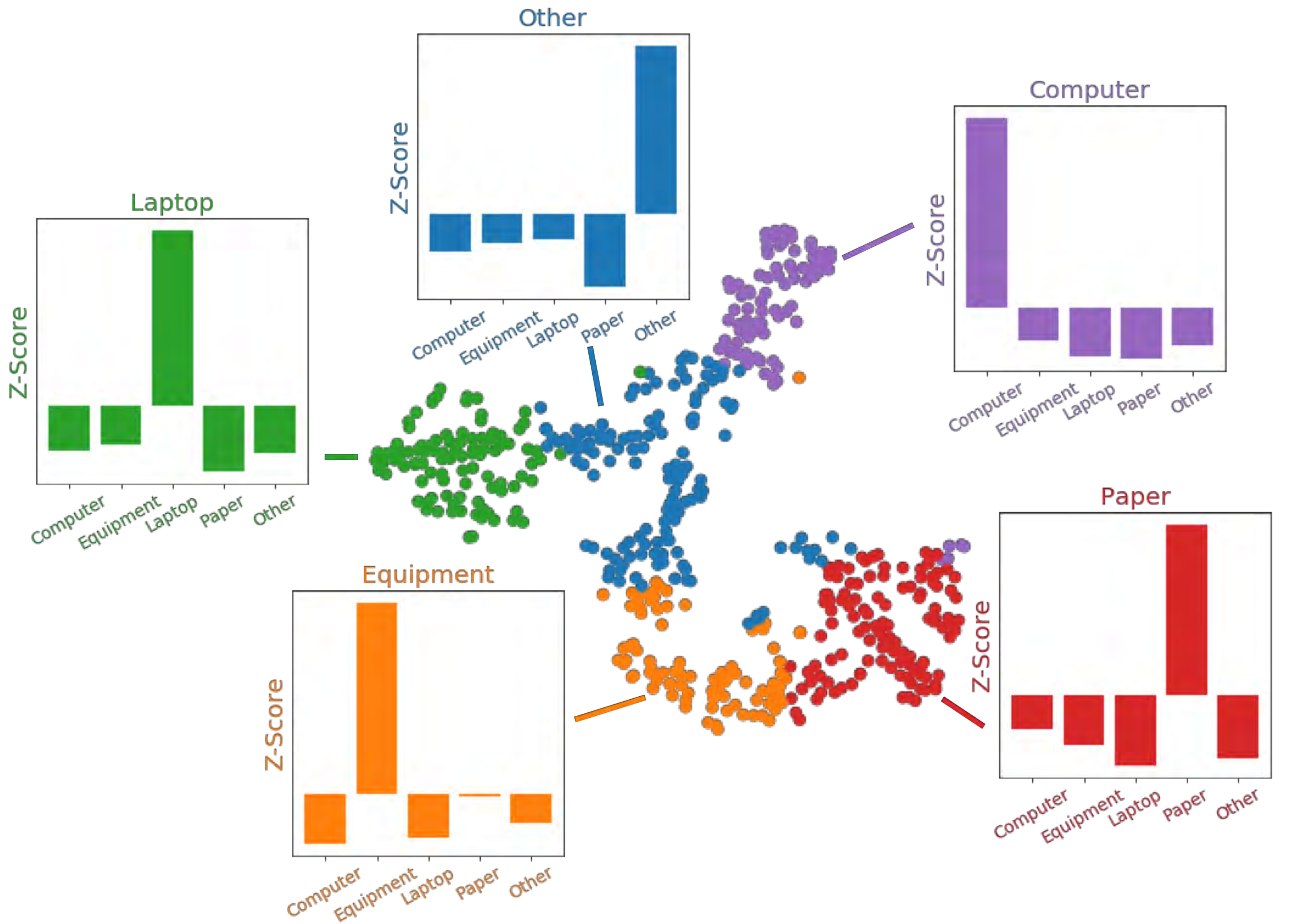
Student Profiles

Average Squared Distance

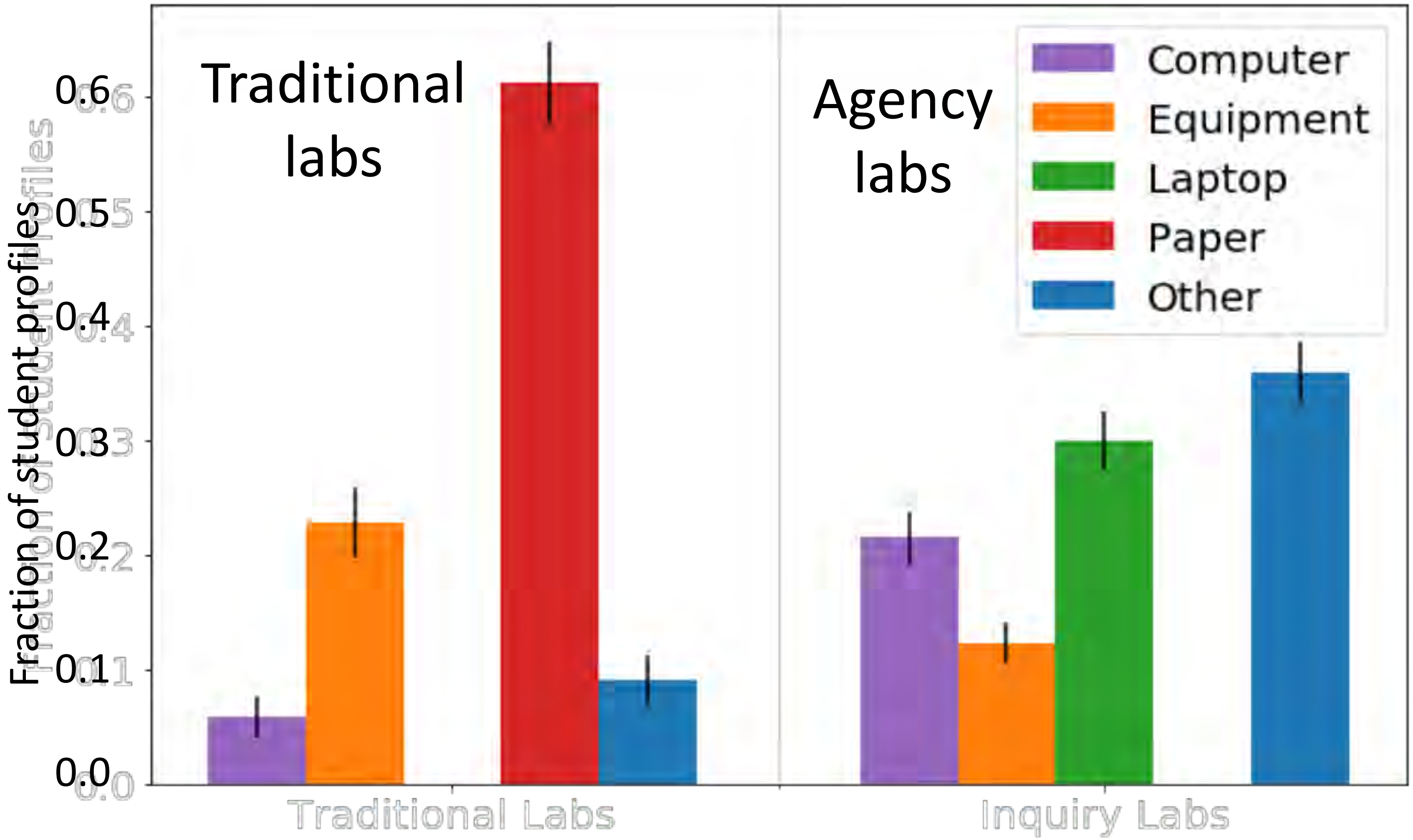


