Reducing the gender gap in the physics classroom

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Why be concerned?

- Boys outperform girls on K-12 standardized science tests (NAEP, TIMSS)
- 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

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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

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Pedagogy and gender

Some teaching practices that appear to help:

- Placing science in a wider context
- Hands-on experiences
- Non-competitive environment
- Opportunities for all students to ask and explain
- Frequent feedback (praise and constructive criticism) to all students

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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

Do these pedagogies help female students?

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Study: effect of pedagogy

- Calculus-based introductory mechanics 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

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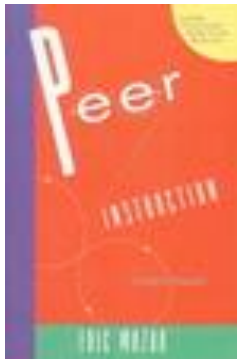
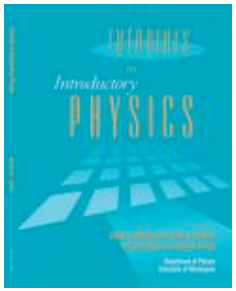
Study: effect of pedagogy

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





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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

Crouch and Mazur, *Am. J. Phys.* **69** (9), 970 (2001).

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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

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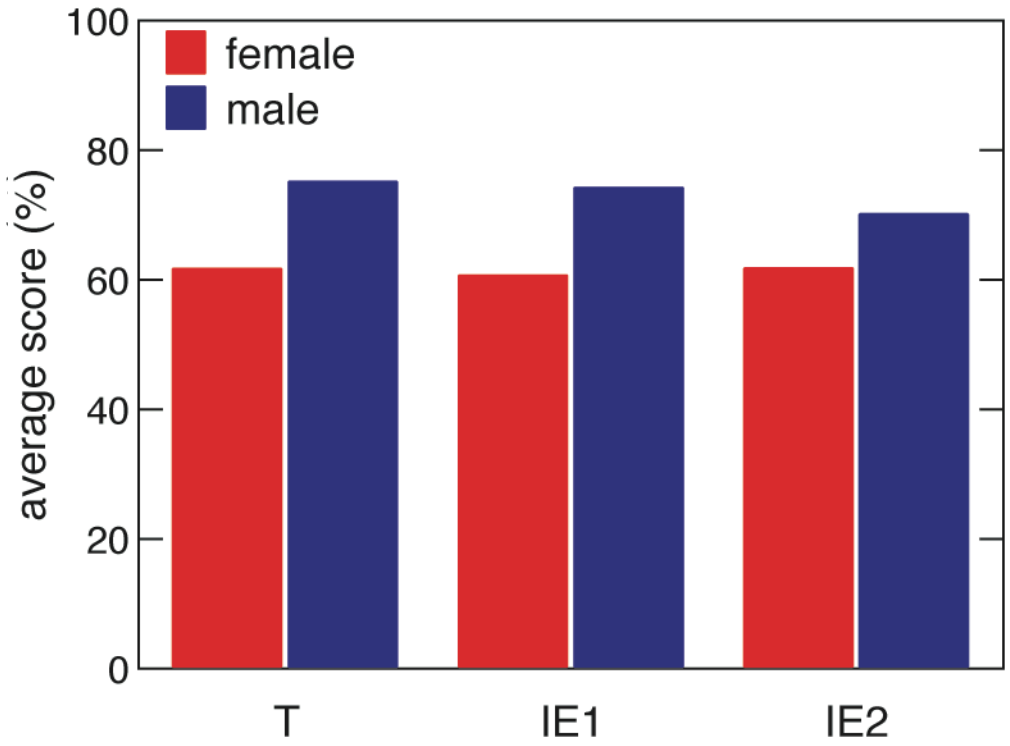
Results: FCI pretest



