Gender and student achievement with Peer Instruction

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Introduction

Many PER-based interactive engagement teaching methods are similar to strategies proposed to benefit female physical science students:
- cooperative classroom environment
- opportunities to for all students to discuss and explain ideas
- direct connection between mathematical, graphical, and verbal representations
- diverse, frequent assessment and feedback

Peer Instruction (PI) is one widely used method for actively engaging students that has been shown to increase students' conceptual understanding.

Research question:
Do male and female students benefit differently in classes taught with Peer Instruction, and from classes taught with Peer Instruction combined with other, more structured interactive engagement methods?

We examined three different pedagogies in introductory mechanics at Harvard University:
- traditional instruction (passive lecturing)
- partially interactive (IE1): class taught with PI, traditional discussion sections
- fully interactive (IE2): class taught with PI, Tutorials in Introductory Physics and cooperative group problem solving in section

The calculus-based class was taught with all three pedagogies over seven years, the algebra-based only with IE2 over two years.

Final exam scores and grades

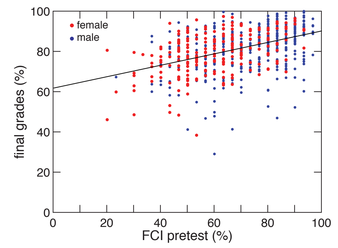
Final exam scores and grades display the same pattern:
- a marginally significant gender gap in the traditionally taught course
- no significant gender gap in the IE2 calculus-based courses (marginal gap in 1997 final exams)
- a statistically significant gender gap in the IE1 calculus-based course (marginal in 1991) and the IE2 algebra-based course that is accounted for by pretest scores

For IE1 calculus-based and IE2 algebra-based, linear regression on final exam scores and on grades shows that gender is not a significant predictor of exam scores or grades when pretest score is included in the regression model. For IE2 calculus-based, gender is not significant even without pretest.

	Model 1	Model 2	Model 3
1995: IE1 calculus-based final grades (N = 188)			
FCI pretest		1.09***	1.07***
gender	-5.63***		-1.31
constant	83.1	58.97	59.76
R-squared	0.065	0.344	0.356
1996: IE2 calculus-based final grades (N = 169)			
FCI pretest		0.597***	0.617***
gender	-1.33		1.09
constant	86.4	73.8	73.02
R-squared	0.006	0.165	0.169
1998: IE2 algebra-based final grades (N = 159)			
FCI pretest		0.571***	0.572***
gender	-2.86**		0.013
constant	86.63	76.82	76.8
R-squared	0.048	0.239	0.239

** $p < 0.01$, *** $p < 0.001$

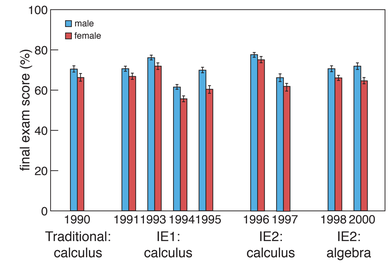
Regression model 1: only variable is gender
Model 2: only variable is pretest
Model 3: both gender and pretest included



Regression plot of student final grade vs. FCI pretest for all students in the IE1 calculus-based courses (all four years). Each point represents a single student. The black line indicates the regression model (coefficients in table). A single regression line matches both the male and the female students.

		Final grade					*Final exam*			
Group	Year	Male	*N*	Female	*N*	M - F	*p*-value	Male	Female	M - F	*p*-value
T calc	1990	83	71	79.89	48	3.11	**0.065**	70.51	66.31	9.38	**0.091**
	1991	83.25	144	81.58	72	1.67	**0.226**	70.6	66.83	3.77	**0.073**
	1993	84.89	143	82.26	79	2.63	**0.054**	76.14	71.89	4.25	**0.036**
	1994	79.32	147	75.86	87	3.46	**0.004**	61.55	55.64	5.91	**0.002**
IE1 calc	1995	83.1	127	77.47	64	5.63	**<0.001**	69.95	60.33	9.62	**<0.001**
	1996	86.4	116	85.07	64	1.33	**0.321**	77.66	75.24	2.42	**0.232**
IE2 calc	1997	81.85	99	80.67	56	1.17	**0.45**	66.39	61.84	4.54	**0.063**
	1998	86.82	71	83.96	88	2.86	**0.006**	70.66	66.1	4.56	**0.018**
IE2 alg	2000	86.37	53	84.09	66	2.28	**0.078**	71.86	64.67	7.19	**0.002**

Average final grades and final exam scores by gender year by year, grouped by method of instruction. A *p*-value of 0.05 indicates that the values being compared (male and female grades or exam scores) differ with 95% confidence.

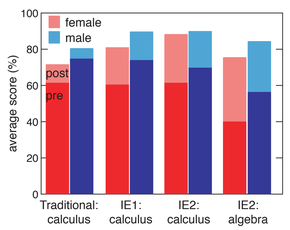


Average final exam scores by gender year by year. Error bars on the graph show the standard error of the data. Corresponding *p*-values are provided in the table above. As can be seen from the table, the equivalent graph for final grades would look very similar.

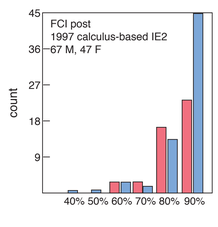
Force Concept Inventory scores

FCI pretest scores consistently show a gender gap.
Posttest scores for the calculus-based class show a reduced gender gap for traditional and IE1 instruction, and show a tiny gap for IE2.
Posttest scores for the algebra-based IE2 class show a reduced gender gap.

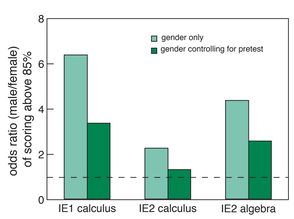
Distributions are skewed toward high scores, so we cannot use linear regression to control for pretest differences; instead we use logistic regression to determine the likelihood of high posttest scores.



Average FCI pretest (dark color) and posttest (lighter color) scores for four different types of instruction and course. No error bars are shown because of the non-normal distributions.



Example of skewed distribution of FCI posttest scores from IE2 instruction.



Male to female ratio of the probability of earning a score above 85% on the FCI posttest. Dashed line indicates equal probability. The IE2 calculus-based ratio found controlling for pretest is not statistically significantly different from one.

In our logistic regression analysis, we convert the FCI posttest score to a categorical variable, either high-scoring (>85%) or low-scoring (<85%) and determine the probabilities for male and female students with the same pretest score to earn high posttest scores.

For the IE2 calculus-based students, male students are more likely to score highly, but when pretest is accounted for, female students are equally likely to earn high scores.

For the IE1 calculus-based students and the IE2 algebra-based students, accounting for pretest reduces but does not eliminate male students' greater likelihood to earn high scores.

Conclusions

Both male and female students benefit from Peer Instruction; female students benefit most in the fully interactive (IE2) calculus-based course. In all interactive courses, FCI pretest scores show a significant gender gap and the posttest gap is reduced or eliminated.

In the calculus-based course, fully interactive (IE2) instruction eliminates the gender gap in grades and FCI posttest scores. Logistic regression indicates that high postttest scores on the FCI are equally likely for males and females when controlling for pretest.

In the partially interactive (IE1) calculus-based course and the IE2 algebra-based course, a marginally significant gender gap in grades can be completely accounted for by differences in preparation as measured by FCI pretest. Logistic regression indicates that much, though not all, of the gender difference in high scoring on the FCI posttest can be accounted for by pretest.

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