Promise and Pitfalls of Reformed Instruction for Female Students

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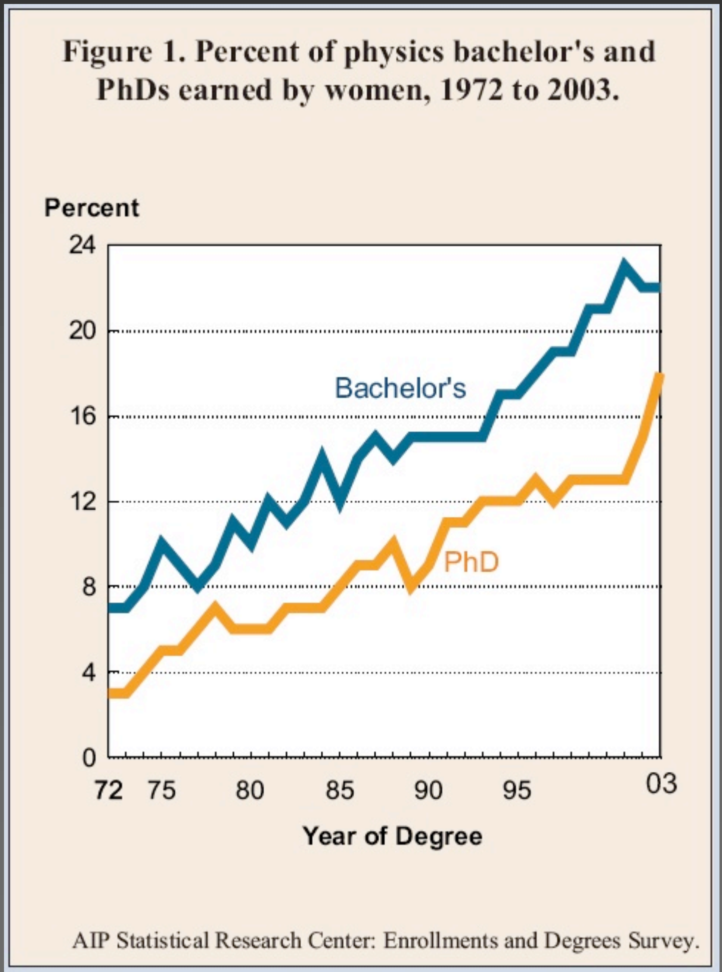
Two Part Workshop

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 wit
- < 20% of PhD's go to
- ~ 20% Undergraduate
- Performance gap, drop

Table 6. Percent of faculty positions in physics held by women, 1994, 1998 and 2002.

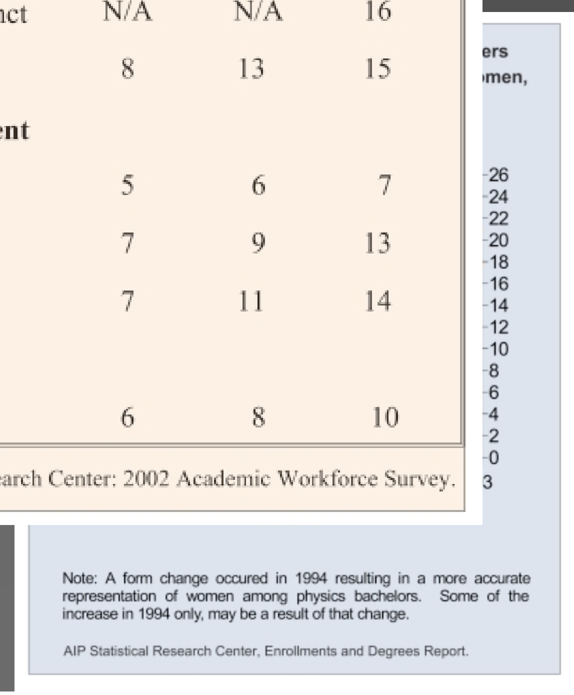
	1994 %	1998 %	2002 %
Academic Rank			
Full professor	3	3	5
Associate professor	8	10	11
Assistant professor	12	17	16
Instructor / Adjunct	N/A	N/A	16
Other ranks	8	13	15
Type of Department			
PhD	5	6	7
Master's	7	9	13
Bachelor's	7	11	14
Overall	6	8	10

AIP Statistical Research Center: 2002 Academic Workforce Survey.

Table 11. Number and percent of physics degrees granted to US citizens by minority / status, class of 2003.

	Bachelor's		Exiting Master's			
	Number	Percent	Number	Percent	Numbe	
African-American	152	4	15	4	12	
Hispanic-American	144	3	14	4	13	
White	3711	87	332	83	465	
Asian-American	171	4	20	5	29	
Other	110	3	18	4	11	2
Total US Citizens	4288	100%	399	100%	530	100%

AIP Statistical Research Center, Enrollments and Degrees Report.



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?

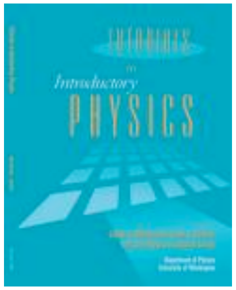
Study: effect of pedagogy

- 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

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

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Study: effect of pedagogy

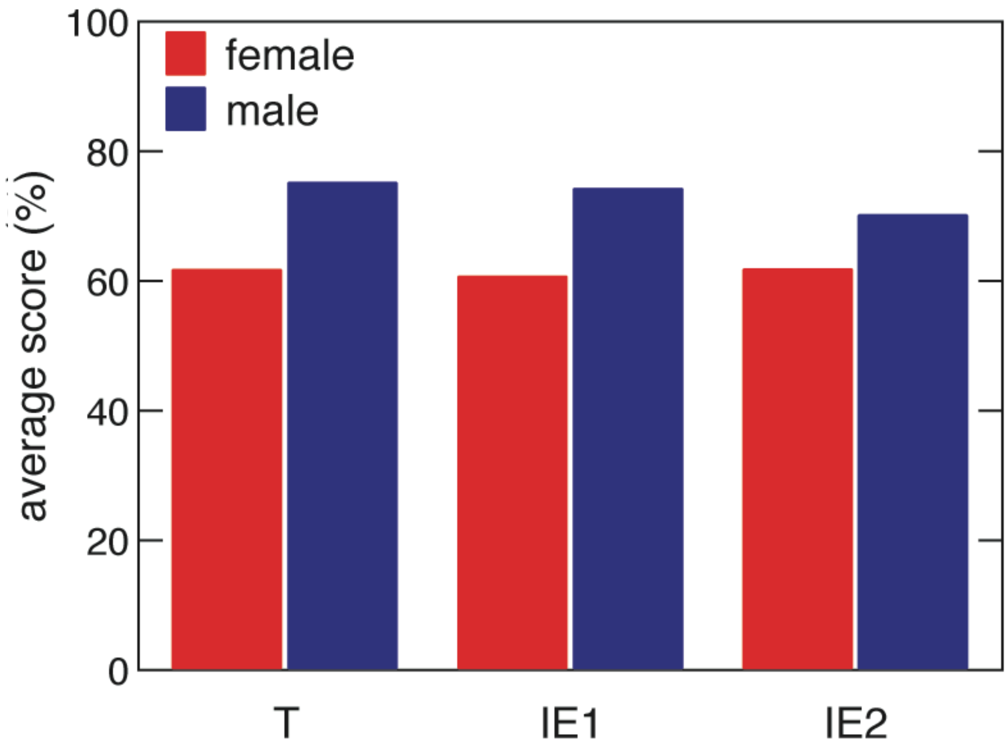
Tutorials: (Univ. of Washington PERG)