Female students start out behind

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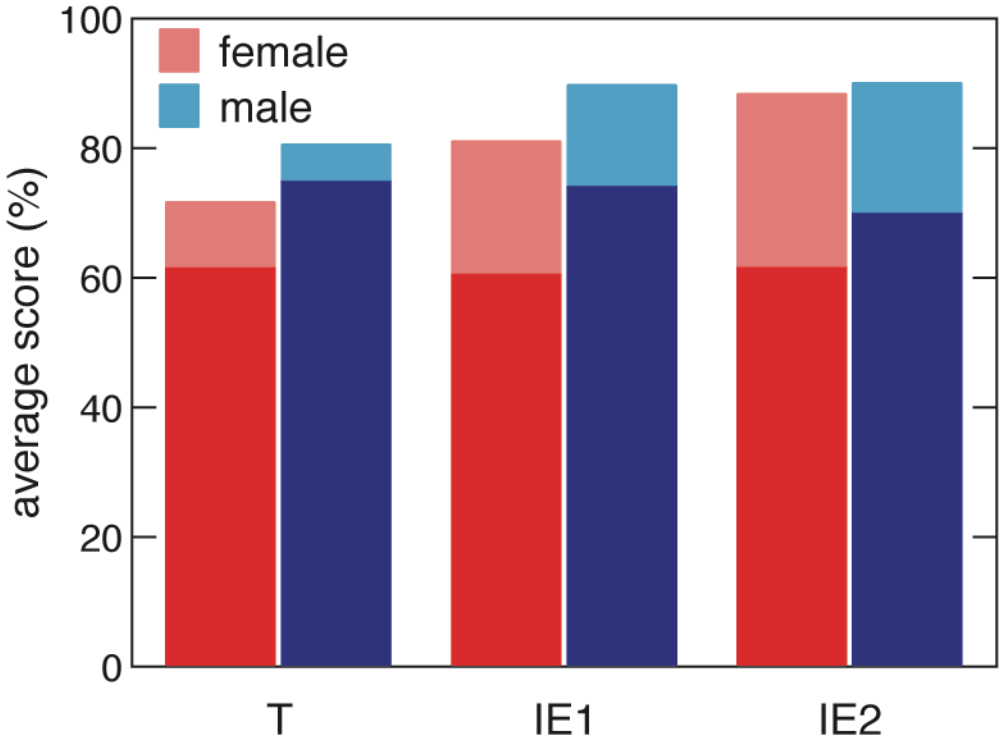
Results: FCI posttest



Fully interactive instruction eliminates gap!

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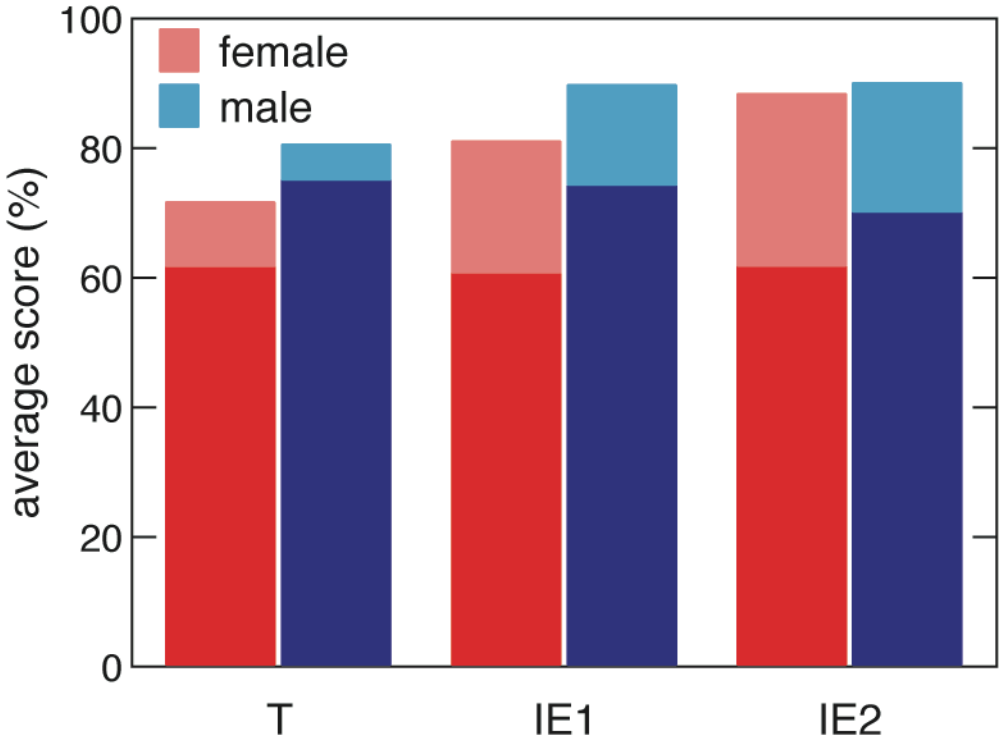
Results: FCI posttest



