Agency and the Equity of Lab Groups

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Purpose

The President’s Council of Cornell Women established the PCCW Affinito-Stewart Grants to assist the university in its efforts to increase the number of women in tenured faculty positions.

PCCW’s primary goals include:

- Expanding the role of women in Cornell’s decision-making groups
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- Attracting outstanding women students, faculty, and staff to Cornell, and enhancing their leadership opportunities
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It is the goal of the PCCW Grants Committee to reach as many Cornell women as possible by awarding grants across all disciplines and schools rather than focusing on specific areas, and by awarding many small grants rather than a few larger grants.

All PCCW grants are made to advance women at Cornell while addressing the university’s priorities.

Affinito-Stewart Grants are intended to lead to:

1. Major funding from foundations or government sources;
2. Publication of books and/or articles in respected scholarly journals; or
3. Other evidence of scholarship appropriate to a specific discipline.

Grant recipients receive funds as transfers to their university accounts at the beginning of the fiscal year following the award. The funds must be used by the end of that fiscal year.

Grant recipients are invited to meet PCCW members at its annual meeting in the fiscal year during which their grants are received.
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
- Kathryn McGill
- Michelle Kelley

**Undergrad:** Zach Whipps

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**Physics**

Affinito-Stewart Grants 2017
Lab work may be “gendered”

James Day
(UBC)
Study 1

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

Holmes, Roll, & Bonn (2014) Physics in Canada
Proportion of time spent on equipment

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

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

\[ F_{score} = 1 \rightarrow \text{Female handling equipment whole time} \]
\[ F_{score} = 0 \rightarrow \text{Female never handled equipment} \]
Proportion of time spent on equipment

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

Predictions?

1) \( F_{\text{score}} = 1 \)

2) \( F_{\text{score}} = 0 \)

3) \( F_{\text{score}} = 0.5 \) and flat or bi-modal

4) \( F_{\text{score}} = 0.5 \) and skewed towards 1

5) \( F_{\text{score}} = 0.5 \) and skewed towards 0

Holmes, Roll, & Bonn (2014) *Physics in Canada*
Proportion of time spent on equipment

In this study, we looked at how often female students in mixed gender pairs use the equipment in a physics lab experiment compared to male students. We found evidence that male students may be more likely to take over the equipment (a large peak in the groups where the male student used the equipment more than 80% of the time). While the effect is still marginal at this point, due to a sample size of only 37 pairs, this motivates further investigation with a larger group of students. We aim to repeat the measurement this coming year to increase our sample size and explore this result further.

It is likely that the use of equipment in a lab experiment is dictated by several factors such as physics knowledge, personalities, previous experience conducting experiments, and confidence levels of the group members. What this research suggests is that whichever other psychological or sociological phenomena dictate the use of lab equipment, these traits may differ by gender. Future research should examine whether any patterns of behaviours exist with same-gender pairs and include

Mean 40% ± 6%
(approximately half time)
*χ²(9) = 16.24, p = .06
γ₁ = 0.4 (positive skew)

Holmes, Roll, & Bonn (2014) *Physics in Canada*
Study 2

HOW DO MALE AND FEMALE STUDENTS DISTRIBUTE TASKS IN MIX-GENDER LAB PAIRS?
Tasks $\approx$ 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

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

Day, Stang, Holmes, Kumar, & Bonn (2016) *Phys. Rev. PER*  
*Bhapkar Test of association*
Distributed tasks

Does it matter?

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

Tasks $\approx$ hands-on

Day, Stang, Holmes, Kumar, & Bonn (2016) *Phys. Rev. PER*
Scores on Concise Data Processing Assessment*

\[ F(1,468) = 16.86^{**}, \ p < .001, \ \eta^2_{\text{partial}} = 0.035 \]
The six assumptions that must first be considered in order to unwittingly be filling the literature with non-replicable research, even a traditional researcher who adopting a traditional procedure.

The CDPA is included in Appendix B. On the pretest, there are shown in Fig. 2 and Table I. These low scores demonstrate that the CDPA is a difficult assessment; in Appendix A.

The two performance item by item shows that the gap is fairly difficult for all students. The quality of fit of a linear model to data, which are equally exceptions are both questions that require judging the gap favoring males, which has a value of (t) 4.69.

To help avoid the fate of nonreplicable results here, the pretest post-test (solid columns) results for the populations studied. The raw CDPA score is out of a maximum possible of ten points. Our students are and 280 male students (the ones for which we have paired pre- and post-test data).

The 95% confidence interval. These data consist of 191 female and 280 male students, but the status quo remains. Uncertainty bars represent learning, but the status quo remains. Uncertainty bars represent how or whether the assumptions should be checked.

The robustness of the techniques with regards to the assumptions, and post-test data. A recent review of the literature on the gender gap on concept inventories in physics provides a summary of these data:

For the pretests and post-tests, for each of the seventeen studies, against which we can contrast our effect size.