Random Profiles

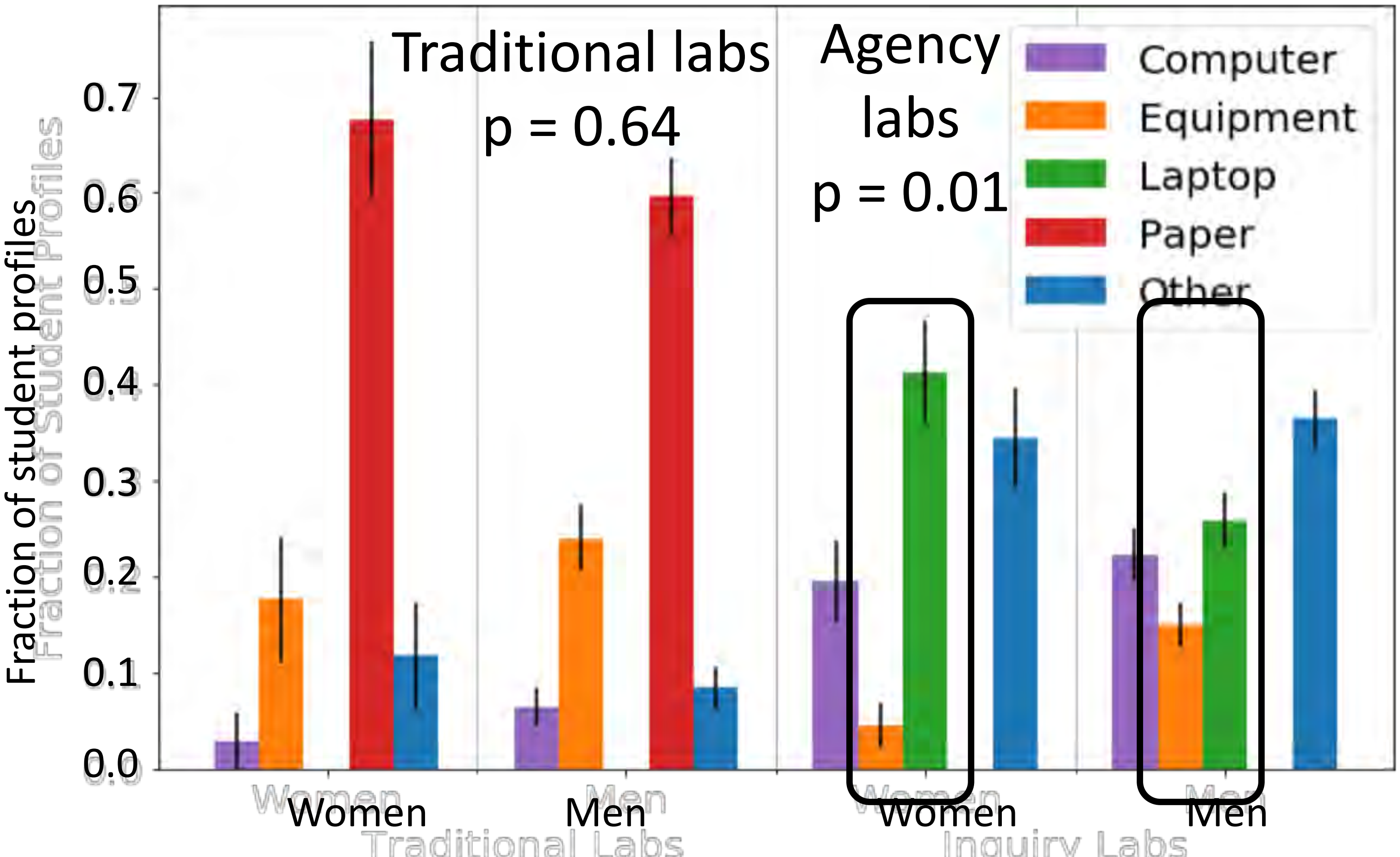


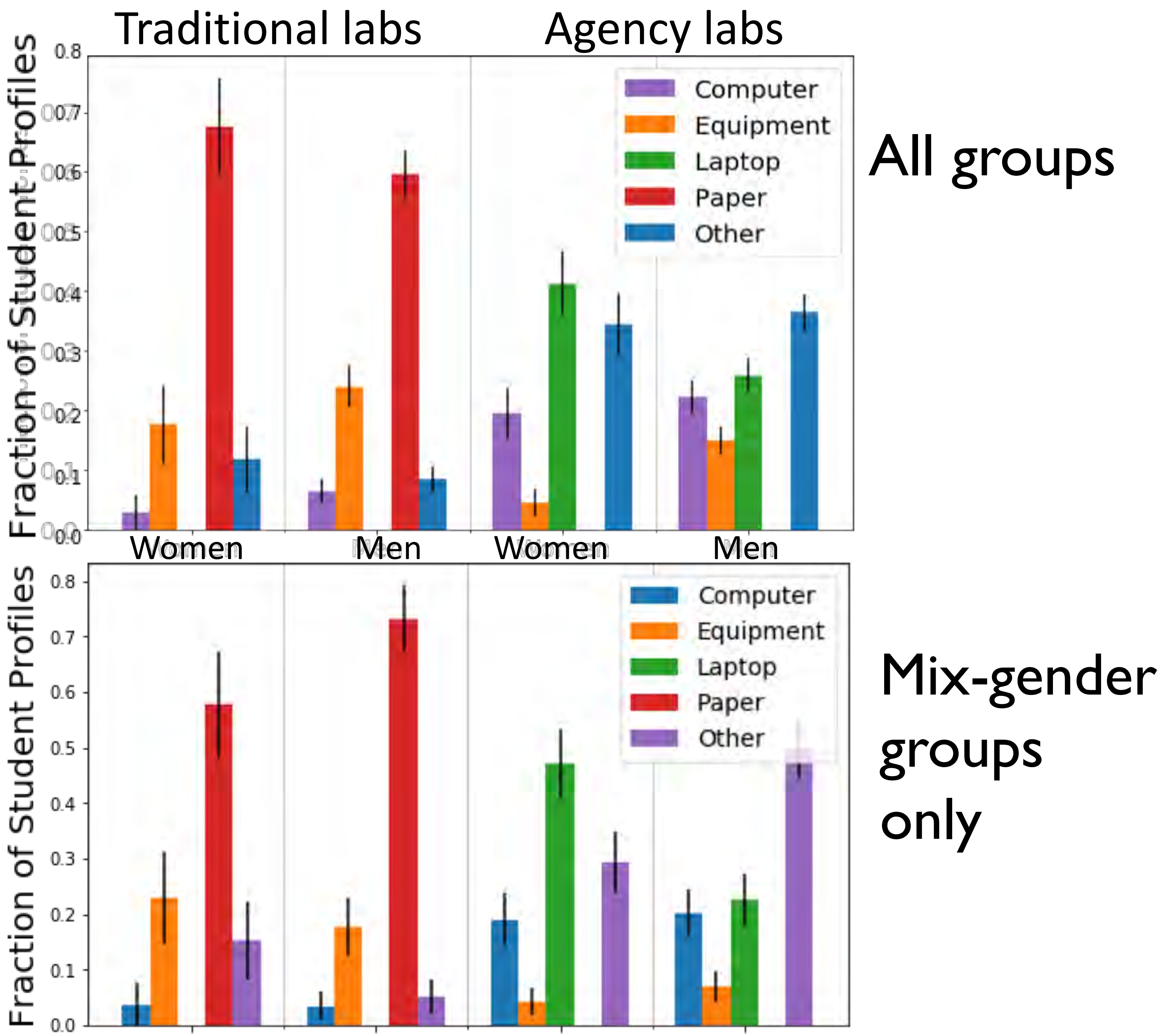

Other
Z-Score
Computer
Equipment
Laptop
Paper
Other
Computer
Z-Score
Computer
Equipment
Laptop
Paper
Other
Laptop
Z-Score
Computer
Equipment
Laptop
Paper
Other
Equipment
Z-Score
Computer
Equipment
Laptop
Paper
Other
Paper
Z-Score
Computer
Equipment
Laptop
Paper
Other