IE2: similar numbers of male and female high scorers

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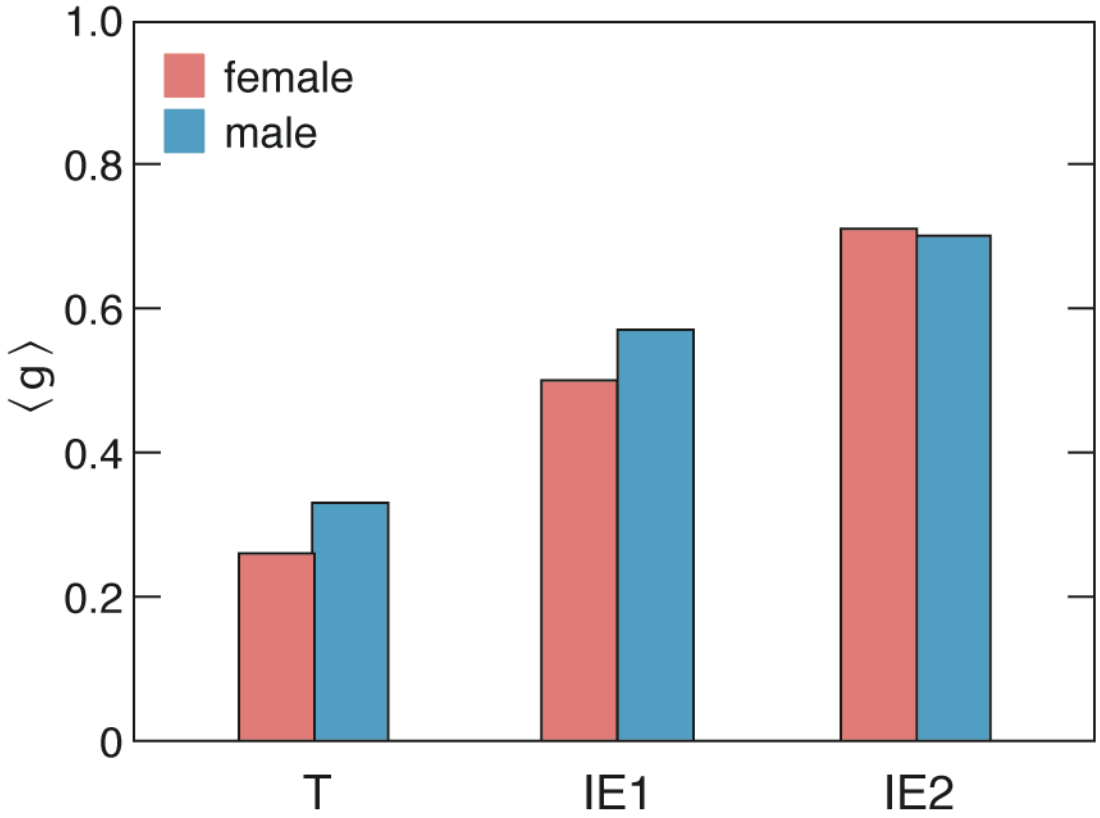
Results: FCI normalized gain

