Impact of Peer Instruction on underrepresented groups

Catherine H. Crouch‡

Jessica Watkins,* Mercedes Lorenzo,† and Eric Mazur

Department of Physics, Harvard University

‡ Department of Physics and Astronomy, Swarthmore College
*Physics Education Research Group, University of Maryland
†IES Universidad Laboral, Albacete, Spain

Diversity and Peer Instruction

Key question: Does Peer Instruction serve underrepresented groups well?

- Conceptual inventories
- Grades*
- Retention*

Many other questions could be asked!

SWARTHMORE

Pedagogical best practices for girls

Research (both K-12 and higher ed) suggests:

- Actively involve students
- Promote cooperative learning/decrease competitiveness
- Emphasize deep understanding
- Build on prior knowledge and experiences
- Provide real-world examples/social context

... These practices generally benefit *all* students

For a review see Brotman and Moore (J. Res. Sci. Teach, 2008).

Best practices for URM

- Many of the same strategies as for girls
- Combat isolation: provide structured opportunities for group work
- Provide active academic mentoring

See for example Treisman (Coll. Math. J., 1992); Maton et al (J. Res. Sci. Teach, 2000).

Do female students achieve at the level of male students with Peer Instruction?

SWARTHMORE

Pedagogy and gender

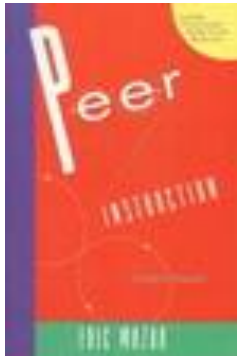
- Calculus-based introductory mechanics for non-majors at Harvard University, 1990 - 1997
- 150-200 students each year, 30-40% women
- Administered Force Concept Inventory as pre- and post-test

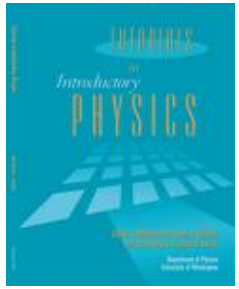
SWARTHMORE

First study: pedagogy and gender

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

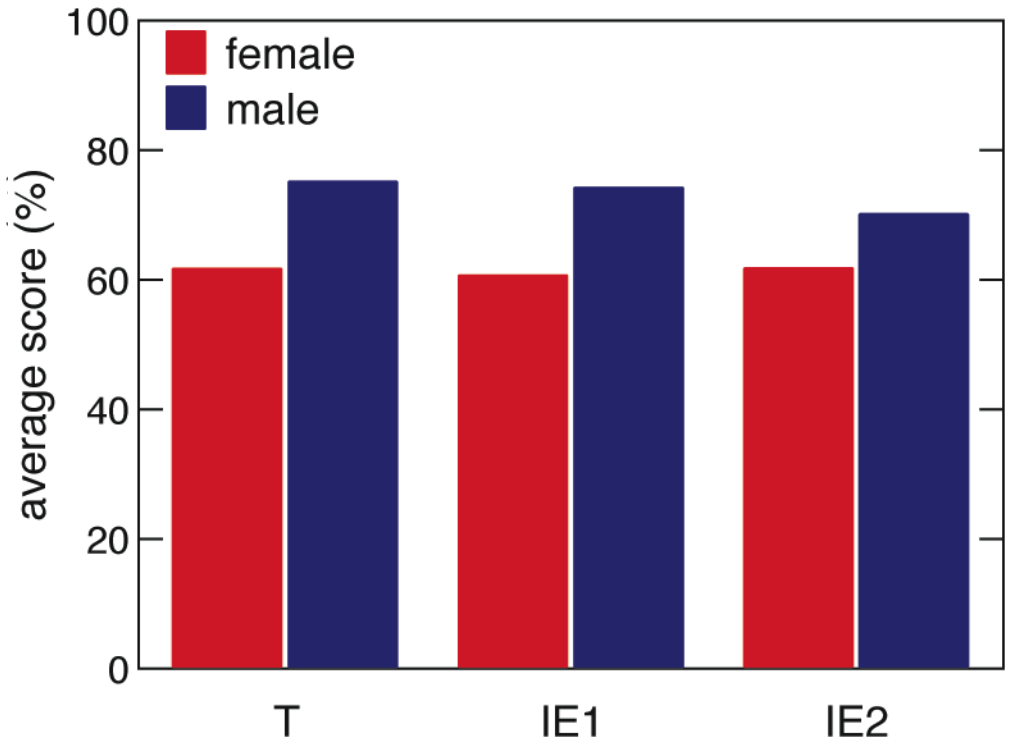




How does male and female performance compare?