Cluster composition: course type

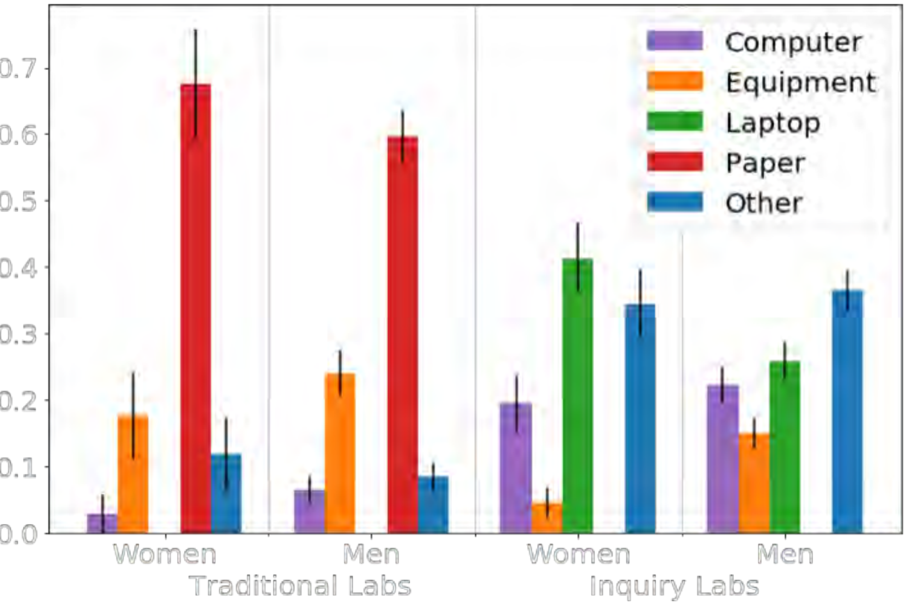


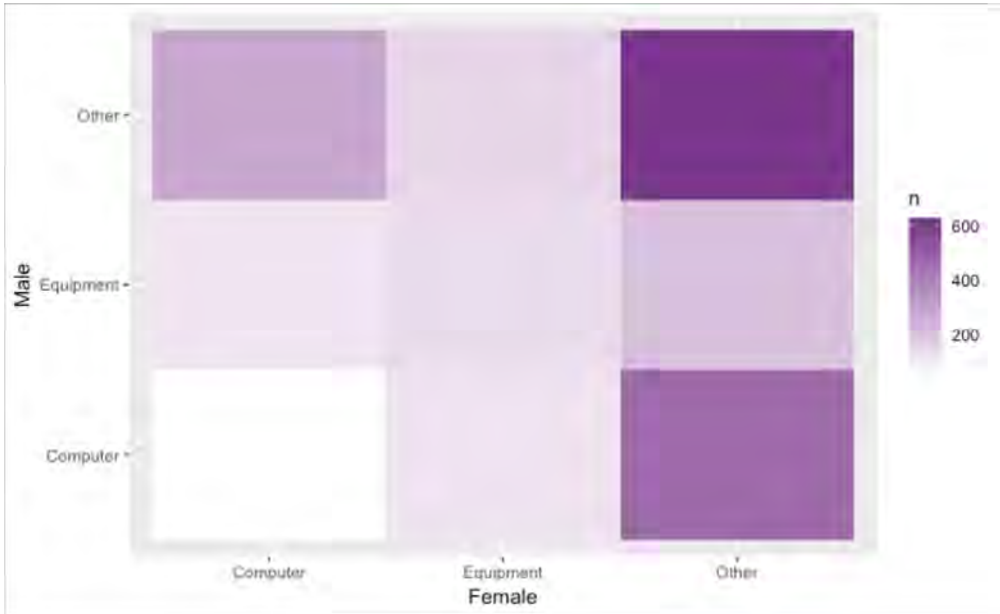
Cluster composition: course type x gender (all students)





Traditional labs
Agency labs
All groups
Mix-gender groups only
Fraction of Student Profiles
Women
Men
Women
Men
Computer
Equipment
Laptop
Paper
Other
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8





Q: What's going on with "Other"?

