Static or Dynamic? The Current Status of Women in Physics

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Overview

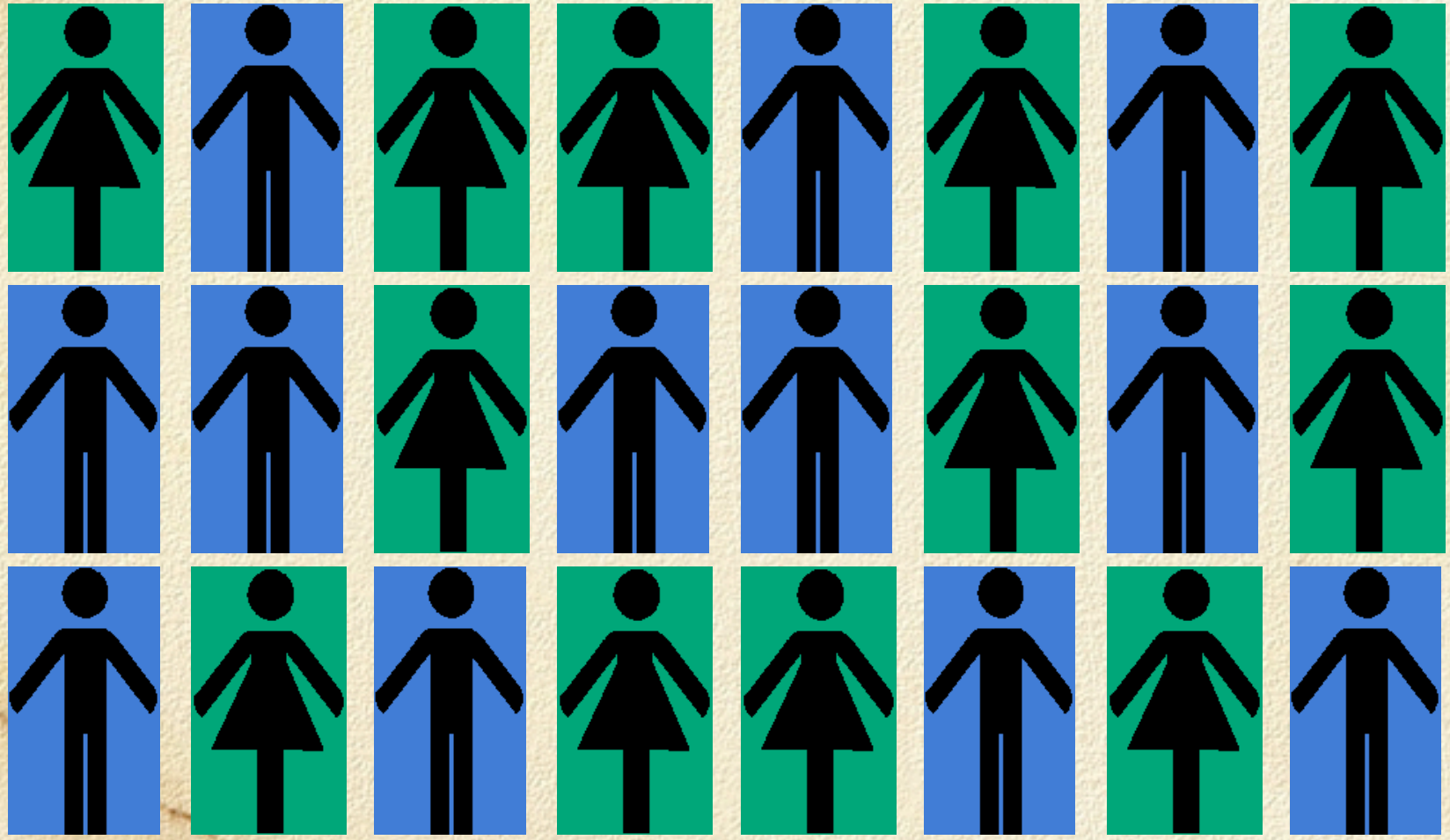
- Current status of women in physics
- Gender gaps in the physics classroom
- Better pedagogy = more women?

Women's Education

- Women receive
  - about half of all high school diplomas,
  - over half of all bachelor's degrees (57%),
  - 59% of master's degrees, and
  - 45% of doctorates
- What about physics?