$$g \equiv \frac{post - pre}{100 - pre}$$



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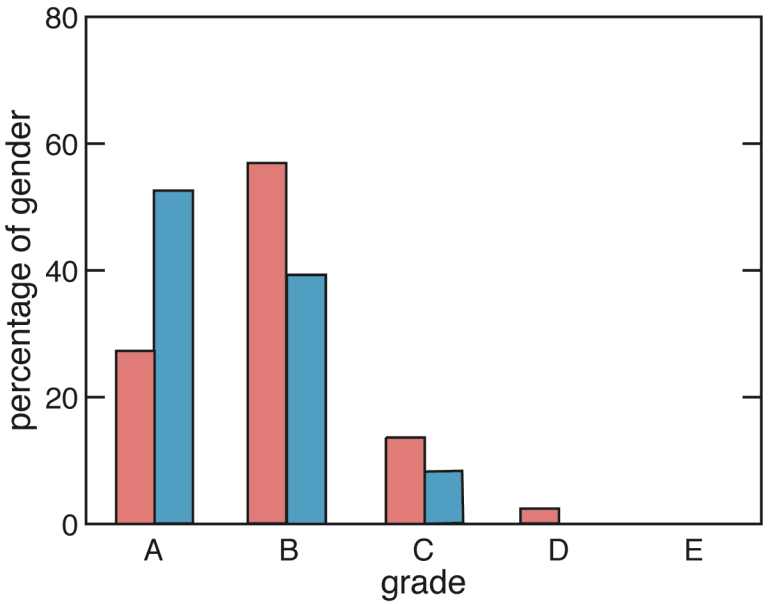
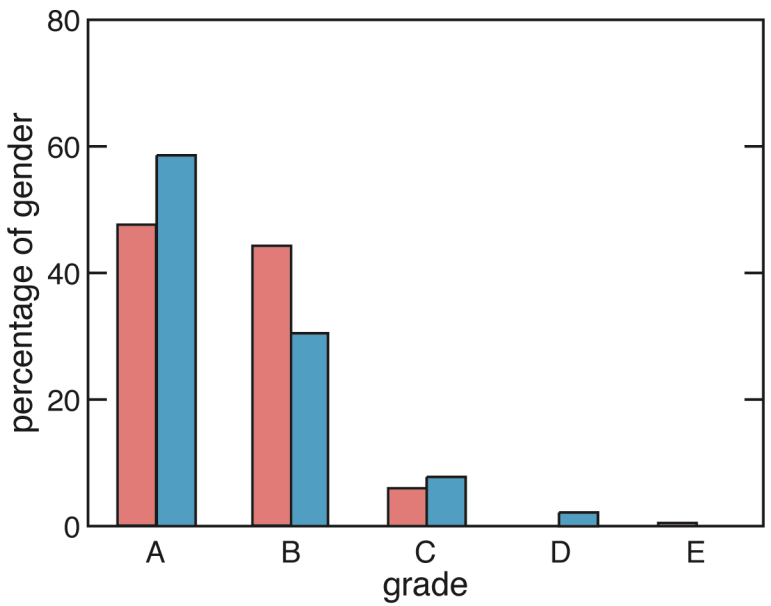
Results: grades

traditional



IE2



More comparable grade distributions with IE2

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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!

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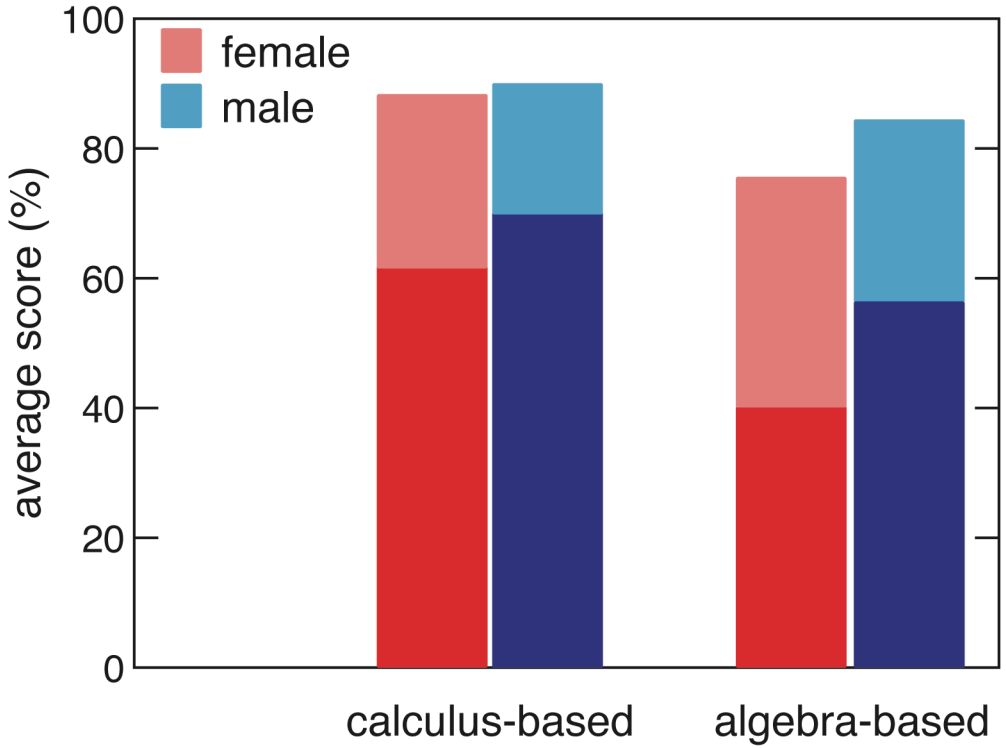
Does it always work?