Tasks ? hands-on

EQUIPMENT

COMPUTER

LAPTOP

PAPER

OTHER

Individual group video

		Men	Women	Total
Cluster	Laptop	4	5	9
	Equipment	1	0	1
	Desktop	1	0	1
	Other	3	4	7
		9	9	18

What are the tasks?

Traditional

Highly structured.

Everyone does the same thing.

Agency

Less structured.

Students choose what to do.

We structured this for designing and conducting experiments, but not equity.

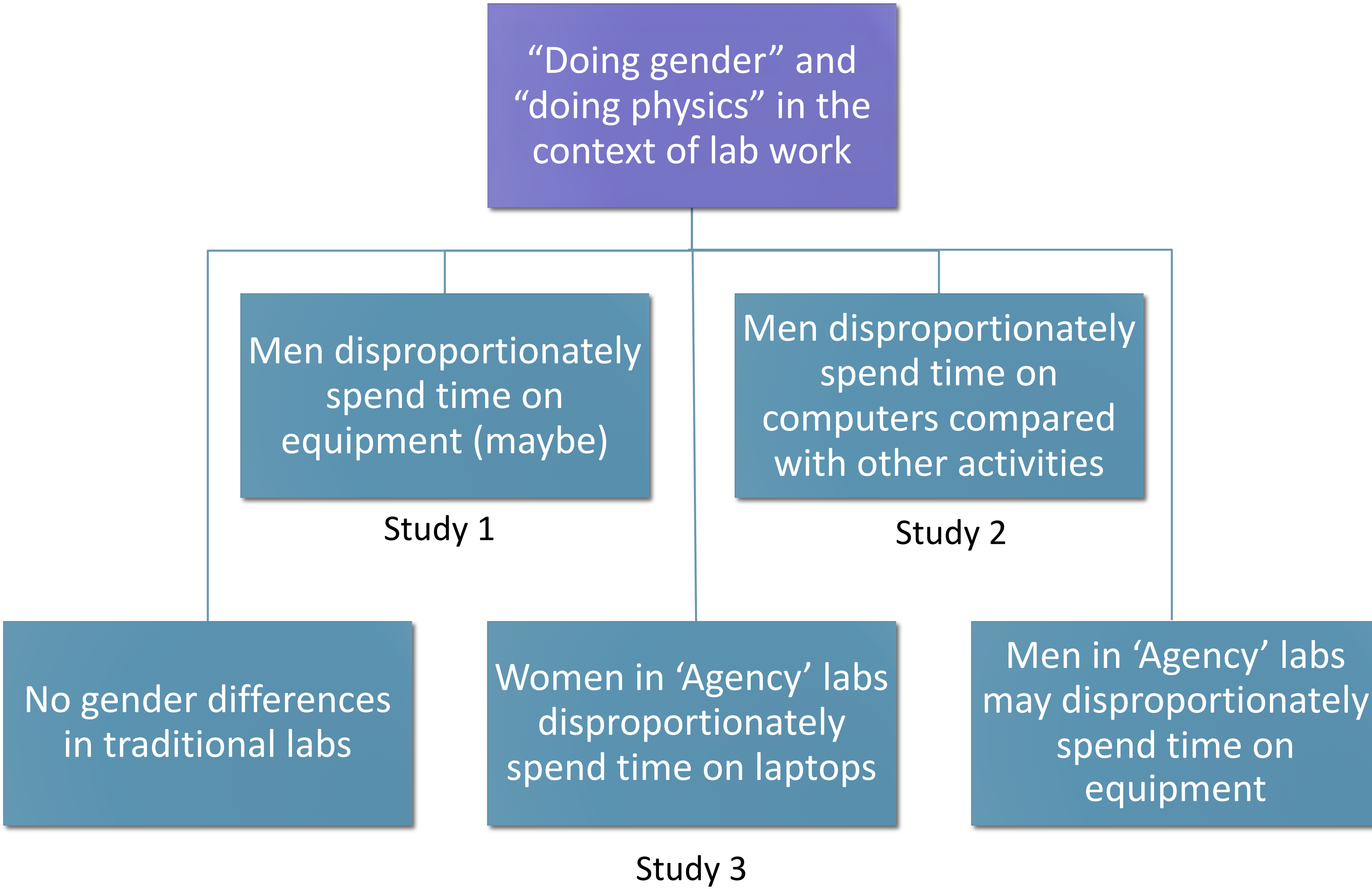
Agency

AN AGENT IS SOMEONE WHO IS MAKING DECISIONS TO PURSUE A GOAL.

Bandura (1989)

*Holmes, Keep, & Wieman (*under review*)

†This is not new… (e.g. cooperative group roles…)


"Doing gender" and "doing physics" in the context of lab work
Men disproportionately spend time on equipment (maybe)
Study 1
Men disproportionately spend time on computers compared with other activities
Study 2
No gender differences in traditional labs
Women in 'Agency' labs disproportionately spend time on laptops
Men in 'Agency' labs may disproportionately spend time on equipment
Study 3

Take-aways:

1. Type of instruction matters.
2. Need to support equity if you give students agency.

Men disproportionately spend time on equipment (maybe)

Study 1

Men disproportionately spend time on computers compared with other activities

Study 2

No gender differences in traditional labs

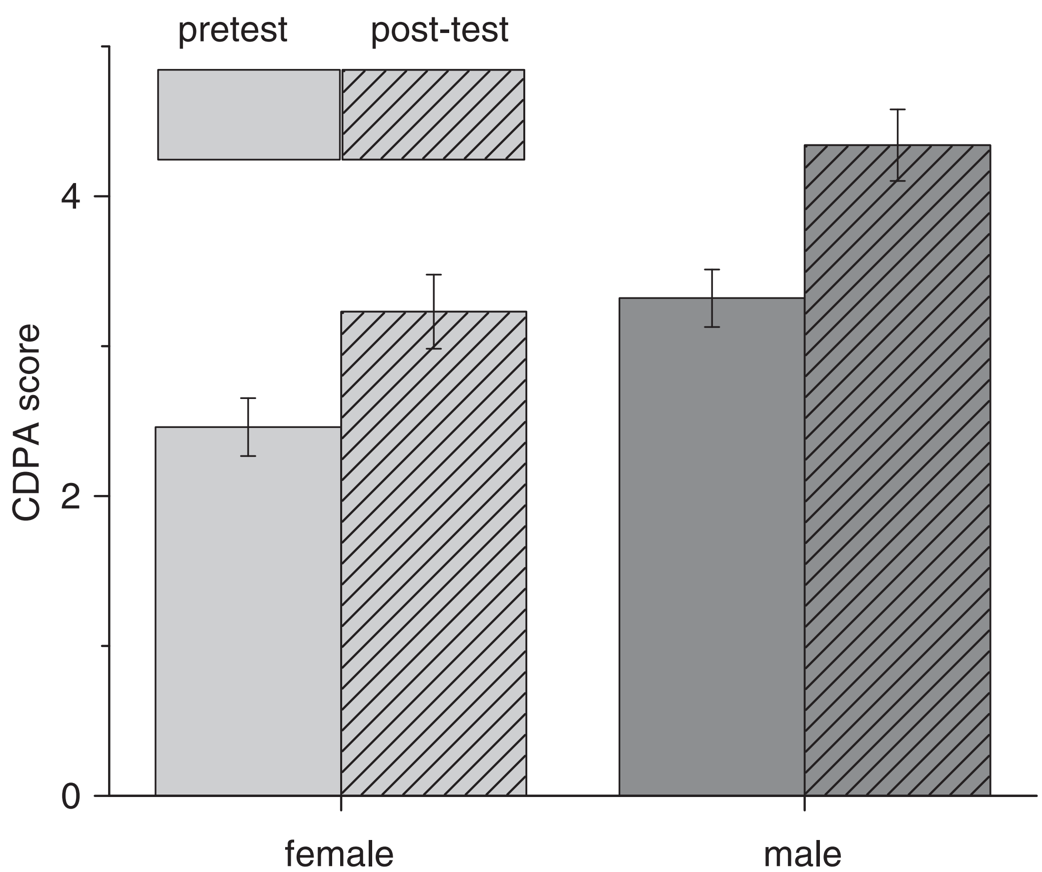
Women in 'Agency' labs disproportionately spend time on laptops