SWARTHMORE

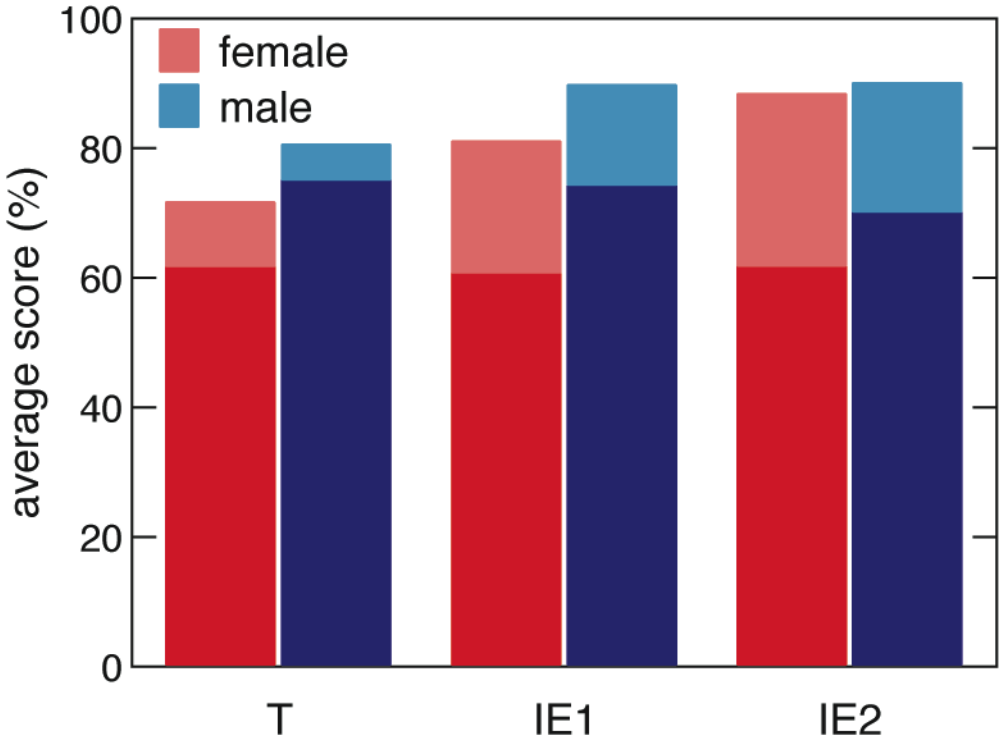
Results: FCI pretest



Female students start out behind

SWARTHMORE

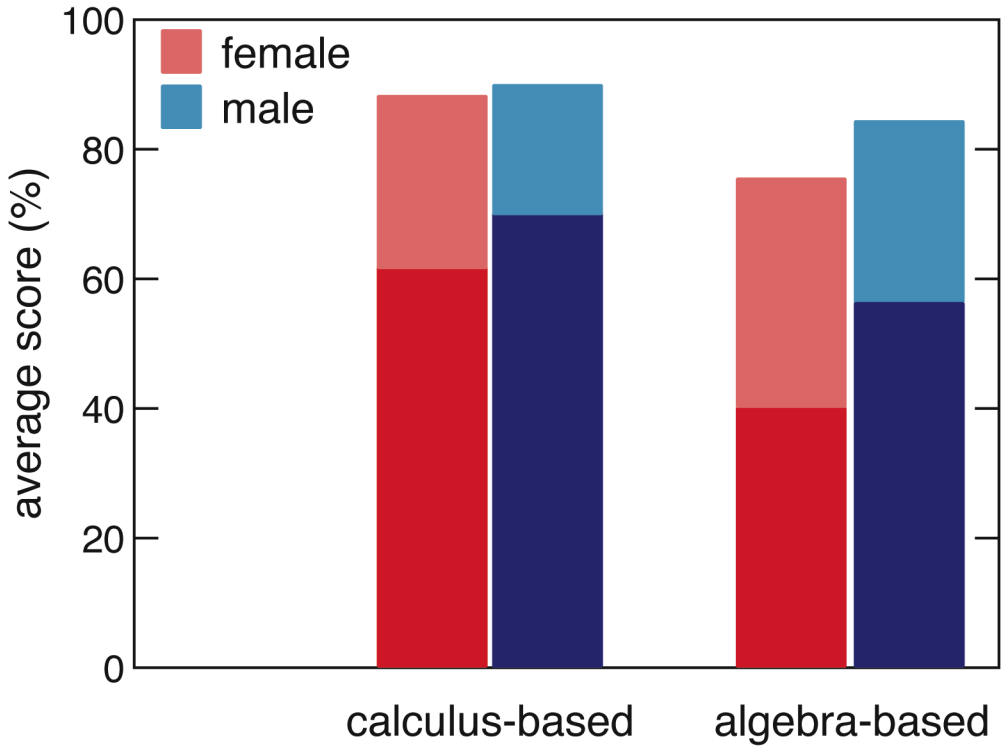
Results: FCI posttest



Fully interactive instruction appears to eliminate gap

SWARTHMORE

Results: algebra-based



Algebra-based (IE2): females gained more

BUT lower posttest scores, slightly smaller normalized gains

SWARTHMORE

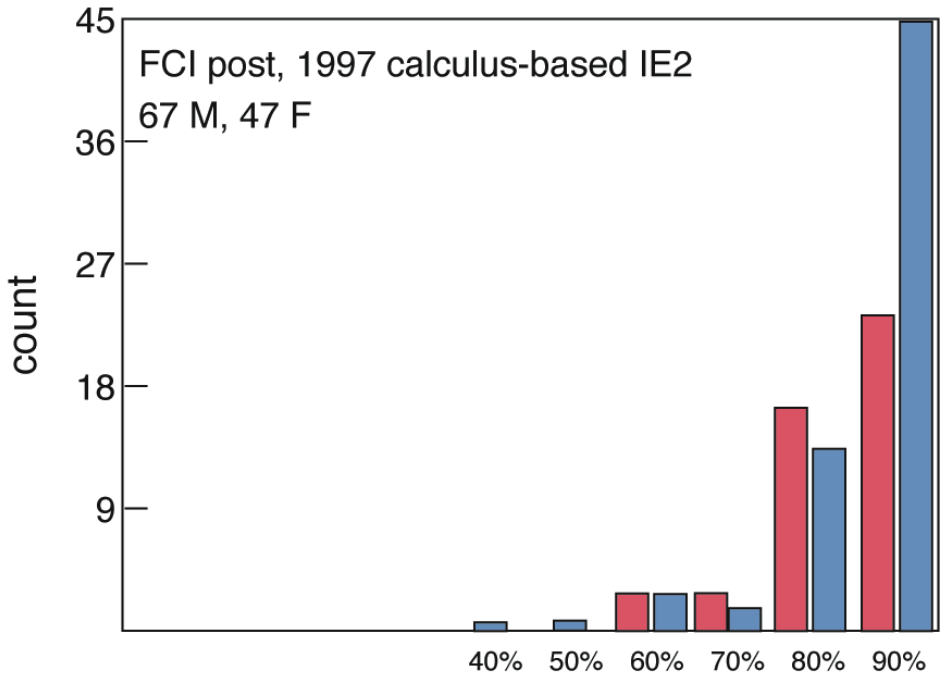
How do we interpret this?

- Many FCI measures
  - absolute gain
  - normalized gain
  - absolute posttest score
- What do we really want to know?
- Regression analysis: control for background

SWARTHMORE

Problem: high posttest scores

- Non-normal posttest score distribution: ceiling effect, invalidates linear regression

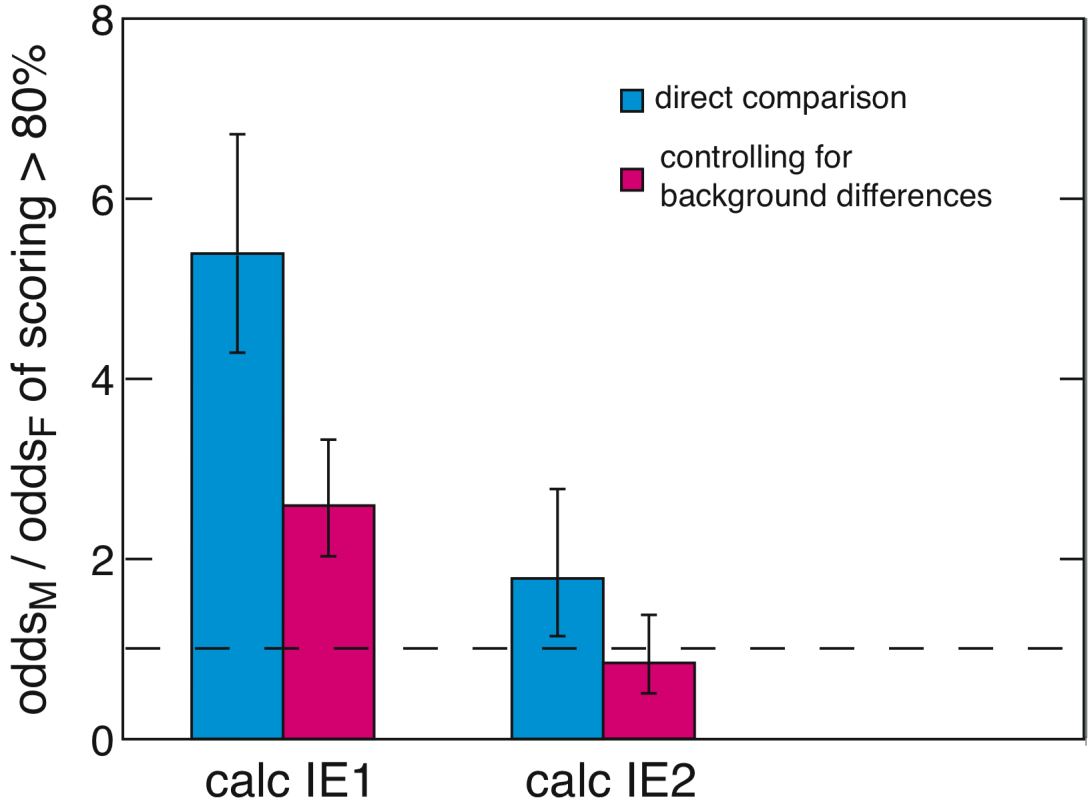


- Solution: divide into high and low scorers

SWARTHMORE

High/low scores: logistic regression

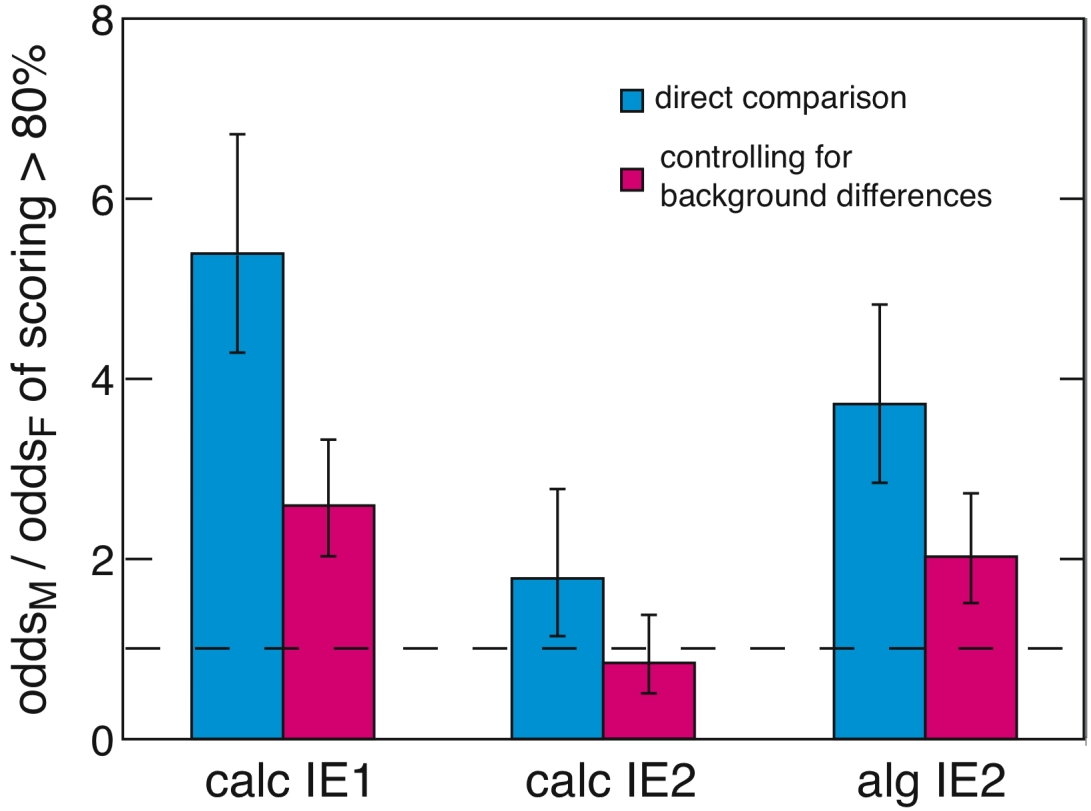
- Find probability of scoring >80%
- IE2: equal male/female odds accounting for background



SWARTHMORE

High/low with algebra-based

- More male high scorers
- Background accounts for much but not all of difference



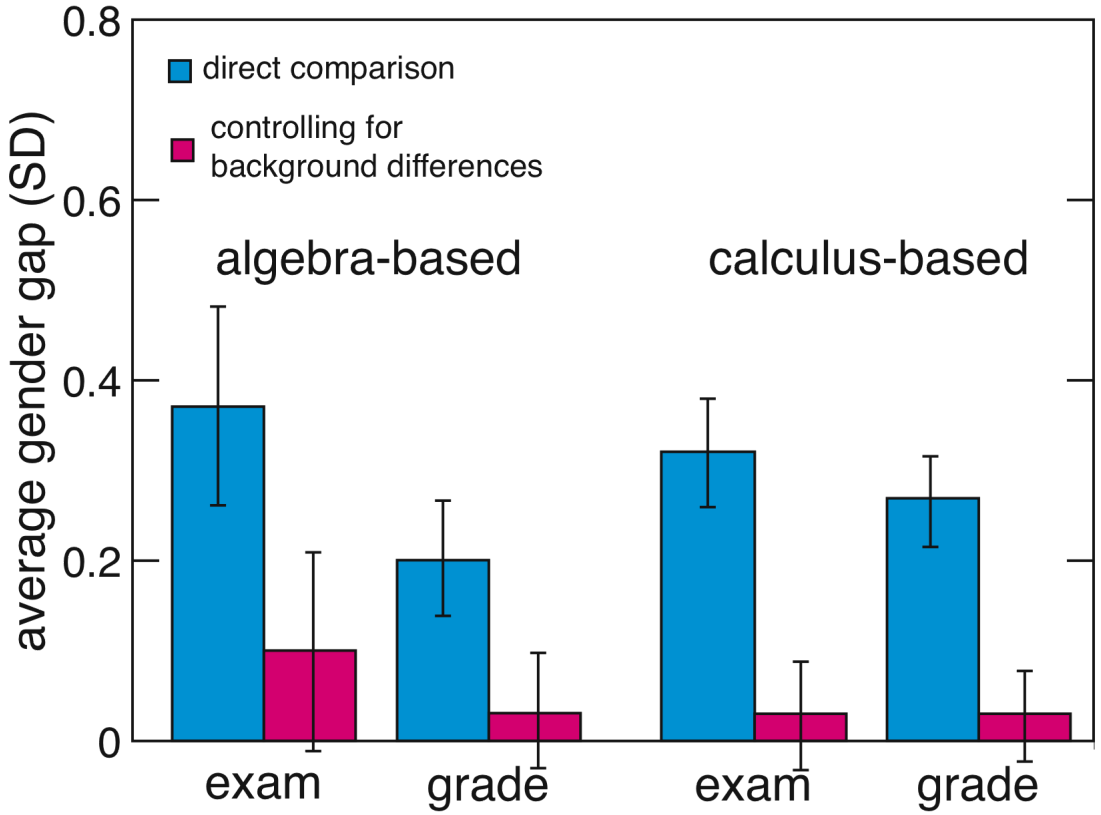
SWARTHMORE

Exam scores and grades

- FCI analysis still murky (ceiling effect)
- Exam scores and grades matter!
- Normally distributed; can use linear regression

SWARTHMORE

Exam scores and grades: gender

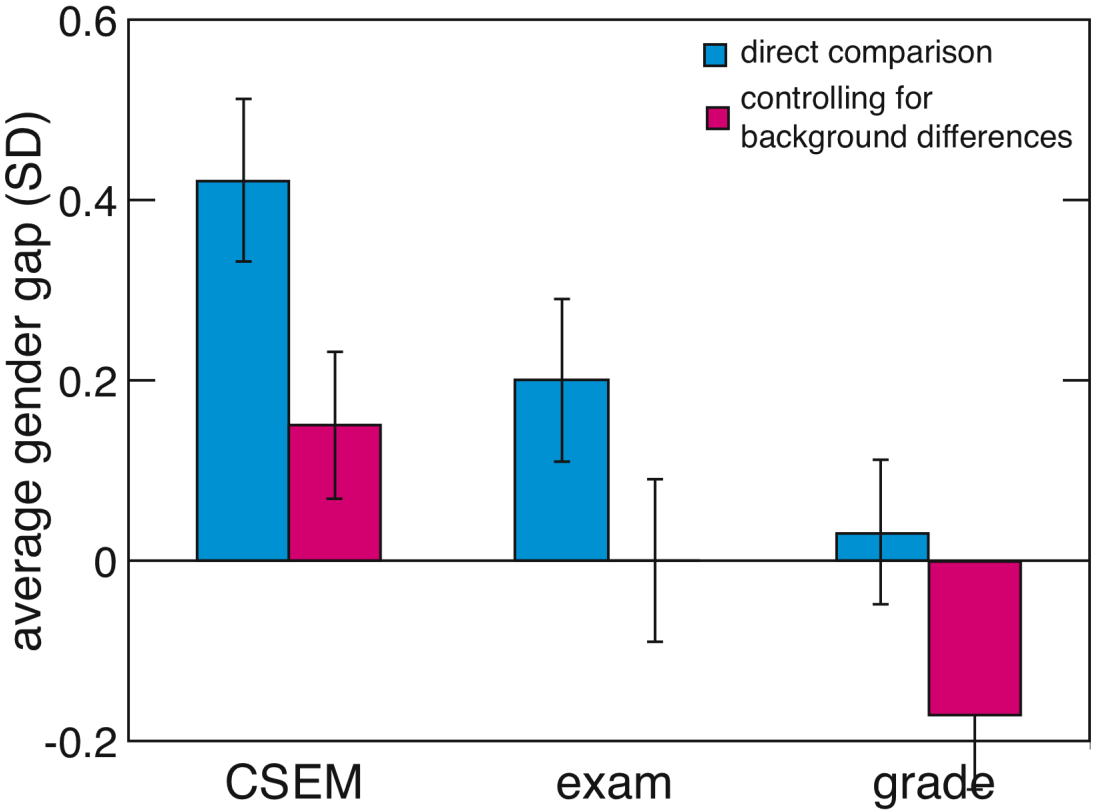


Males earn slightly higher exam scores (~4-5%) and course grades (~2-3%) than females

Gap is entirely attributable to background

SWARTHMORE

Electricity and magnetism: gender



Exam, grade gaps attributable to background

Females earn *better* grades by background!

Small CSEM gap (2 points out of 32)

SWARTHMORE

Gender and Peer Instruction

- Females have weaker average preparation (FCI pretest)
- *All* students show greatest FCI gains from PI/ IE2
- Females do as well on exams, grades, and CSEM as males with the same background (FCI murky)

SWARTHMORE

University of Colorado results

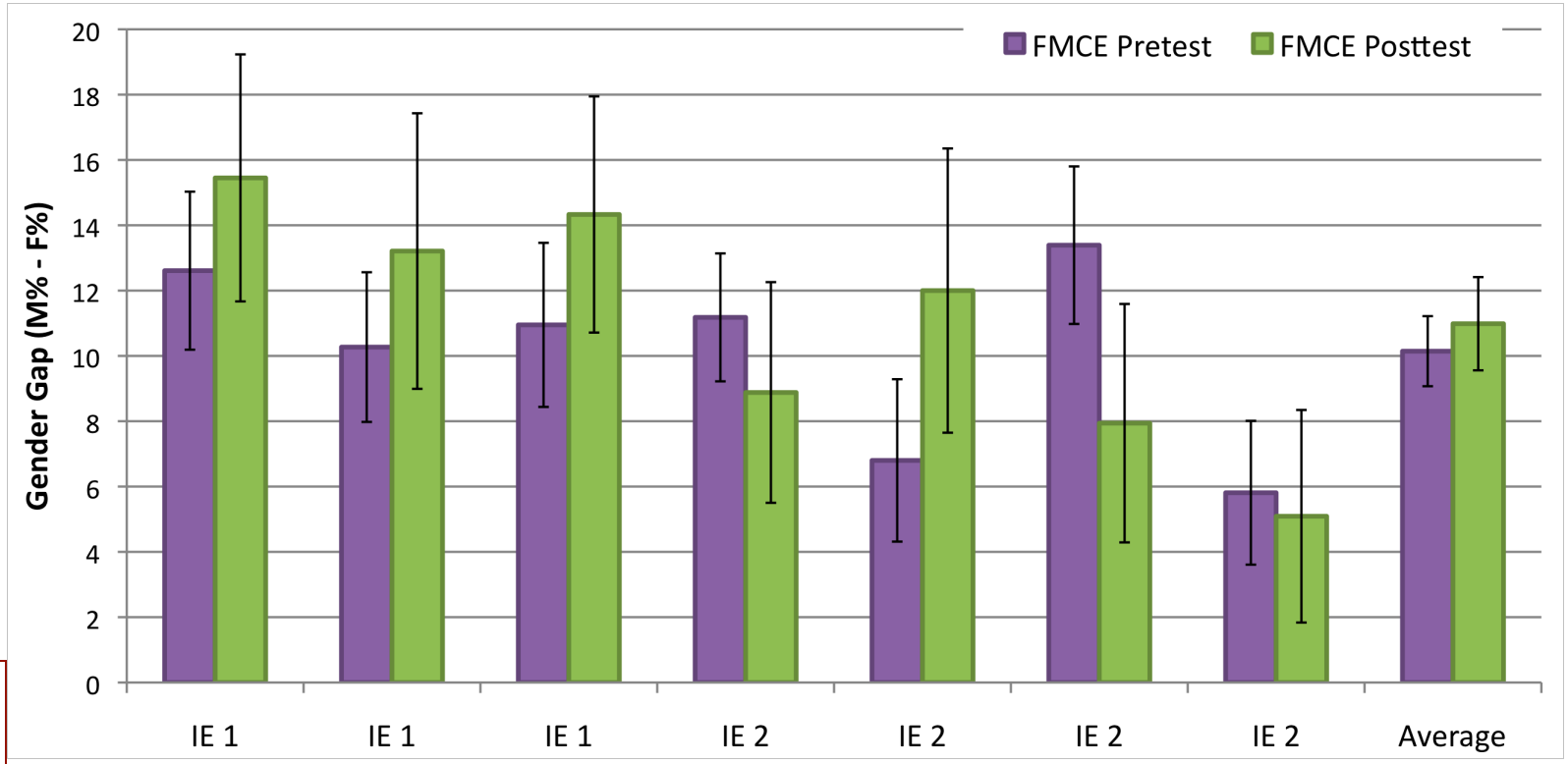
- Also use PI (both with and without other innovations)
- Larger class (400-600), smaller fraction female
- Average pretest score is lower
- Broadly consistent conclusions about gender effects in mechanics

Pollock *et al*, PRST-PER 3, 010107 (2007)
Kost *et al*, PRST-PER 5, 010101 (2009)
Kost *et al*, PERC Proceedings (2009).

SWARTHMORE

UC: FCME and gender

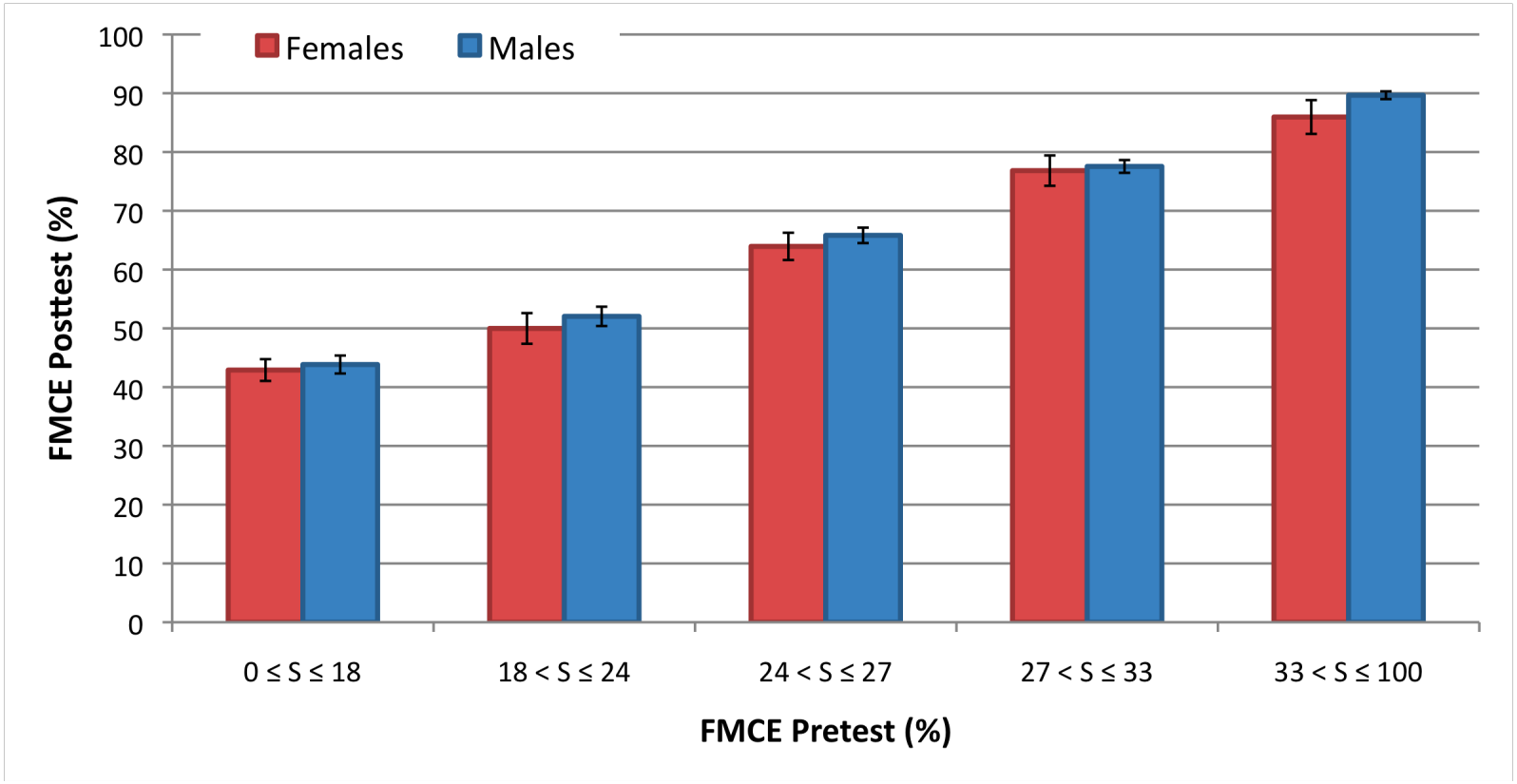
- Same absolute gains by males and females
- Posttest gender gap often smaller, but never zero
- PI/IE2 implementation probably matters