- Algebra-based: females gained more, but didn't catch up
- Calculus-based: may be saturating the test

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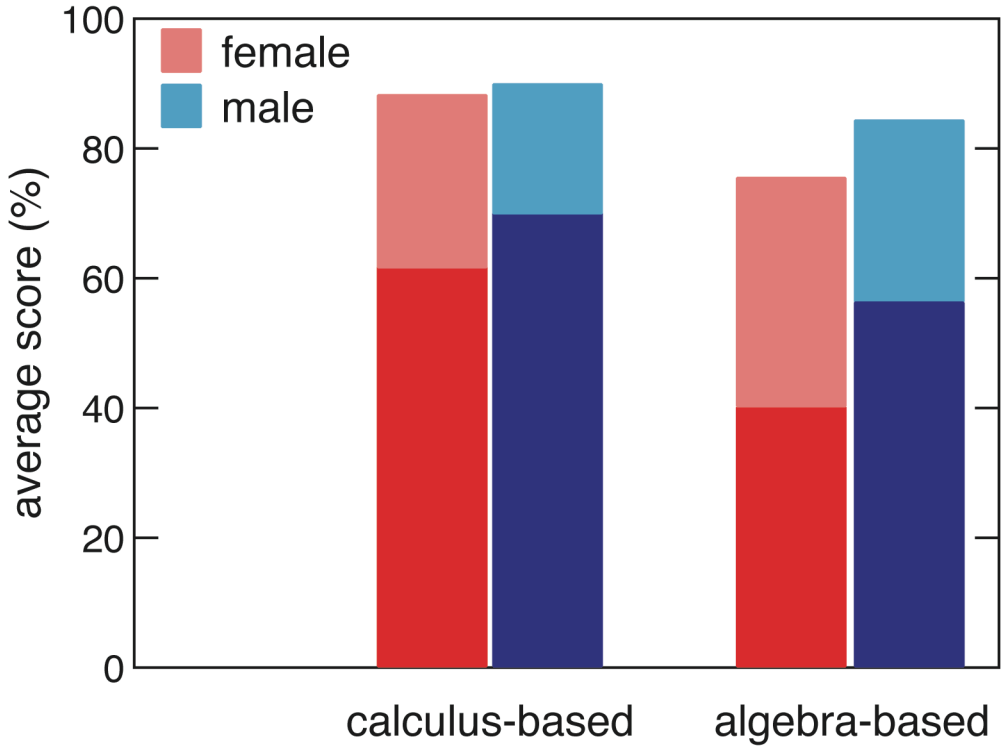
Does it always work?



- Reformed methods often help, but not always …. (Finkelstein A21.003)

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Conclusions

In the Harvard calculus-based course:

- All students benefit from interactive instruction (IE1 and IE2)
- FCI gender gap eliminated in IE2 course
- Comparable number of male and female high scorers in IE2
- Grade distributions become more balanced

Lorenzo, Crouch, and Mazur, *Am. J. Phys.* **74** (2), 118 (2006).

