The Persistence of the Gender Gap in Introductory Physics

Lauren Kost, Steven Pollock, Noah Finkelstein
Department of Physics, University of Colorado at Boulder
per.colorado.edu

Introduction and Background

Previously, we observed a ***gender difference of 10%*** on the pre and post FMCE[1] at CU. The posttest gender gap exists in both partially and fully interactive courses.[2] Prior research suggested that ***differences in student background and preparation*** may contribute to the persistence of the gender gap.[3]

Several researchers have investigated the ***factors that influence student performance*** in introductory physics. These factors include: high school physics experience[4], math preparation[5], affective factors[4], level of interactive engagement[2,6,7].

Course and Student Population

7 semesters of intro calc-based mechanics (sp 04 – sp 07)

IE1: Peer Instruction using ConcepTests[8], online homework systems[9], and voluntary help-room sessions on problem solving homework
IE2: Additionally used *Tutorials for Introductory Physics*[10]

Student population is

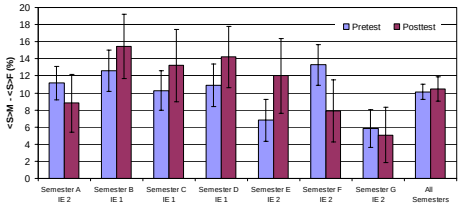
- 25% female
- 50% engineering majors
- 6% physics majors
- 80% white
- 87% took high school physics
- 400 to 600 students per semester

Data Sources

Variables	Data Collected
Post physics conceptual understanding	FMCE Posttest
Prior physics conceptual understanding	FMCE Pretest
Prior academic achievement	High school GPA
Prior math understanding	SAT-Math, ACT-Math, 2 CU placement tests
Course preparation for college physics	Yrs. high school physics and calculus
Prior attitudes and beliefs about physics and about learning physics	CLASS pretest[11]
Demographics	gender, major, ethnicity

Differences by Gender

Conceptual Understanding

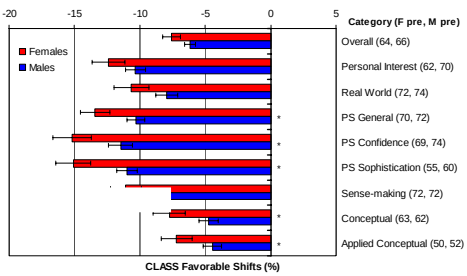


The gender gap sometimes increases from pre to posttest, sometimes decreases, and sometimes stays the same.

Faculty and class practices influence the gender gap.

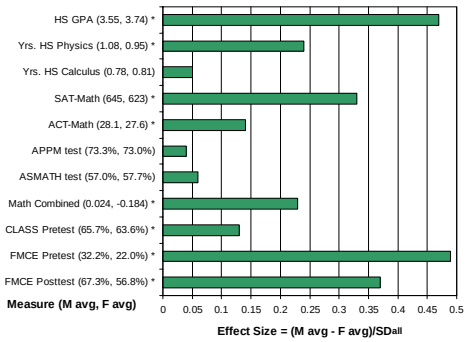
All error bars represent standard errors of the mean.
* indicates statistically significant at p<0.05.

Attitudes and Beliefs



Both male and females shift towards less expert-like attitudes and beliefs; females have more negative shifts in all categories. *Males and females experience the course differently.*

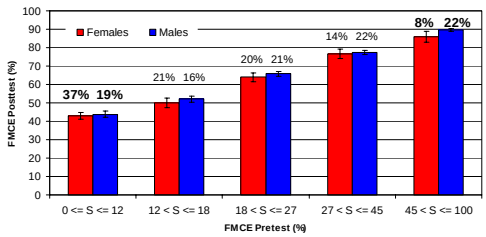
Student Background



There are significant differences in the backgrounds of males and females. *Males and females are differently prepared for introductory physics course.*

Correlations with Background

Impact of Pretest



Students are binned by pretest score and then male and female average posttest scores are calculated. There are *no significant differences ($p>0.1$) in any individual bin.* Percentages indicate the percentage of the women (men) from the total in each bin. Correlation between pre and post test is r = 0.56.