Men in 'Agency' labs may disproportionately spend time on equipment

Study 3

“I’m pretty sure you just told me to use highly structured traditional labs.”

I can’t see why you might think that…



BUT no correlation with scores and computer usage

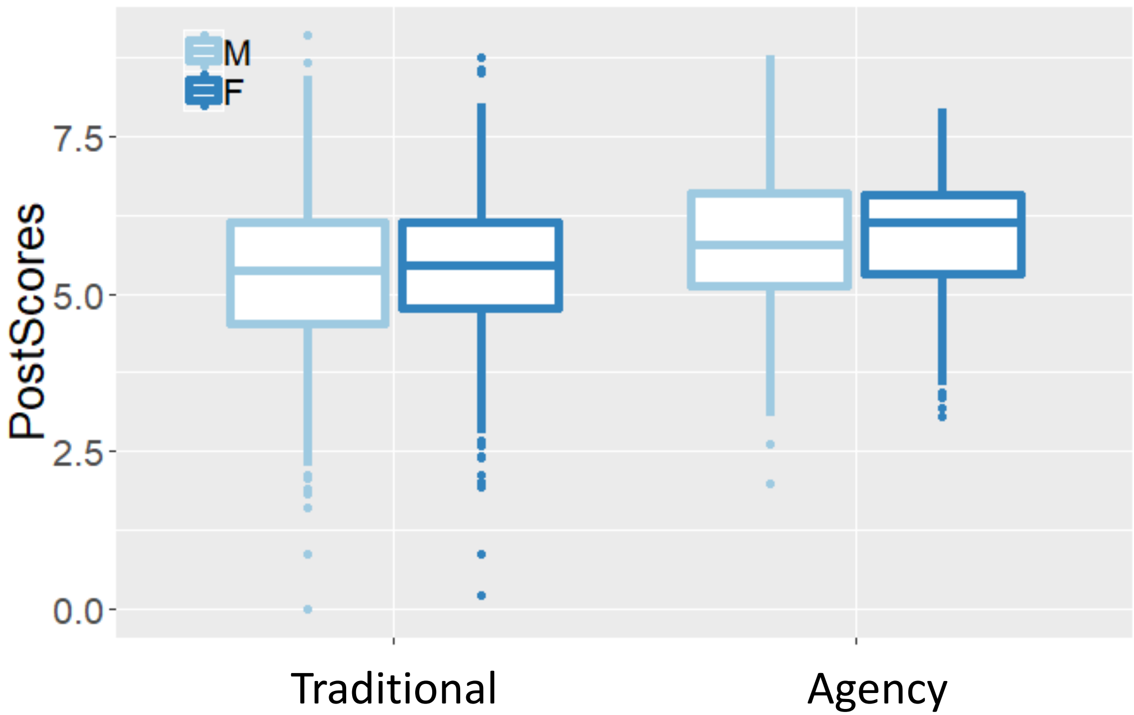
$^{*}r_s = 0.084$, $p = .353$

Remember this?

Day, Stang, Holmes, Kumar, & Bonn (2016) *Phys. Rev. PER*

*Spearman correlation coefficient

Physics Lab Inventory of Critical Thinking (n=1830)



Agency labs improve student critical thinking.
Even more so for women!

Walsh & Holmes (in prep)

Does it matter?

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