- 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)

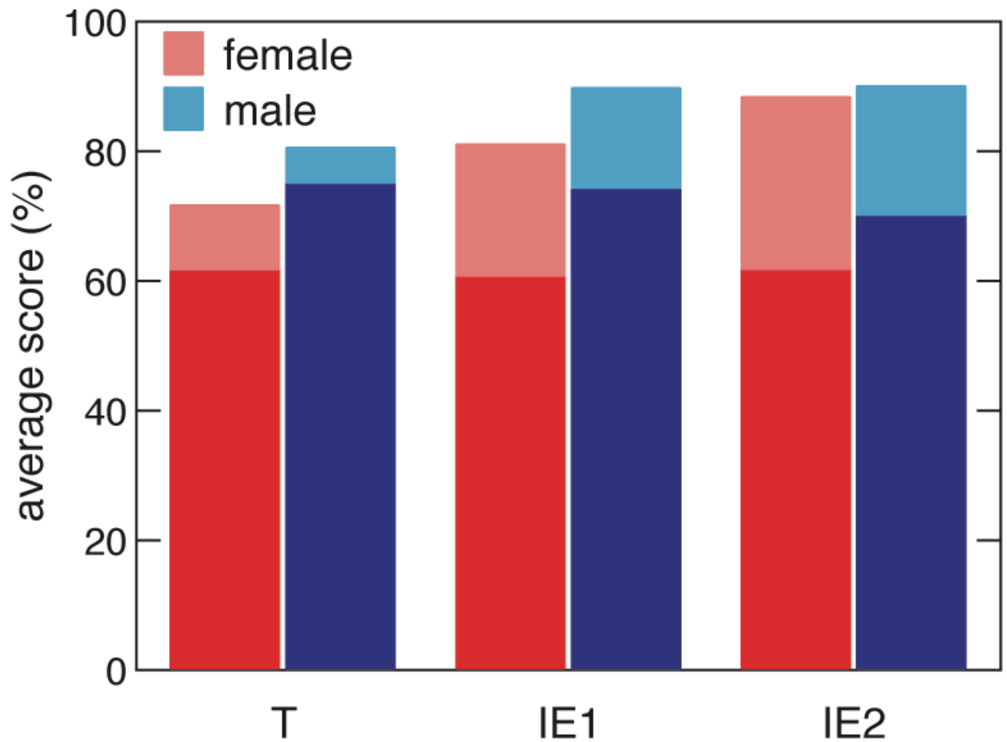
- Students instructed in problem-solving strategies
- Groups of three work on challenging problems

Results: FCI pretest



Female students start out behind

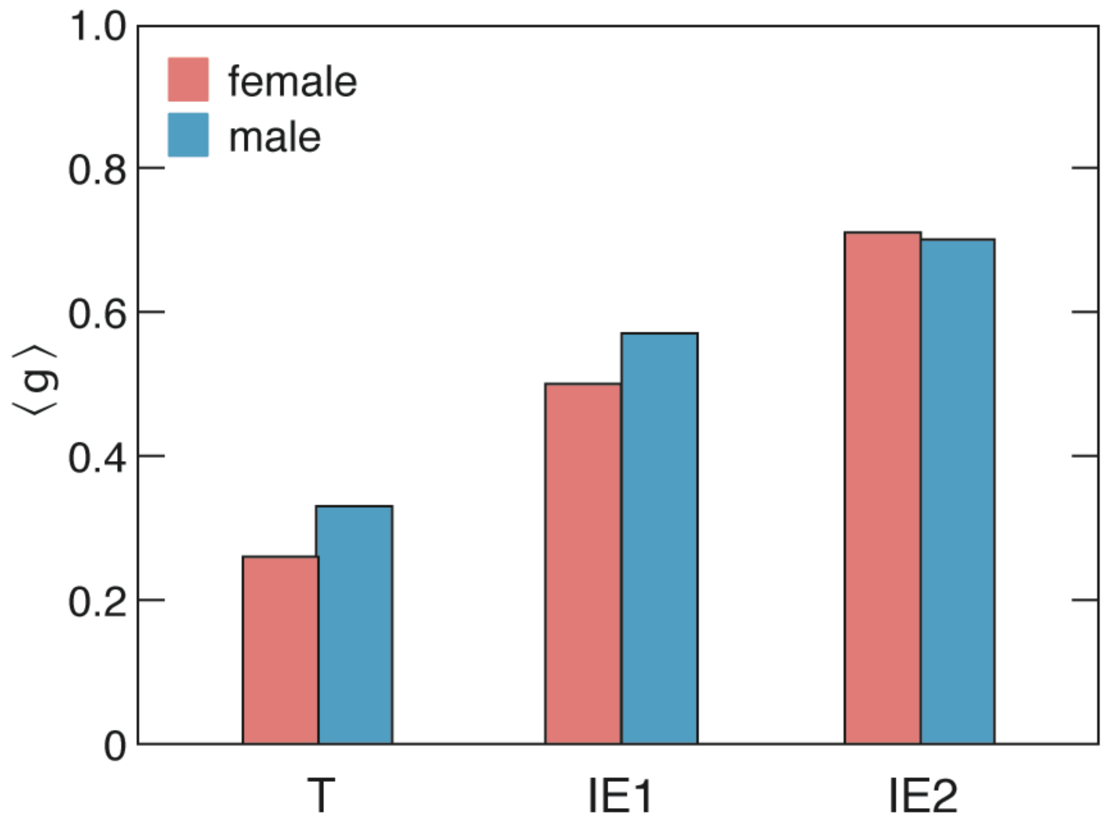
Results: FCI posttest



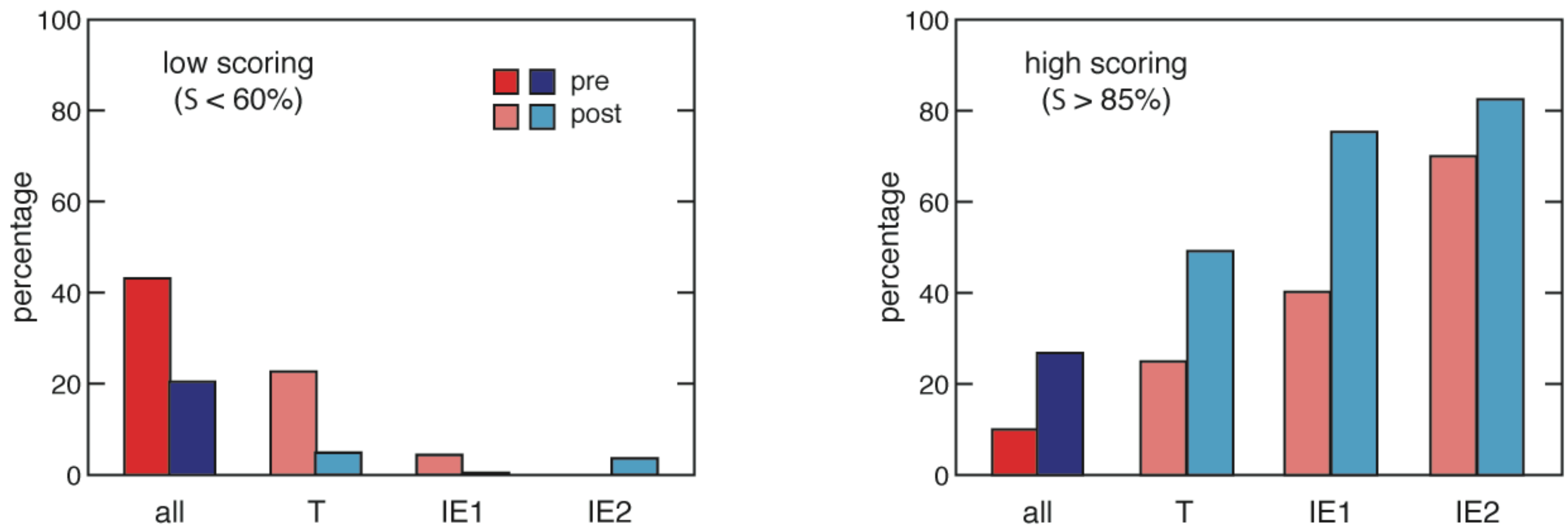
Fully interactive instruction eliminates gap!

Results: FCI normalized gain

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



Results: low and high scores

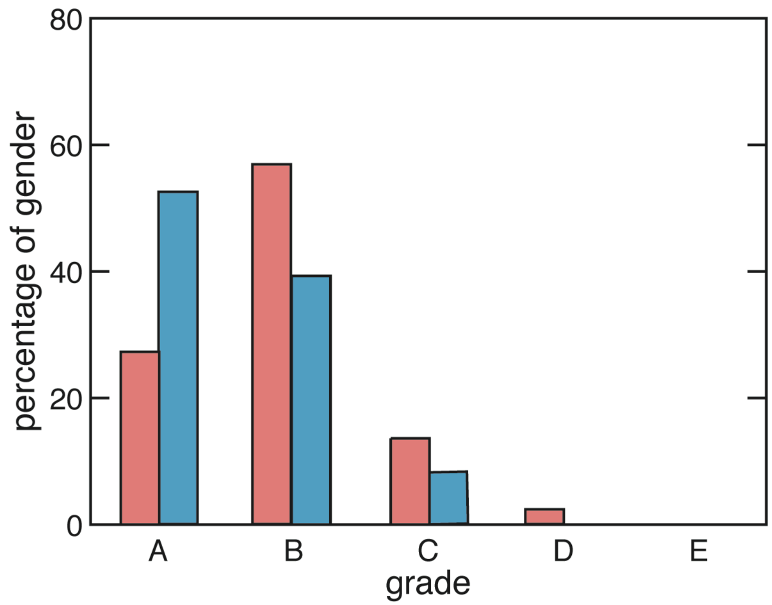


Both male and female low posttest scores eliminated

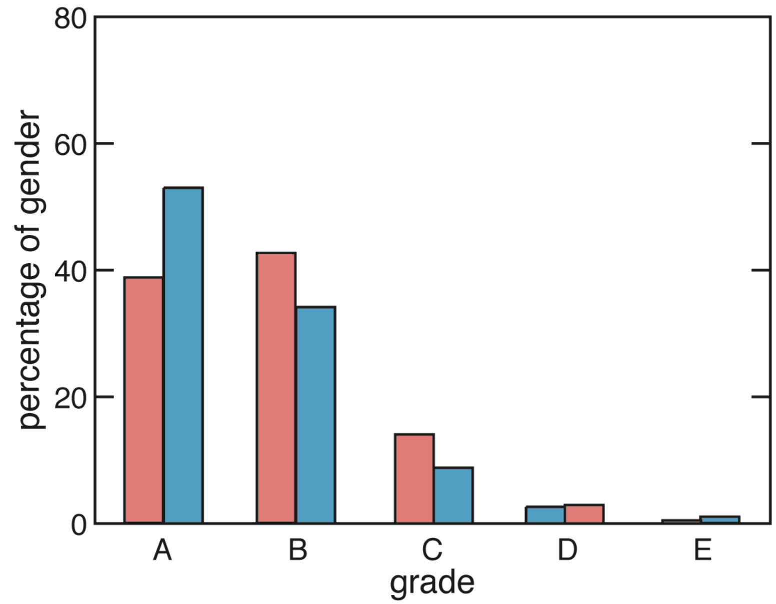
Comparable numbers of male and female high scorers

Results: grades

traditional



IE1



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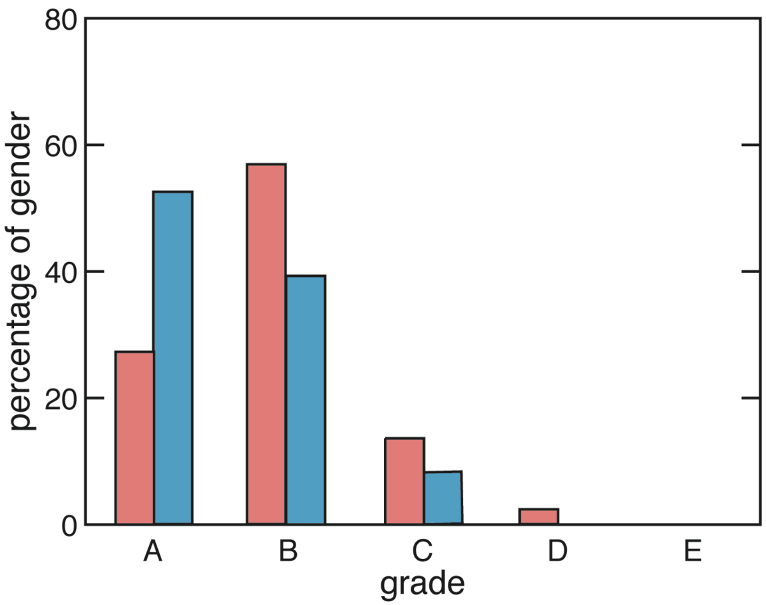
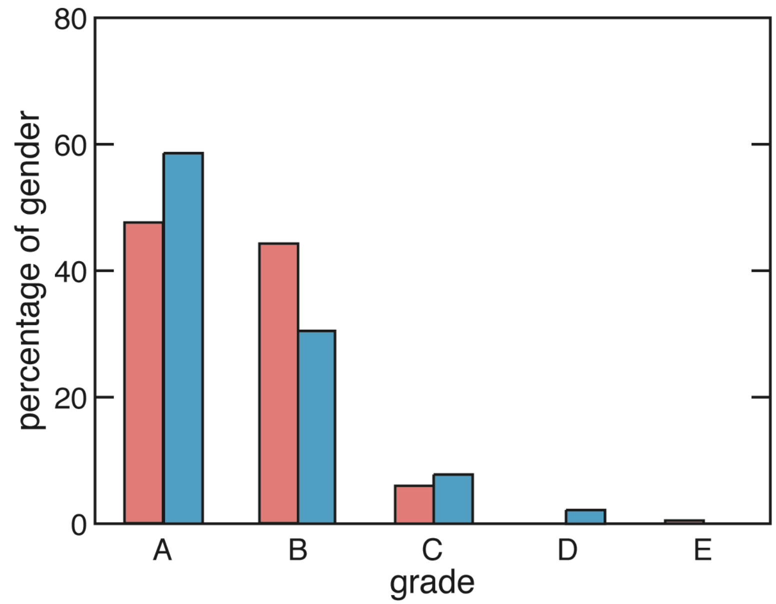
Results: grades

traditional



IE2

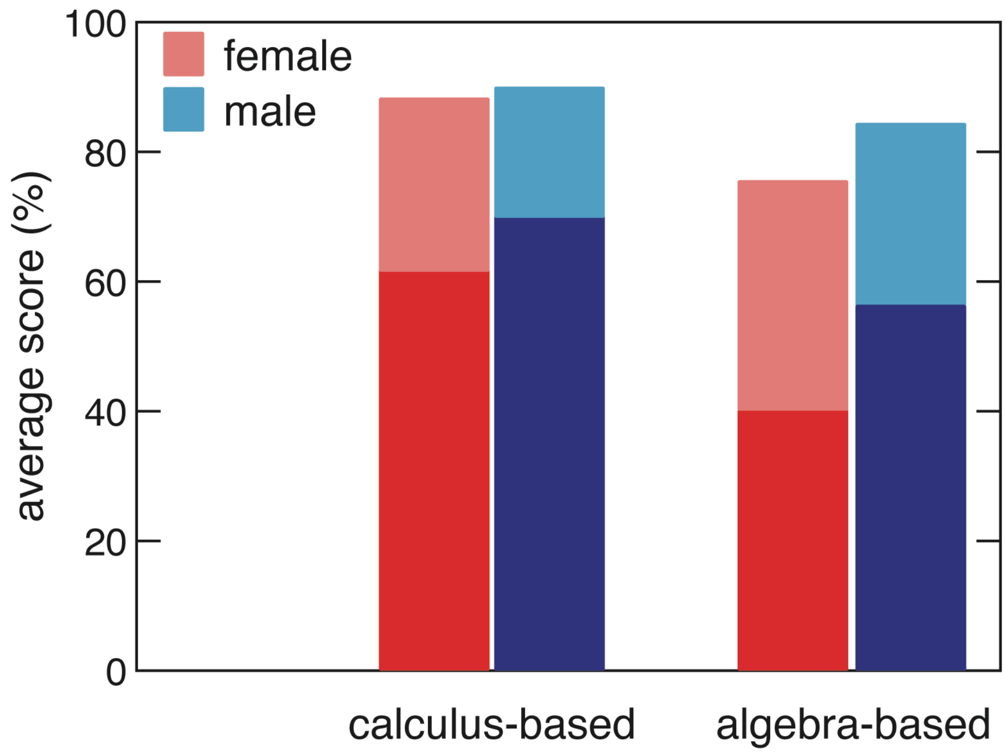


More comparable grade distributions with IE2

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

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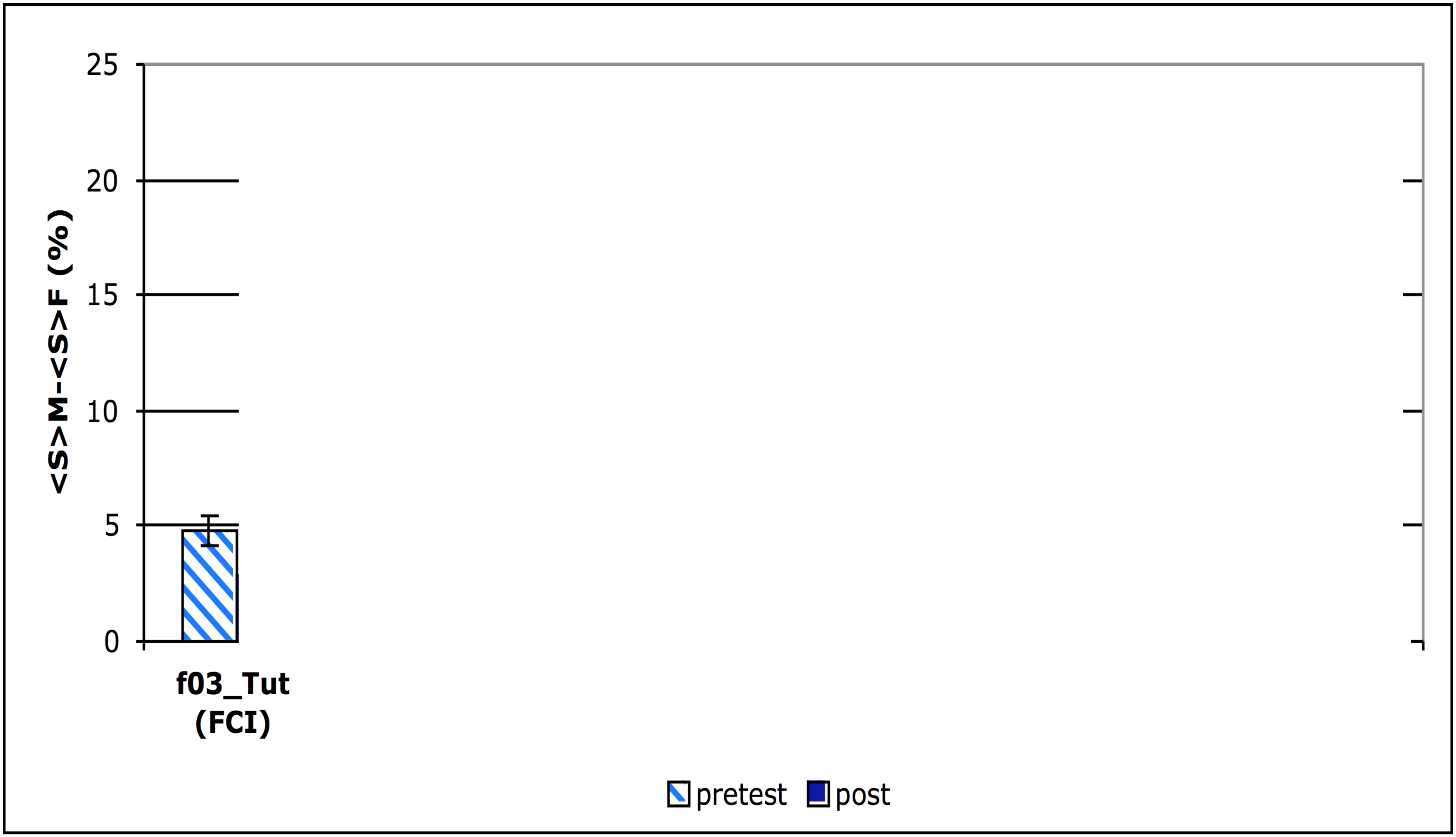
How do male and female students perform at U Colorado?