Impact of High School Preparation

FMCE PRETEST (%)	Males	Females	M – F
Had HS Physics	33.5	23.9	9.6 *
No HS Physics	20.2	15.8	4.4 *
Phys. – No Phys.	13.3 *	8.1 *	

FMCE POSTTEST (%)	Males	Females	M – F
Had HS Physics	68.0	58.9	9.1 *
No HS Physics	60.7	44.9	15.8 *
Phys. – No Phys.	7.3 *	14 *	

There are *significant differences ($p<0.01$) between males and females who did and did not take high school physics.*

Regression Analyses

Multiple Regression Analysis

$$FMCEPOST = b_0 + b_1 FEMALE + \sum_{k=2}^{N} b_k VAR_k$$

Predictors	b
Intercept	32.9
Female	**-9.2**
FMCE Pretest	0.59
Combined Math Score	7.2
CLASS Pretest	0.26
2004 Fall Semester	1.3
2005 Spring Semester	-5.6
2005 Fall Semester	-8.7
2006 Spring Semester	-2.9
2006 Fall Semester	-0.93
Female×FMCE Pretest	**0.2**
Multiple R-squared	0.44

$$M - F = 9.2 - 0.2\,FMCEPRE$$

- Estimated *average gender difference is **3.2%***, reduced from the observed 10.7% difference
- **70% of the gender gap in posttest scores can be accounted for by background.**
- Data are non-normal, so we cannot make rigorous statistical inferences.

Logistic Regression Analysis

$$\ln(odds(FMCEPOST > 60\%)) = b_0 + b_1 FEMALE + \sum_{k=2}^{N} b_k VAR_k$$

Predictors	b
Intercept	-2.9
Female	**-0.23**
FMCE Pretest	0.08 *
Combined Math Score	0.55 *
CLASS Pretest	0.02 *
2004 Fall Semester	0.14
2005 Spring Semester	-0.68 *
2005 Fall Semester	-0.75 *
2006 Spring Semester	-0.1
2006 Fall Semester	-0.06
Pseudo R-squared	0.45

- Observed ratio in odds is $odds_F/odds_M = 0.5$.
- After controlling for background, the *ratio in odds is **0.8*** (not statistically different from 1).
- **60% of the gender gap in odds can be accounted for by background.**

Discussion of Results and Conclusions

Interpretation 1: The gap is not due to gender:

- female students with ***similar pretest*** as male students, achieve ***similar posttest scores***
- variation in posttest scores can be ***attributed to factors other than gender***

Interpretation 2: We argue, however, that there is an *implicit* gender bias:

- female students have less physics and math background knowledge and less expert-like attitudes and beliefs
- we do not teach the lower-starting students as well
- ***female students are disproportionately represented in the population that is less supported in these classes***
- student background is the *mechanism* of bias

Findings are consistent with Tatum's "smog of bias"[12] and Valian's "accumulated advantage" [13]

Recognizing that student preparation in physics and mathematics is a means by which this bias is propagated allows us, as researchers and educators, to proactively address the challenges of the gender gap in physics.

Summary

- The gender gap exists in both partially and fully interactive courses.
- Males and females have ***significantly different background and preparation*** for college physics. These differences contribute to the observed gender gap.
- Using regression analyses, we find that ***the gender gap*** (in posttest scores and in odds of scoring above 60%) ***is substantially reduced*** when background and preparation are taken into account.
- Between ***60% and 70% of the gender gap can be accounted for*** by differences in male and female prior physics and math understanding and prior attitudes and beliefs.
- 30% to 40% of the gender gap cannot be accounted for by differences in student backgrounds.

References & Acknowledgements

1. R.K. Thornton and D.R. Sokoloff, *Am. J. Phys.* **66**, 228 (1998).
2. S.J. Pollock et al. *Phys. Rev. ST PER* **3**, 010107 (2007).
3. L.E. Kost et al. *PERC Proceedings 2007*, p. 136.
4. Z. Hazari et al. *Sci. Ed.* **91**, 847 (2007).
5. D.E. Meltzer, *Am. J. Phys.* **70**, 1259 (2002).
6. R.R. Hake, *Am. J. Phys.* **66**, 64 (1998).
7. M. Lorenzo et al. *Am. J. Phys.* **74**, 118 (2006).
8. E. Mazur, *Peer Instruction: A Users Manual*, Upper Saddle River, NJ: Prentice-Hall, 1997.
9. CAPA, http://www.lon-capa.org/; Mastering Physics, http://www.masteringphysics.com/.
10. L.C. McDermott and P.S. Shaffer, *Tutorials in Introductory Physics*, Upper Saddle River, NJ: Prentice-Hall, 2002.
11. W.K. Adams et al. *Phys. Rev. ST PER* **2**, 010101 (2006).
12. B.D. Tatum, *Why Are All the Black Kids Sitting Together in the Cafeteria? And Other Conversations About Race*, New York: Basic Books, 1997.
13. V. Valian, *Why So Slow: The Advancement of Women*, Cambridge: The MIT Press, 1999.

Thanks to PhysTEC (APS/AIP/AAPT), NSF CCLI (DUE0410744) and NSF CAREER (0448176). Thanks to D. Briggs, J. Watkins, the CU Physics Department, and the PER at Colorado group for ongoing support.

Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF)