Promise and Pitfalls of Reformed Instruction for Female Students

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Two Part Workshop

I. Gender in the big picture and its role in science (and vice versa)

II. Rising to the concrete: research / practice that might have something to say about undergraduate education
Good news about gender

- Nearly half of HS physics students are girls
- Undergrad male and female majors pursue physics careers in the same proportions
Why be concerned?

- Boys outperform girls on K-12 standardized science tests (NAEP, IAEP, TIMMS)
- K-12 science gender disparities increase with age
- In AP physics only 36% (AP-B) or 27% (AP-C) of students are girls
- Only 22% of bachelor’s degrees in physics are earned by women
Physics Statistics

- 20 PhD institutions with 4 female faculty
- < 20% of PhD’s go to women
- ~ 20% Undergraduate majors
- Performance gap, dropout rates


<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
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Table 11. Number and percent of physics degrees granted to US citizens by minority status, class of 2003.

<table>
<thead>
<tr>
<th>Minority Status</th>
<th>Bachelor's</th>
<th>Exiting Master's</th>
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<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
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<tr>
<td>African-American</td>
<td>152</td>
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<tr>
<td>Hispanic-American</td>
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<td>3</td>
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<tr>
<td>White</td>
<td>3711</td>
<td>87</td>
</tr>
<tr>
<td>Asian-American</td>
<td>171</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>110</td>
<td>3</td>
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<tr>
<td>Total US Citizens</td>
<td>4258</td>
<td>100%</td>
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Note: A form change occurred in 1994 resulting in a more accurate representation of women among physics bachelors. Some of the increase in 1994 only may be a result of that change.
How do we explain this?

To examine gender effects in education and scientific professions, begin by examining gender in our society.
A common language

Schiebinger’s definitions: (pg 8 & 16)

**Gender** - power relations between the sexes

**Female / Male** - biological sex

**Feminine / Masculine** - idealized mannerisms and behaviors of women / men in a particular culture - might also be adopted by other sex

**Gender ideologies** - acceptable traits for men and women

**Gender identity**: - how any individual appropriates aspects of gender ideology

**Gender ascription** - behaviors expected of an individual based on sex
M/C Question

a) Science is gendered but only through practice (the content, subject matter is neutral)
b) Science is gendered in both content and practice
c) Science is not gendered
d) It depends on specific activities (some science is, some is not)
Broad framing questions

Is science gendered
  – In practice?
  – In content?

What might gender-explicit science look like
  – In practice?
  – In content?

What might gender-inclusive education look like?
Exercise

- Identify and discuss classroom practices that is gendered

- Identify and discuss science practices that are gendered
Is this a matter

• Of privilege and power?
  – It’s not a matter of exclusion
  – But science is predisposed / supportive of a particular paradigm

• For the marginalized to solve?
Promise and pitfalls of reformed instruction for female students: Part II

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Pedagogy and gender

Some proposed sources of K-12 gender gap:

- Girls have less hands-on experience with science
- Science perceived as a male activity: girls are less confident and encouraged less
- Girls perceive (physical) science as less beneficial to society
- Teachers often interact less with girls than with boys
- Boys often dominate classroom activities

References provided in separate bibliography
Pedagogy and gender

Some teaching practices that appear to help:
- Hands-on experiences
- Non-competitive environment
- Opportunities for all students to ask and explain
- Frequent feedback (praise and constructive criticism) to all students
- Placing science in a wider context
Interactive engagement

Research-based pedagogies:

☐ Involve all students actively in learning
☐ Require students to articulate their ideas
☐ Frequently involve collaborative or cooperative activities
☐ Frequently involve hands-on activities

Student learning gains demonstrated thoroughly by PER

Do male and female students respond differently?
Study: effect of pedagogy

- Calculus-based introductory physics for non-majors at Harvard University, 1990 - 1997
- 150-200 students each year, 30-40% women
- Administered Force Concept Inventory as pre- and post-test
Study: effect of pedagogy

Three pedagogies:
- Traditional (passive lecturing)
- Partially interactive (IE1): *Peer Instruction* in class, traditional discussion section
- Fully interactive (IE2): *Peer Instruction* in class, *Tutorials* and cooperative groups in section
Study: effect of pedagogy

*Peer Instruction:*
- Lectures interspersed with conceptual questions
- All students given time to think, respond, and discuss
- Students gain conceptual understanding
- Quantitative problem-solving skills remain strong