Gender Gap (FMCE) at CU
(male score - female score)



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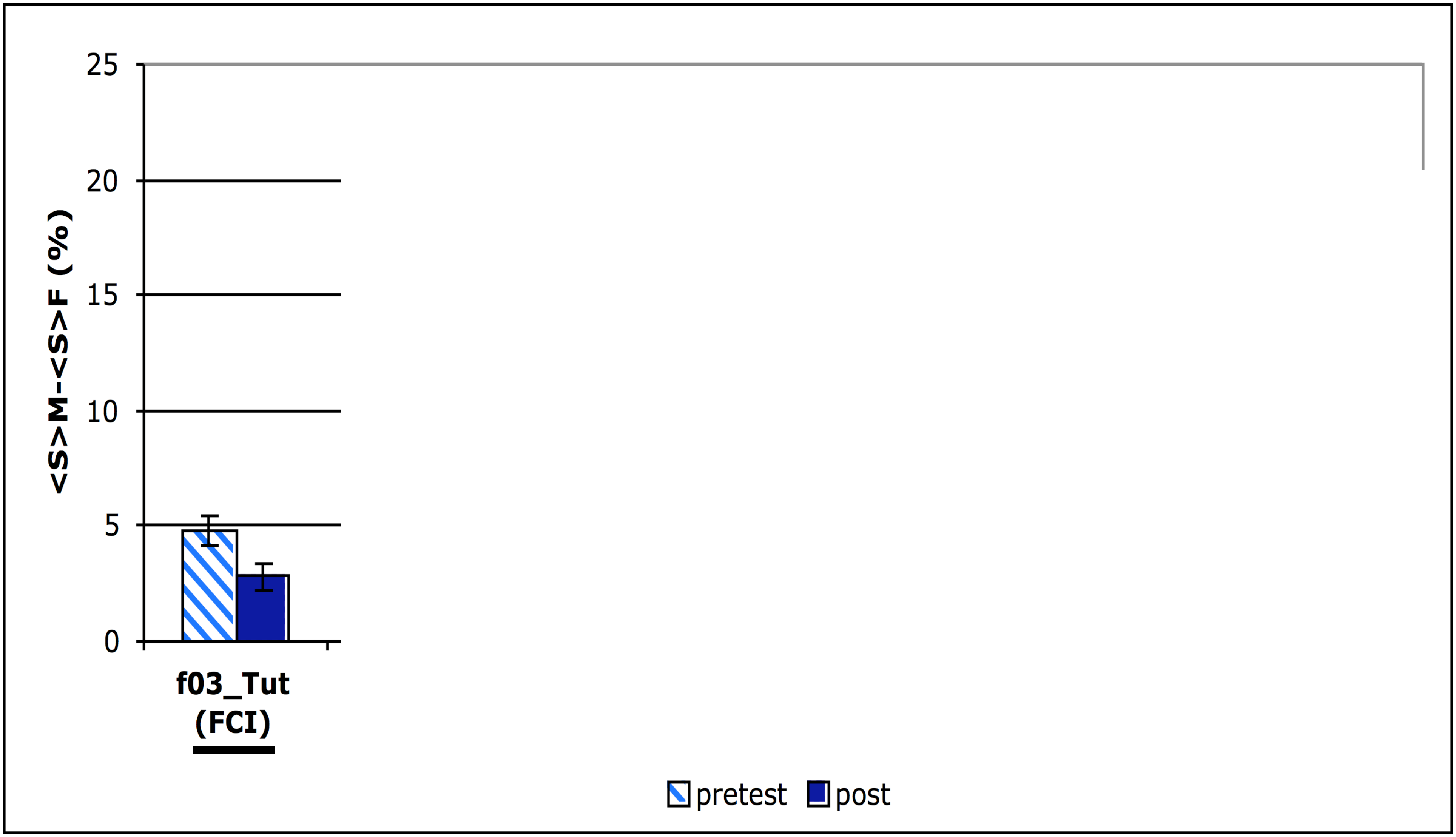

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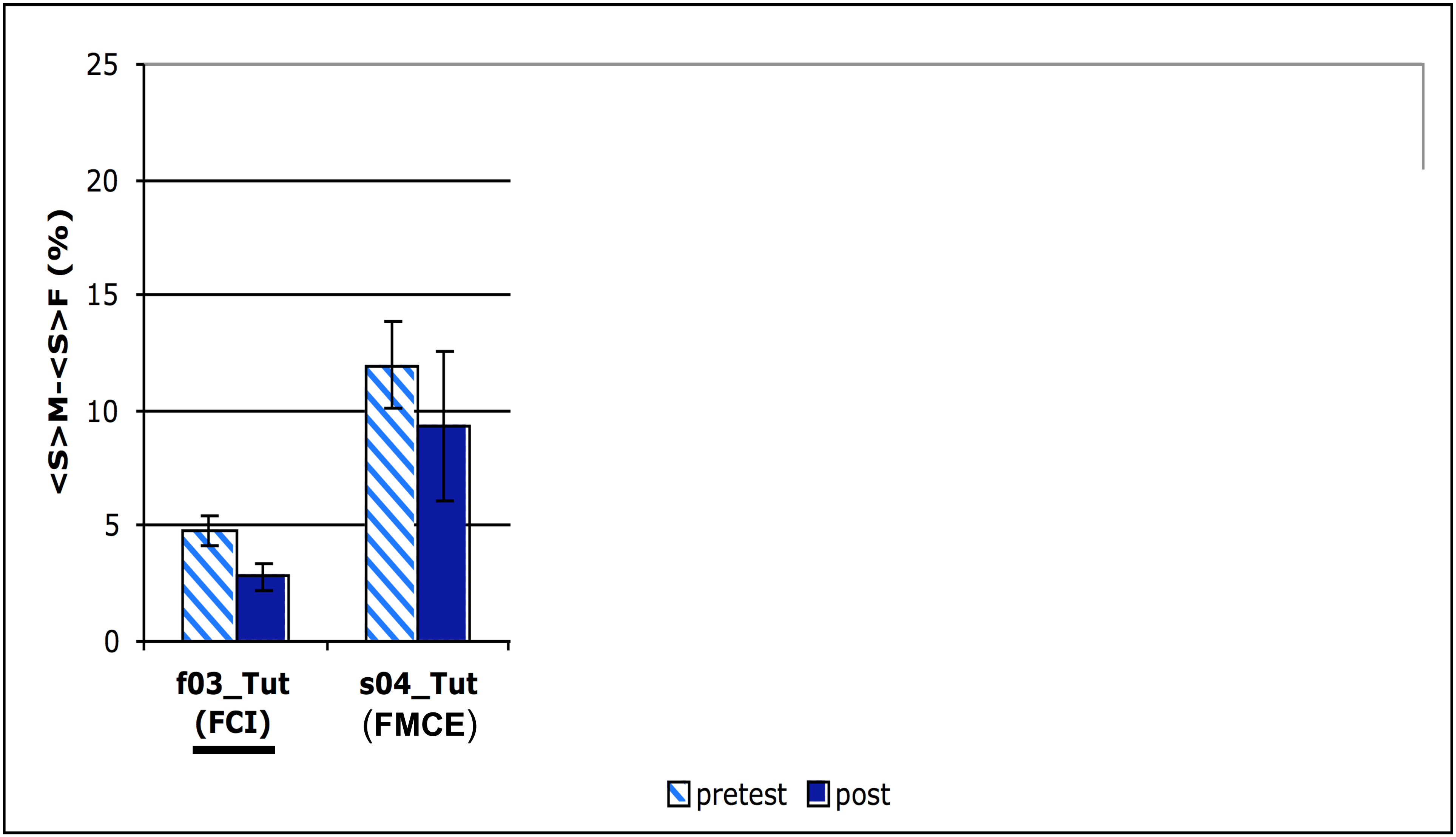

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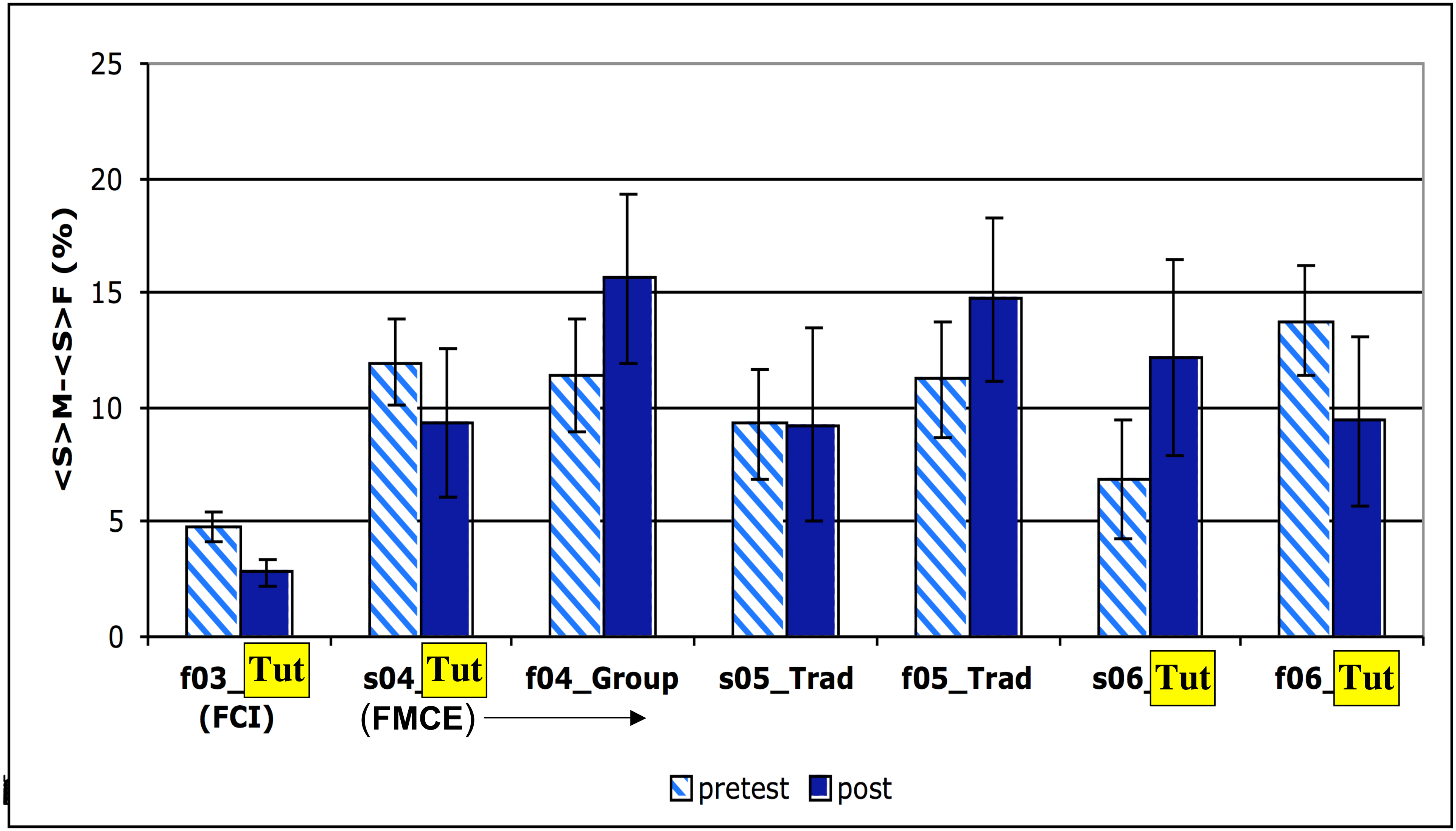
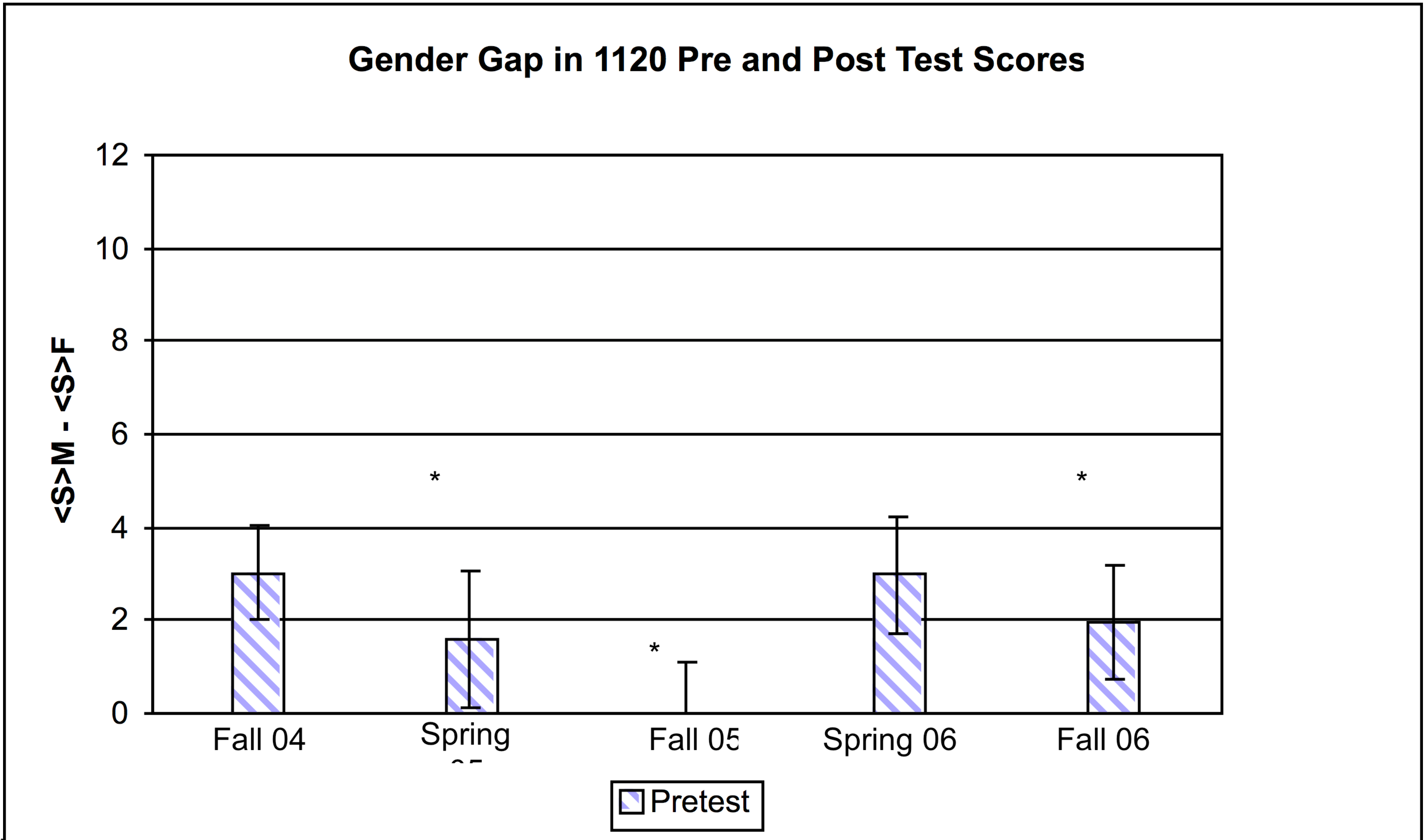


Gender gap (BEMA)
CU 2nd semester (E&M)



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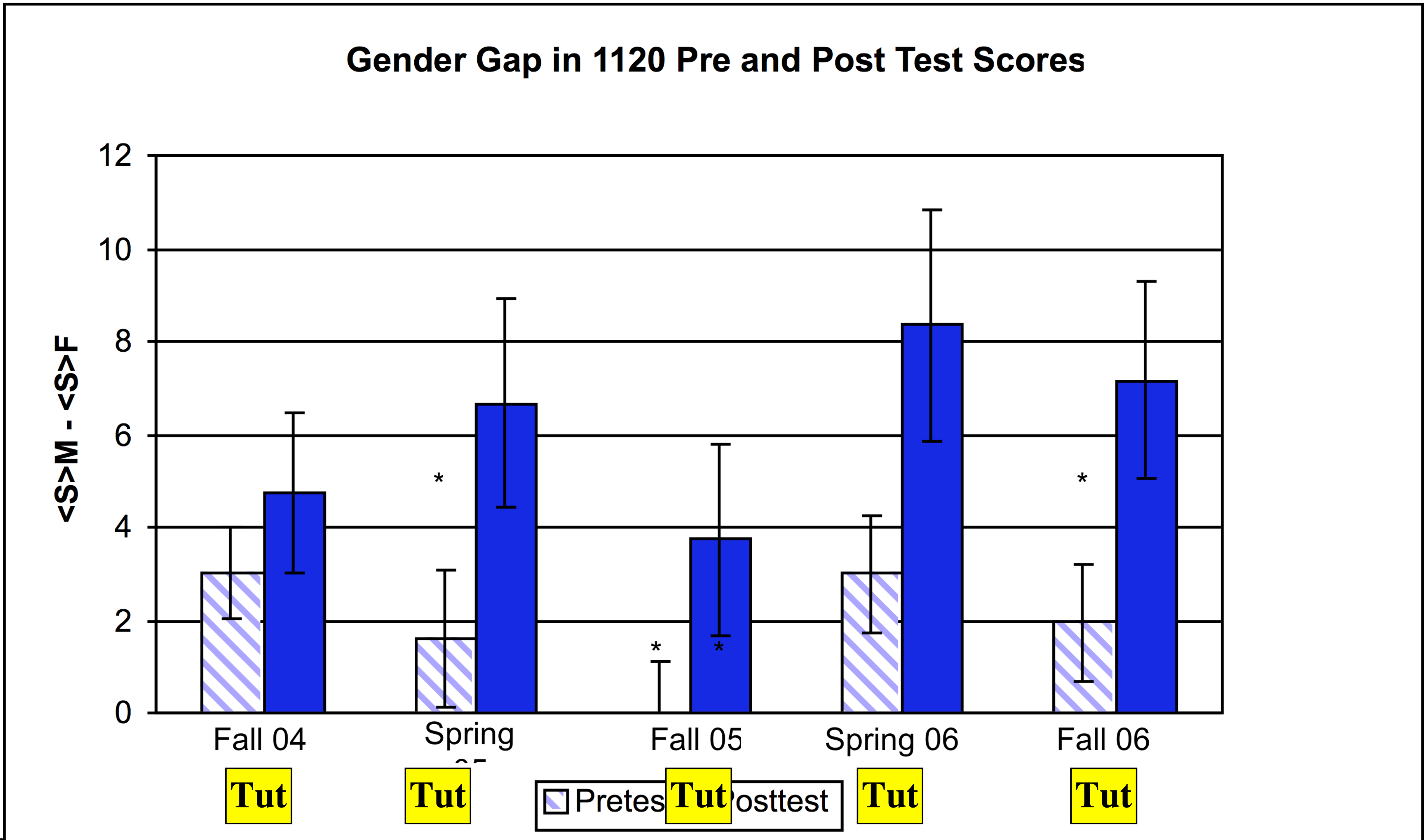
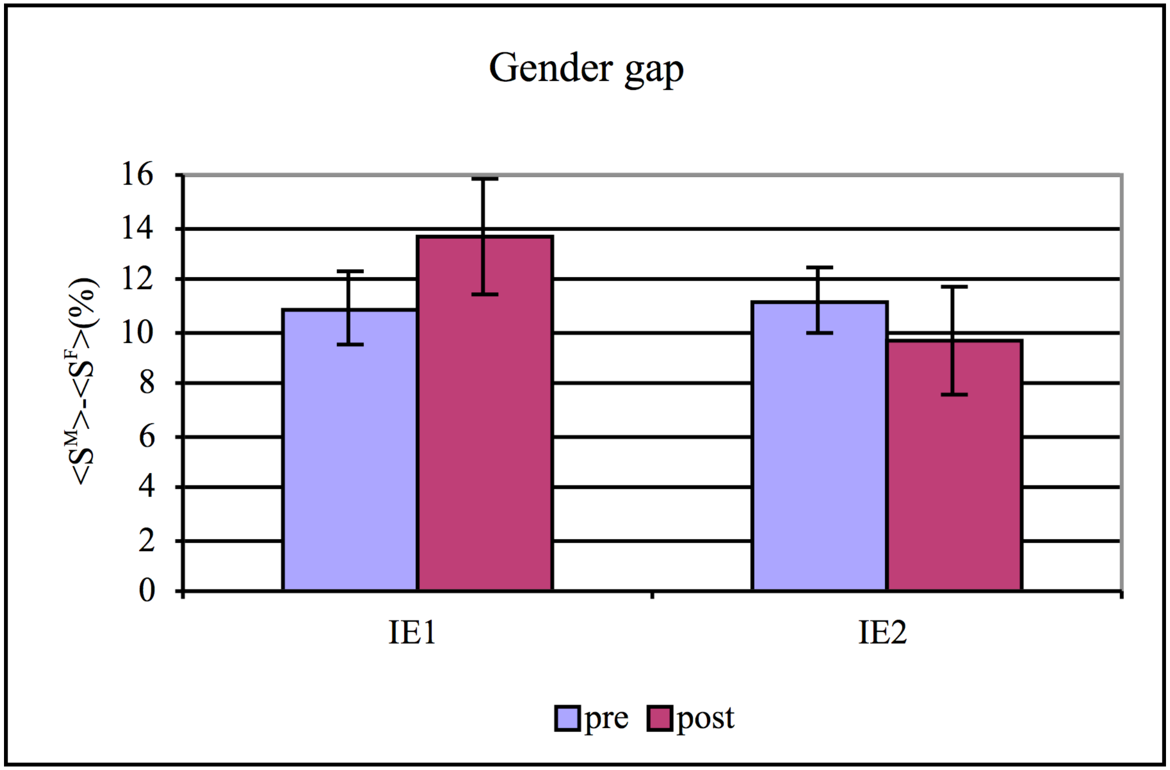
Gender gap (BEMA)
CU 2nd semester (E&M)

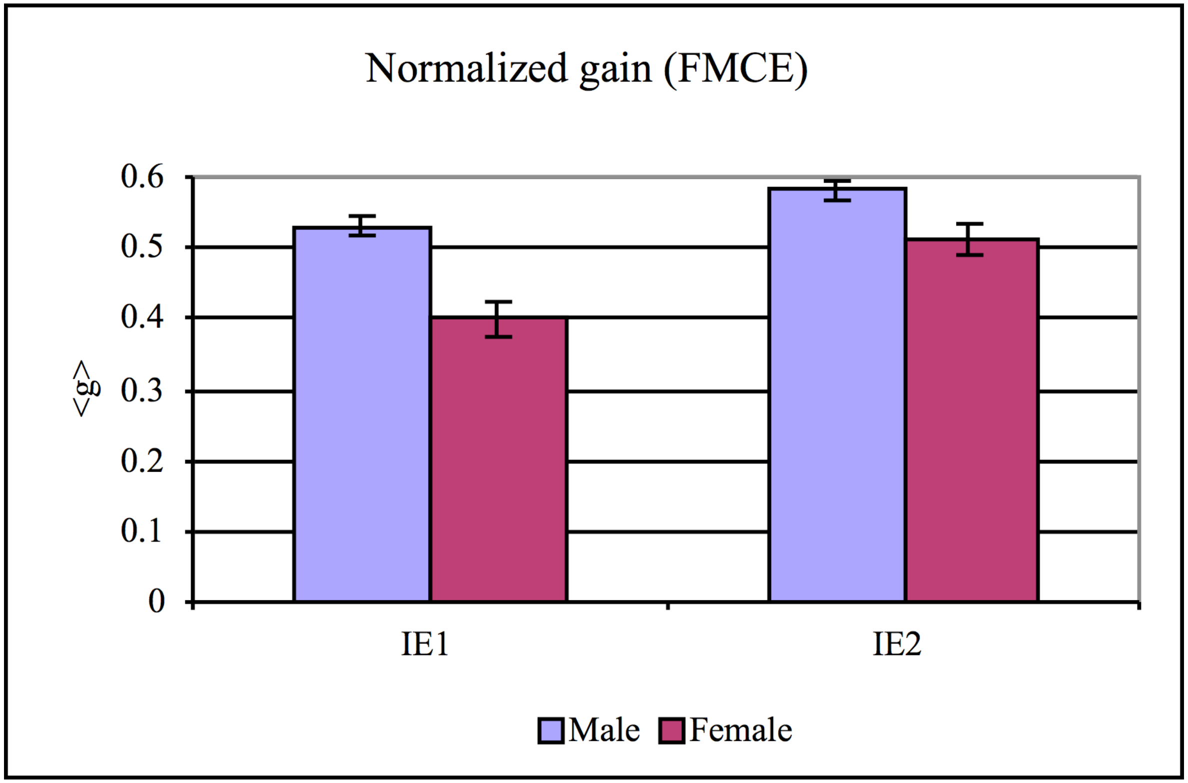


Summary (FMCE)



- No elimination of gender gap
- Considerable instructor effects term to term

Summary (FMCE)



- Difference in male / female gain <g>
- IE2 still better than IE1

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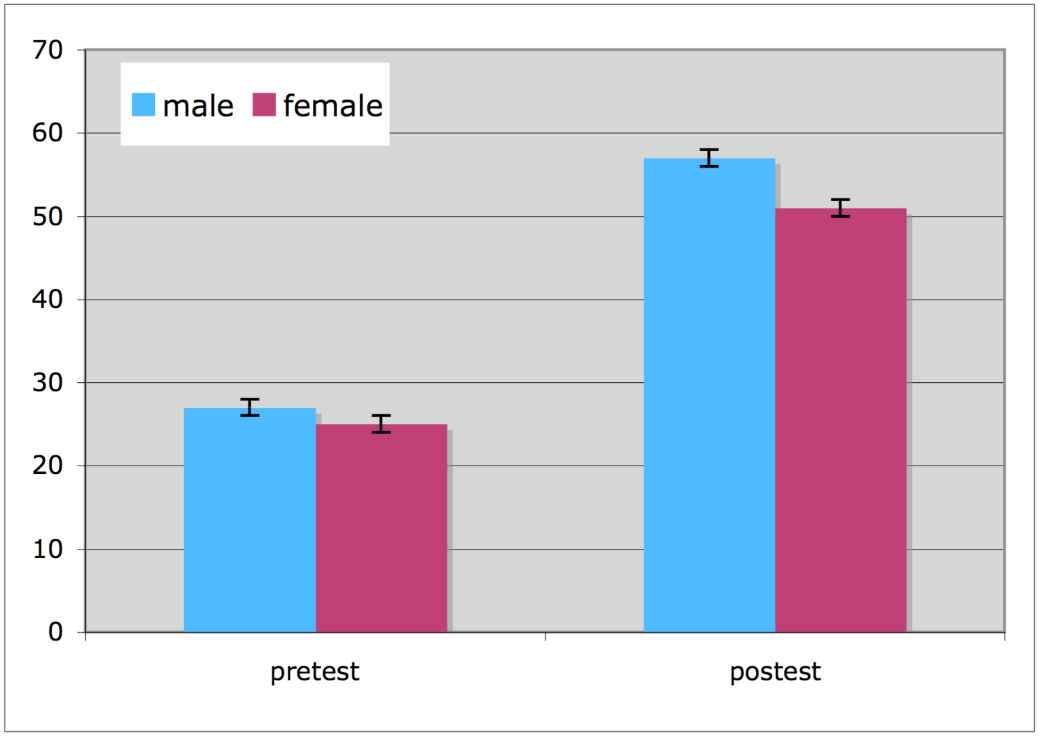
Summary (BEMA)



- 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

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- Invaluable input from Apriel Hodari (CNA Corporation), Melissa Dancy (UNC-Charlotte), Laura McCullough (UW-Stout)

FCI and MBT data

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

FCI gain data

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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