SWARTHMORE

UC: FCME, gender, and background

Posttest gap is accounted for by background



SWARTHMORE

UC: grades and gender

- Over seven semesters, females earn very slightly lower grades (0.11 points on 4 point scale)
- This difference can be accounted for by background (Kost, personal communication)
- Differences in individual semesters range from 0.04 to 0.17 points (not significant)
- Males' exam scores are higher by ~5%; females' homework scores are higher by ~5%

SWARTHMORE

Gender and Peer Instruction

Bottom line: PI appears to serve female students as well as male students, but does not overcome starting gaps

Implementation is probably important!

Consistent with University of Minnesota study of FCI and grades

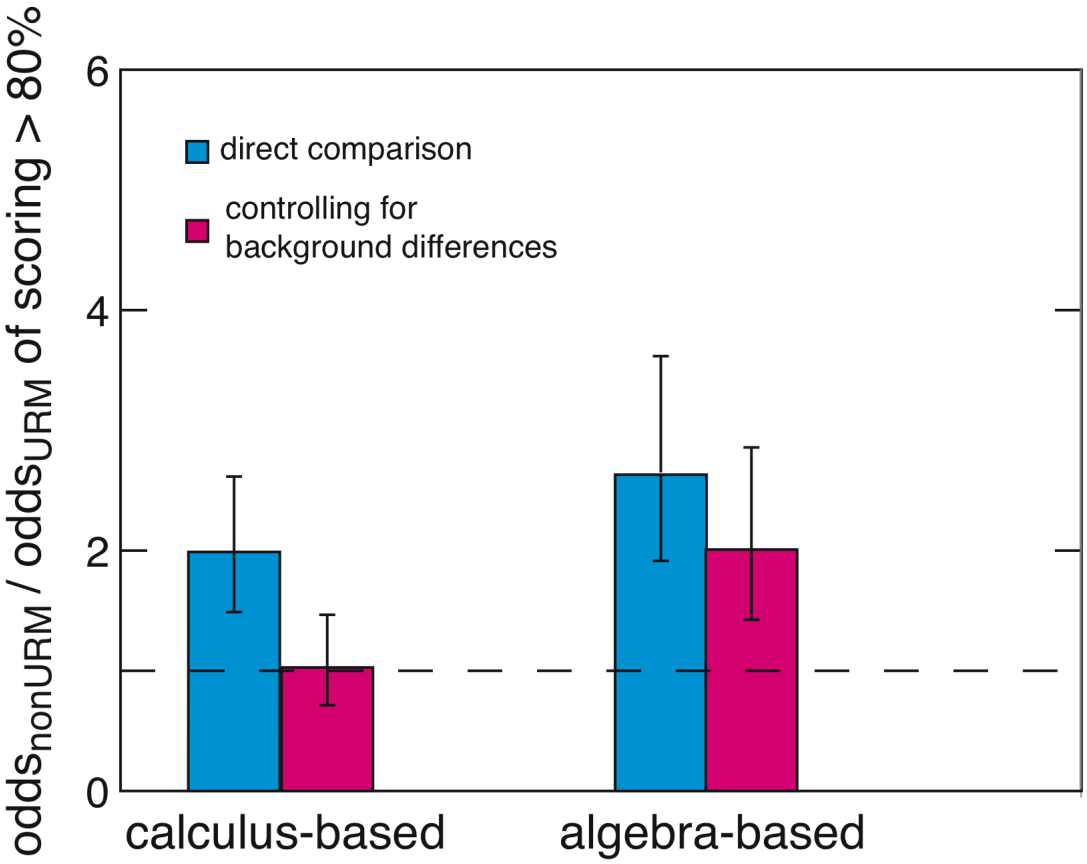
SWARTHMORE

Do underrepresented minorities achieve at the level of majority students with Peer Instruction?

SWARTHMORE

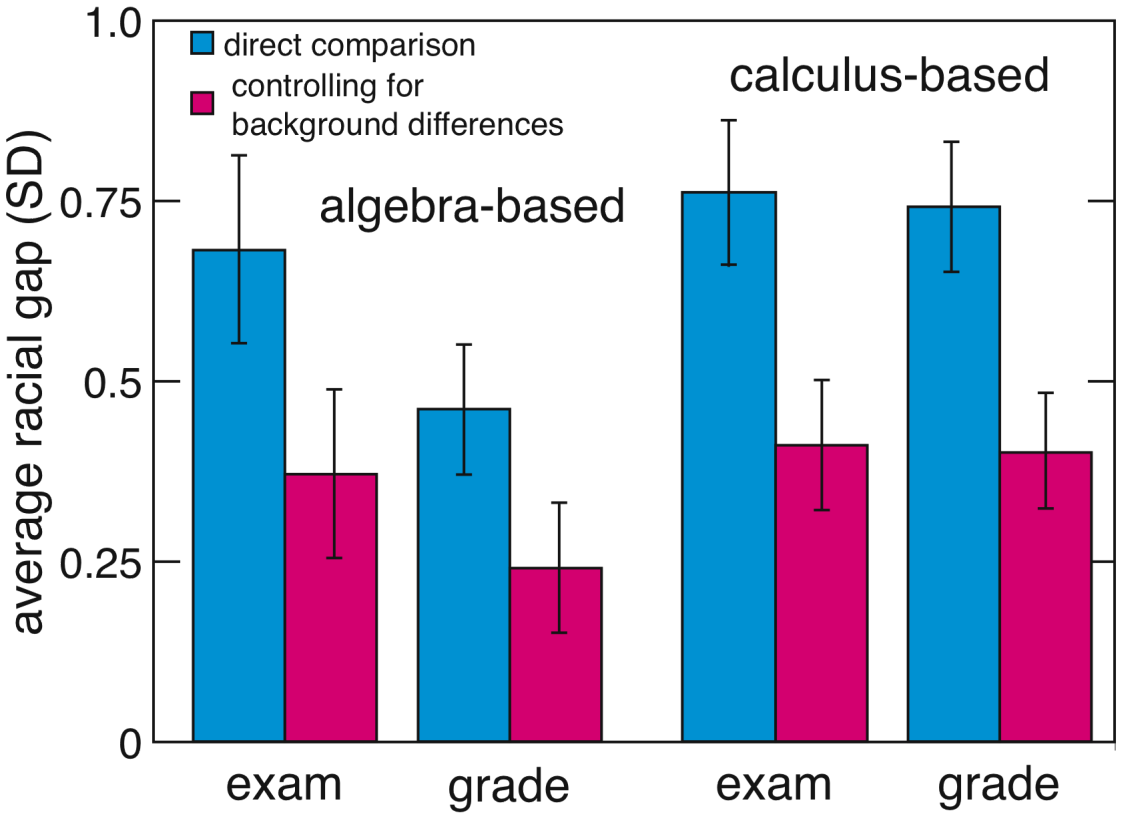
FCI high/low with URM

- Calc-based shows no gap after controlling for background, slight gap persists in alg-based



SWARTHMORE

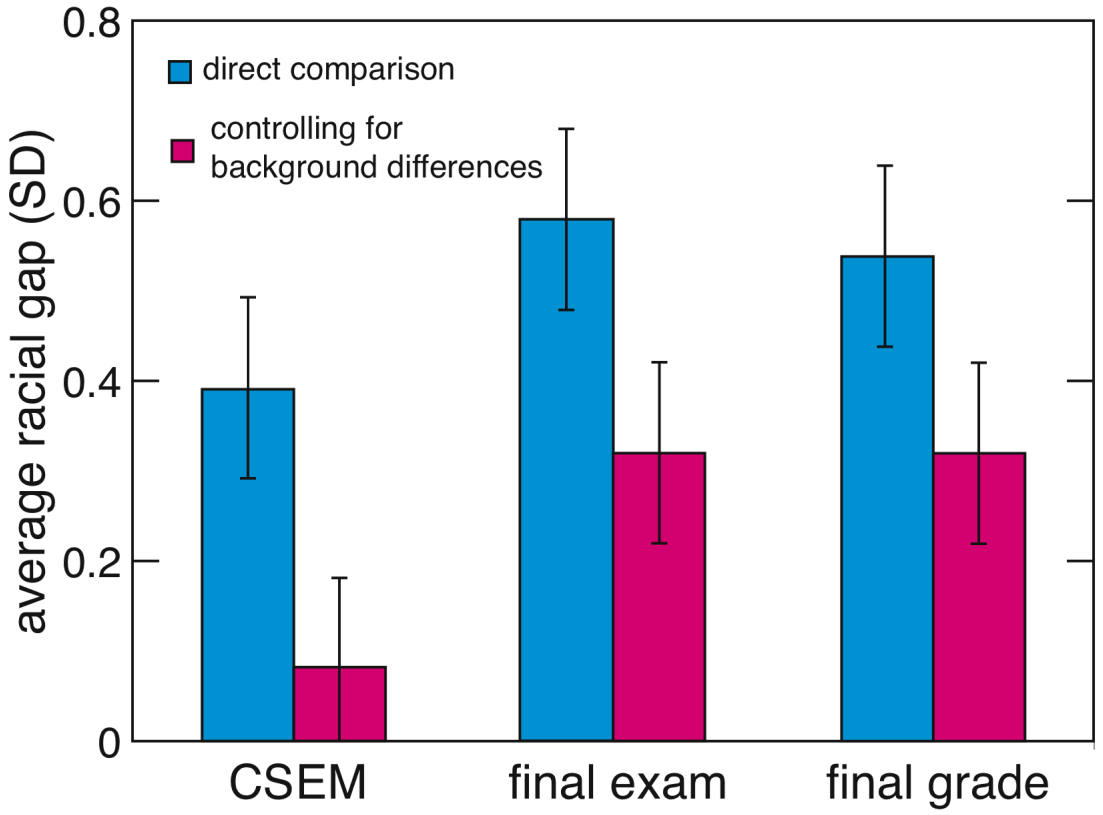
Exam scores and grades: URM



URM earn appreciably lower exam scores (8-13%) and grades (3-8%)

Gap is greater than background predicts

Electricity and magnetism: URM



CSEM gaps attributable to background, but not exams (~5-7%) or grades (~2-4%)!

SWARTHMORE

URM and Peer Instruction

Key findings:

- Females and URM have weaker average preparation (FCI pretest)
- *All* students show greater FCI gains from PI
- Females do as well on exams, grades, and CSEM as males with the same background (FCI murky)
- In this population, URM do as well on CSEM, but underperform on exams and grades

SWARTHMORE

Why the URM grade gap?

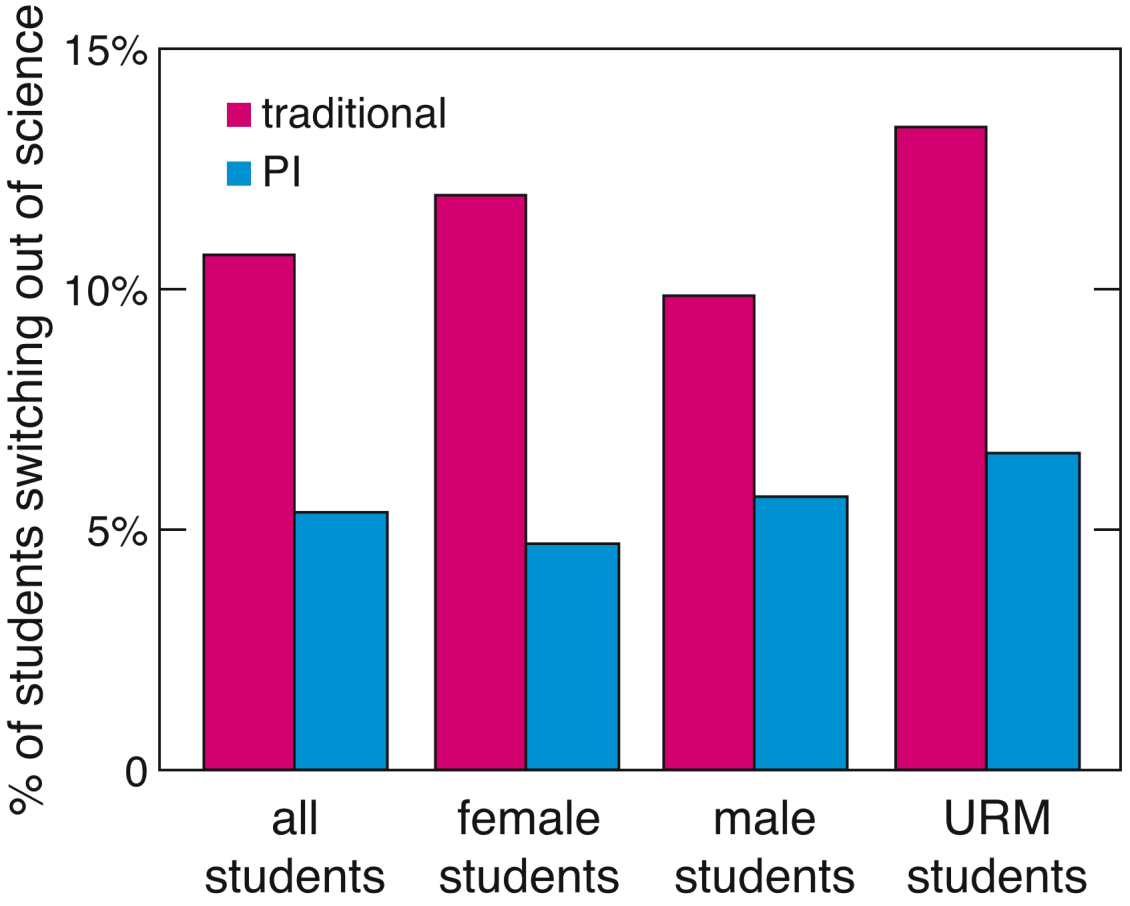
- URM homework scores (quantitative problem solving) are lower
- URM students may not be collaborating as much
- Stereotype threat on high-stakes assessments?

SWARTHMORE

Does Peer Instruction affect retention of underrepresented groups in science majors?

SWARTHMORE

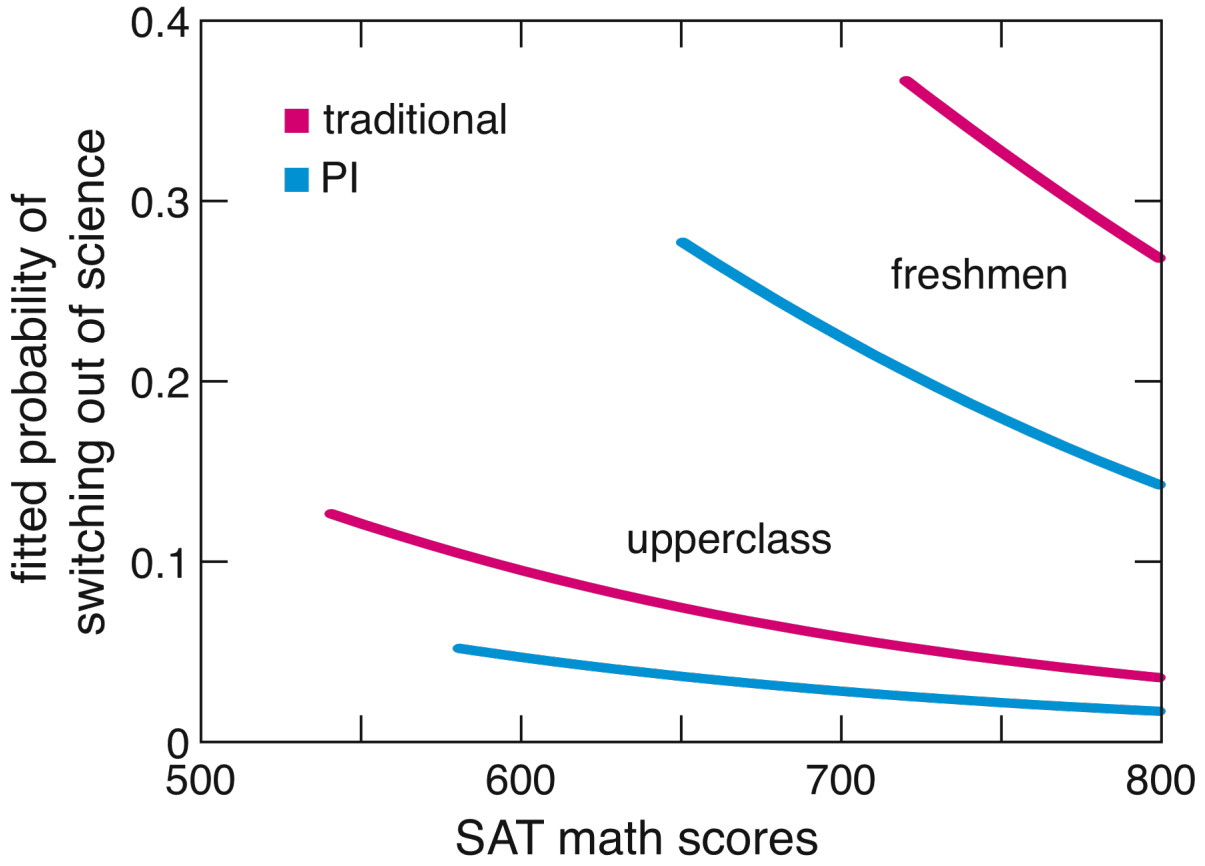
Retention: Harvard calc-based



PI halves the rate of switching out of science for all groups

SWARTHMORE

Retention



PI halves the rate of switching out of science for all groups

SWARTHMORE

Retention

Study of prospective engineers: one good early course confirmed choice to pursue engineering

PI course might play that role?

Lichtenstein, ASEE Annual Conference, 2007.

SWARTHMORE

Other questions for other talks

How does implementation affect underrepresented groups?

Does PI affect attitudes and confidence differently for males and females?

SWARTHMORE

Conclusions

- Females/URM have weaker preparation
- Although PI/IE2 produces greater gains for all students, differences persist
- Gender gaps attributable to background
  -> PI appears to serve females as well as males
  -> pay attention to implementation
- URM students underperform in grades even accounting for background
  -> requires further study
- PI courses improve retention for all groups

SWARTHMORE

Thanks to….

Jessica Watkins

PER@Colorado (especially Lauren Kost, Noah Finkelstein, and Steven Pollock)

University of Minnesota PER (especially Jen Docktor and Ken Heller)

NSF for funding

New results from Kost and Watkins: Session DH, Pavilion West, 5:40 – 6 p.m. today!

SWARTHMORE