Study: effect of pedagogy

*Tutorials*: (Univ. of Washington PERG)

- Students work in small groups through guided exercises
- Exercises focus on research-identified student difficulties
- Exercise require students to explain their ideas

*Cooperative group problem solving*: (Heller group)

- Students instructed in problem-solving strategies
- Groups of three work on challenging problems
Results: FCI pretest

Female students start out behind
Results: FCI posttest

Fully interactive instruction eliminates gap!
Results: FCI normalized gain

\[ g = \frac{\text{post} - \text{pre}}{100 - \text{pre}} \]
Results: low and high scores

Both male and female low posttest scores eliminated
Comparable numbers of male and female high scorers
Results: grades

traditional

IE1
Results: grades

More comparable grade distributions with IE2
Why IE2?

- Consistent emphasis on concepts and understanding
- Provides more practice articulating ideas
- May increase female students’ confidence and comfort with interaction
- Research required to understand this!
Does it always work?

- Algebra-based: females gained more, but didn’t catch up
- Calculus-based: may be saturating the test
How do male and female students perform at U Colorado?
Gender Gap (FMCE) at CU
(male score - female score)
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(male score - female score)
Gender Gap (FMCE) at CU
(male score - female score)
Gender Gap (FMCE) at CU
(male score - female score)
Gender gap (BEMA) 
CU 2nd semester (E&M)

Gender Gap in 1120 Pre and Post Test Scores

- Fall 04
- Spring
- Fall 05
- Spring 06
- Fall 06

* denotes significance
Gender gap (BEMA)
CU 2nd semester (E&M)
Summary (FMCE)

- No elimination of gender gap
- Considerable instructor effects term to term
Summary (FMCE)

- Difference in male / female gain <g>
- IE2 still better than IE1
Summary (BEMA)

- Create gender gap
- Smaller than 1st semester gap
What might be the problem?

Not all students are the same:
- Harvard calculus-based: students may be particularly confident and outspoken

Not all instruction is the same
- Participation may not be equally useful for students
- Participation may not be equally widespread
- Cooperative classroom environment essential
- Students must value the discussion process
Pitfalls of interactive engagement

Female students may:
- Want someone to give them the answer (instructor or a more capable peer)
- Be less willing to disagree with their peers
- Find the discussion process more intimidating

Students are individuals:
- some males lack assertiveness, confidence
- some females are very assertive and confident!
Discussion

- Describe the teaching strategies you use in your classroom
- Describe how to make these strategies more or less female-friendly
- What still needs to be learned?
Acknowledgements

- Work supported by the NSF
- Harvard collaborators: Eric Mazur, Mercedes Lorenzo, and Jessica Watkins
- UC-Boulder collaborators: Steven Pollock, Michael Dubson, and the PER@C group
- Invaluable input from Apriel Hodari (CNA Corporation), Melissa Dancy (UNC-Charlotte), Laura McCullough (UW-Stout)
## FCI and MBT data

<table>
<thead>
<tr>
<th>Group</th>
<th>Year</th>
<th>$N^M$</th>
<th>$N^F$</th>
<th>MBT (%)</th>
<th>$S^M$</th>
<th>$S^F$</th>
<th>$S^M - S^F$</th>
<th>$p$-value</th>
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<td></td>
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<td>82 (14)</td>
<td>78 (13)</td>
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### FCI pretest score (%)

<table>
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<th>$S^M_i - S^F_i$</th>
<th>$p$-value</th>
<th>$S^M_f$</th>
<th>$S^F_f$</th>
<th>$S^M_f - S^F_f$</th>
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<td>74 (15)</td>
<td>62 (16)</td>
<td>12</td>
<td>&lt; 0.0001</td>
<td>86 (8.6)</td>
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<td>72 (14)</td>
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<td>72 (18)</td>
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### MBT (%)

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<th>IE1</th>
<th>1990</th>
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## FCI gain data

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<th>FCI average normalized gain (%)</th>
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</tr>
<tr>
<td></td>
<td>22 (14)</td>
<td>29 (18)</td>
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** These $p$-values are calculated from the distributions of individualized normalized gain for males and for females. No $p$-values are calculated for the $T$ group because of the lack of a pretest; the gains are calculated using the average IE pretest.