Figure 3 shows a histogram of the effect sizes, on seventeen separate studies that they reviewed in particular, see Figs. 1 and 2 of Madsen et al. in overestimation or underestimation of inferential measures can influence both type I and type II errors, as well as result in overestimation or underestimation of inferential measures.

An effect size is a quantitative measure of the strength of a particular phenomenon. Knowing the magnitude of an effect—or whether there is a significance. We use Hedges et al. and mean differences to calculate effect sizes, which allows us to ascertain the practical significance of statistical barter.

A large effect size is one that is big enough and/or consistent enough but which you can only see through careful study. A large effect size is one that is big enough and/or consistent enough that you may be able to see it through careful study. A large effect size is one that is big enough and/or consistent enough that you can only see through careful study. A large effect size is one that is big enough and/or consistent enough that you can only see through careful study.

A medium effect size lies between the above two. A small effect size is one in which there is a small absolute difference does not take into account the variability in scores[29].

— something is really happening in the world— but which you can only see through careful study. A large effect size is one that is big enough and/or consistent enough that you can only see through careful study. A large effect size is one that is big enough and/or consistent enough that you can only see through careful study.

— but which you can only see through careful study. A large effect size is one that is big enough and/or consistent enough that you can only see through careful study.
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.
Benefits of agency include

- Learning
- Self-efficacy
- Motivation
- Persistence in STEM

Bandura 1982; 1989; Carlone et al. 2015; Calabrese Barton & Tan 2010; Ko et al. 2014...
NOT about removing structure.

<table>
<thead>
<tr>
<th>Change goals</th>
<th>Traditional</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforce concepts</td>
<td>Experimentation skills</td>
<td></td>
</tr>
<tr>
<td>&quot;Do this four times.&quot;</td>
<td>&quot;How many trials will you run?&quot;</td>
<td></td>
</tr>
</tbody>
</table>
| "Take the mean and standard error." | "How will you analyze your data?"

1Holmes & Smith, in press with *The Physics Teacher*  
2Holmes, Keep, & Wieman, under review  
*Agency labs, see www.PhysPort.org/curricula/thinkingcritically
Study 3

HOW DO MALE AND FEMALE STUDENTS DISTRIBUTE TASKS IN DIFFERENT LABS?
Tasks ≈ hands-on

EQUIPMENT  COMPUTER  LAPTOP  PAPER  OTHER

Quinn, McGill, Kelley, Smith, & Holmes, 2018 PERC Proceedings
Comparing traditional and agency labs

|                             | Control                  | Agency                                  |
|                             | Conceptual physics       | Uncertainty and data analysis           |
|                             |                         | Critical thinking skills                |
| Learning objectives         | Individual Worksheets   | Group e-Notebooks                       |
| Student products            |                         |                                        |
| 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

~3~
Turn each profile into z-Scores

143 Students
522 Profiles
Why z-scores and cluster analysis?

DISCUSSION

In this study, we looked at how often female students in mixed gender pairs use the equipment in a physics lab experiment compared to male students. We found evidence that male students may be more likely to take over the equipment (a large peak in the groups where the male student used the equipment more than 80% of the time). While the effect is still marginal at this point, due to a sample size of only 37 pairs, this motivates further investigation with a larger group of students. We aim to repeat the measurement this coming year to increase our sample size and explore this result further.

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Cluster analysis

Student Profiles

Average Squared Distance

Random Profiles

Number of Clusters
Cluster composition: course type

![Bar chart showing the fraction of student profiles in Traditional and Agency labs. The bars for Traditional labs are much higher than those for Agency labs, indicating a significantly larger proportion of student profiles in Traditional labs.](chart.png)
Cluster composition: course type x gender (all students)

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agency labs</strong></td>
<td>p = 0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Traditional labs</strong></td>
<td>p = 0.64</td>
<td></td>
</tr>
</tbody>
</table>
Q: What’s going on with “Other”?
Tasks ⚒ hands-on

- EQUIPMENT
- COMPUTER
- LAPTOP
- PAPER
- OTHER

?
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Men</th>
<th>Women</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laptop</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Equipment</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Desktop</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>9</strong></td>
<td><strong>9</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>
What are the tasks?
AN AGENT IS SOMEONE WHO IS MAKING DECISIONS TO PURSUE A GOAL.

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.

*Holmes, Keep, & Wieman (under review)  †This is not new… (e.g. cooperative group roles...)

Bandura (1989)
“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 - Study 3

Women in ‘Agency’ labs disproportionately spend time on laptops - Study 3

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.

**Study 1**
Men disproportionately spend time on equipment (maybe)

**Study 2**
Men disproportionately spend time on computers compared with other activities

**Study 3**
- 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
“I’m pretty sure you just told me to use highly structured traditional labs.”

I can’t see why you might think that...
Remember this?

BUT no correlation with scores and computer usage

\[ r_s = 0.084, p = 0.353 \]
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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**Physics**

**Biology**

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