Talk posted at http://mazur-www.harvard.edu

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Data tables: FCI and FBT

Group	Year	N^M	N^F	MBT (%)			
				S^M	S^F	$S^M - S^F$	p-value
T	1990	61	44	69 (12)	63 (15)	5.5	0.0452
	1991	105	61	75 (12)	68 (13)	7.1	0.0004
	1993	91	52	75 (13)	70 (12)	4.4	0.0462
	1994	121	77	79 (13)	72 (12)	6.6	0.0003
IE1	1995	115	61	79 (13)	70 (13)	8.3	< 0.0001
	1996	94	52	77 (13)	71 (13)	5.9	0.0082
IE2	1997	67	47	82 (14)	78 (13)	3.8*	0.144

Group	FCI pretest score (%)				FCI posttest score (%)			
	S_i^M	S_i^F	$S_i^M - S_i^F$	p-value	S_f^M	S_f^F	$S_f^M - S_f^F$	p-value
T	–	–	–	–	82 (13)	71 (16)	10	0.0004
	74 (15)	62 (16)	12	< 0.0001	86 (8.6)	78 (11)	7.9	< 0.0001
	72 (14)	61 (14)	11	< 0.0001	88 (7.0)	80 (11)	8.2	< 0.0001
	75 (15)	60 (16)	15	< 0.0001	89 (8.1)	81 (12)	7.6	< 0.0001
IE1	72 (18)	60 (17)	13	< 0.0001	90 (9.4)	83 (14)	7.4	< 0.0001
	71 (19)	61 (19)	9.8	0.0039	90 (11)	87 (10)	3.3*	0.0828
IE2	71 (19)	62 (20)	8.5	0.0205	92 (11)	91 (8.3)	1.5*	0.429

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Data tables: FCI gains

Group	FCI gain (%)				FCI average normalized gain (%)			
	G^M	G^F	$G_i^M - G_i^F$	p-value	$\langle g \rangle^M$	$\langle g \rangle^F$	$\langle g \rangle^M - \langle g \rangle^F$	p-value**
T	9.2	10	1		0.33	0.26	0.07	
	12 (11)	17 (13)	-4.3	0.0262	0.47	0.43	0.04*	0.6126
	16 (12)	18 (11)	-2.7*	0.1713	0.56	0.47	0.09*	0.7154
	14 (12)	21 (11)	-7.0*	<0.0001	0.56	0.53	0.03*	0.5776
IE1	18 (14)	24 (15)	-5.1	0.0228	0.66	0.58	0.08*	0.6462
	20 (14)	26 (16)	-6.5	0.0103	0.67	0.67	0.00*	0.3818
IE2	22 (14)	29 (18)	-7	0.0197	0.73	0.75	-0.02*	0.9764

** 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.

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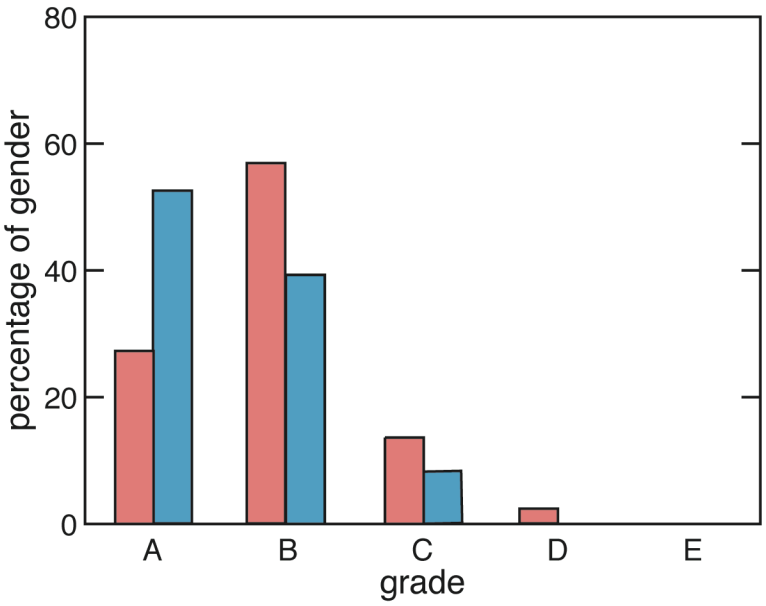
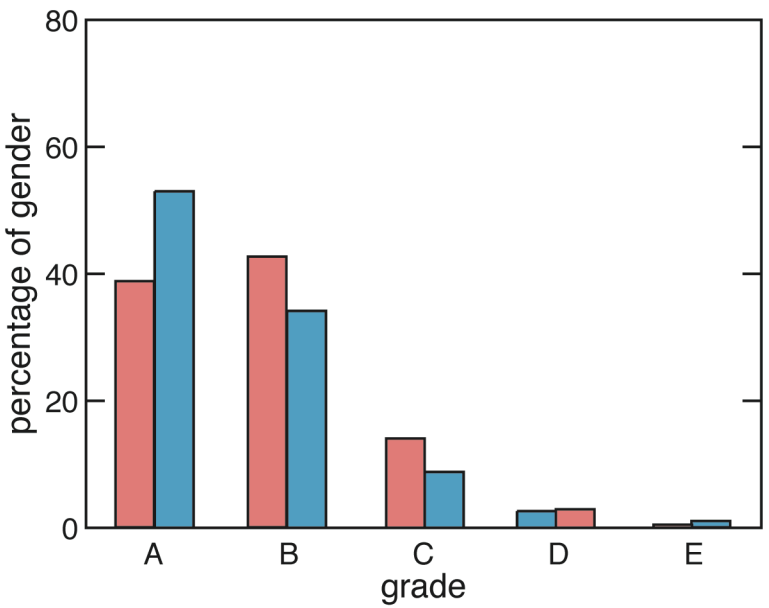
IE1 grade distribution

traditional



IE1



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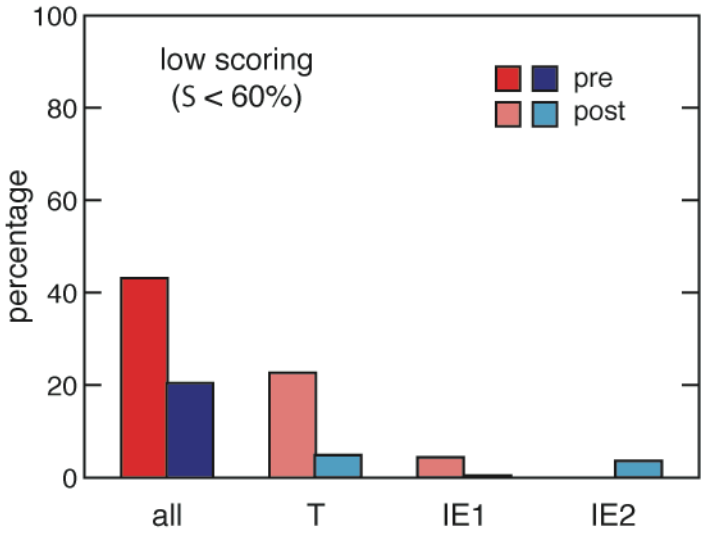
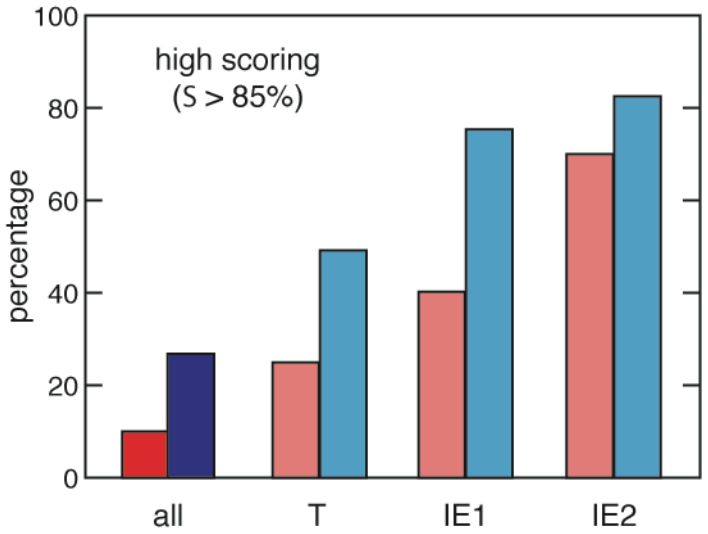
FCI low and high scorers





Both male and female low posttest scores eliminated

Comparable numbers of male and female high scorers

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