Data from http://caspar.nsf.gov (NSF and NCES sources)

High School Physics

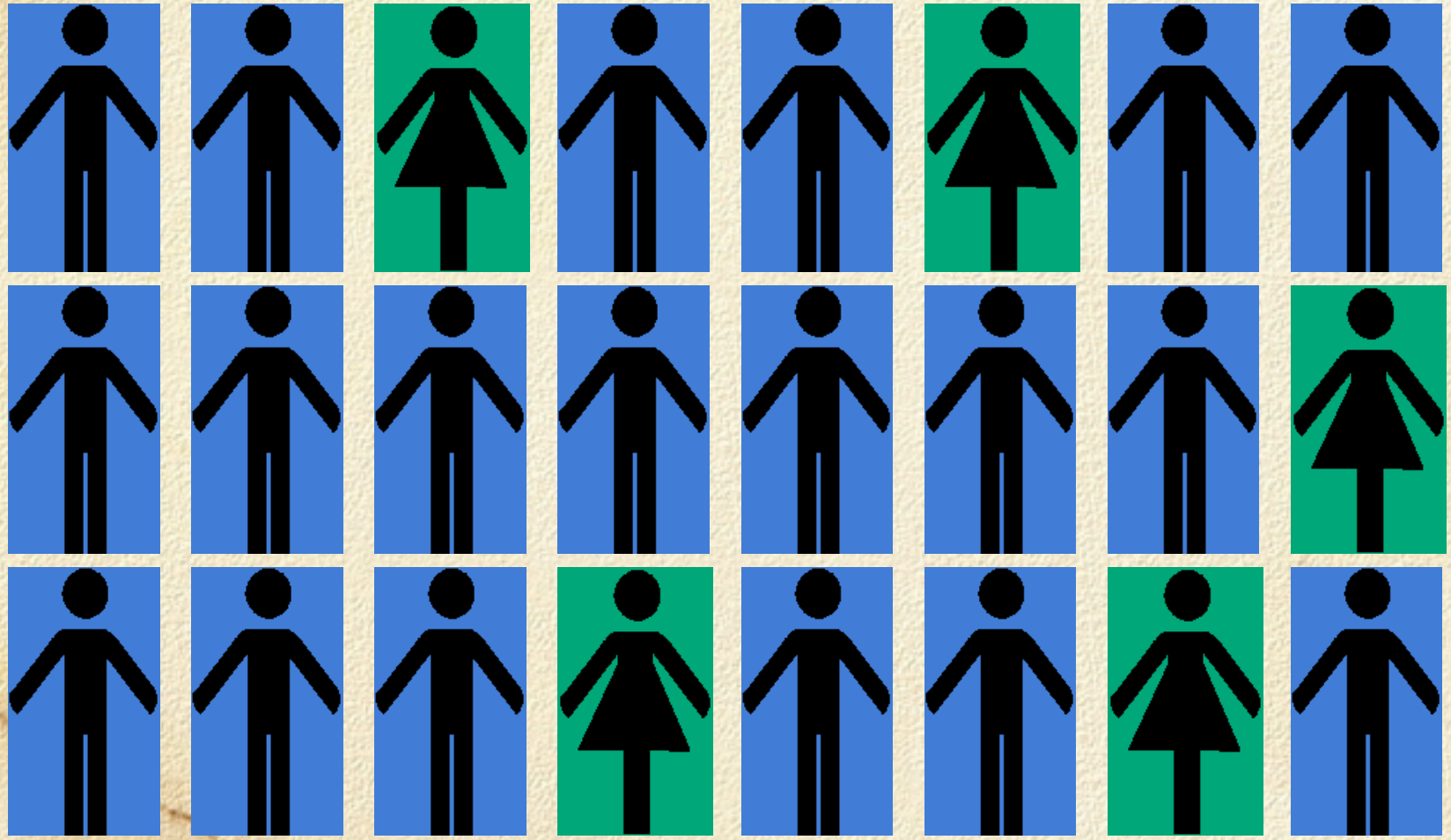


High School Physics

- 46% of high school physics students are female!
  (31% of students take HS physics)
- But…
- Girls are still less likely to be in the AP courses which are better preparation for college coursework

*Neuschatz, Michael, and Mark McFarling. 2003. *Broadening the Base: High School Physics at the Turn of New Century.* College Park, MD: American Institute of Physics.

Undergraduate Physics

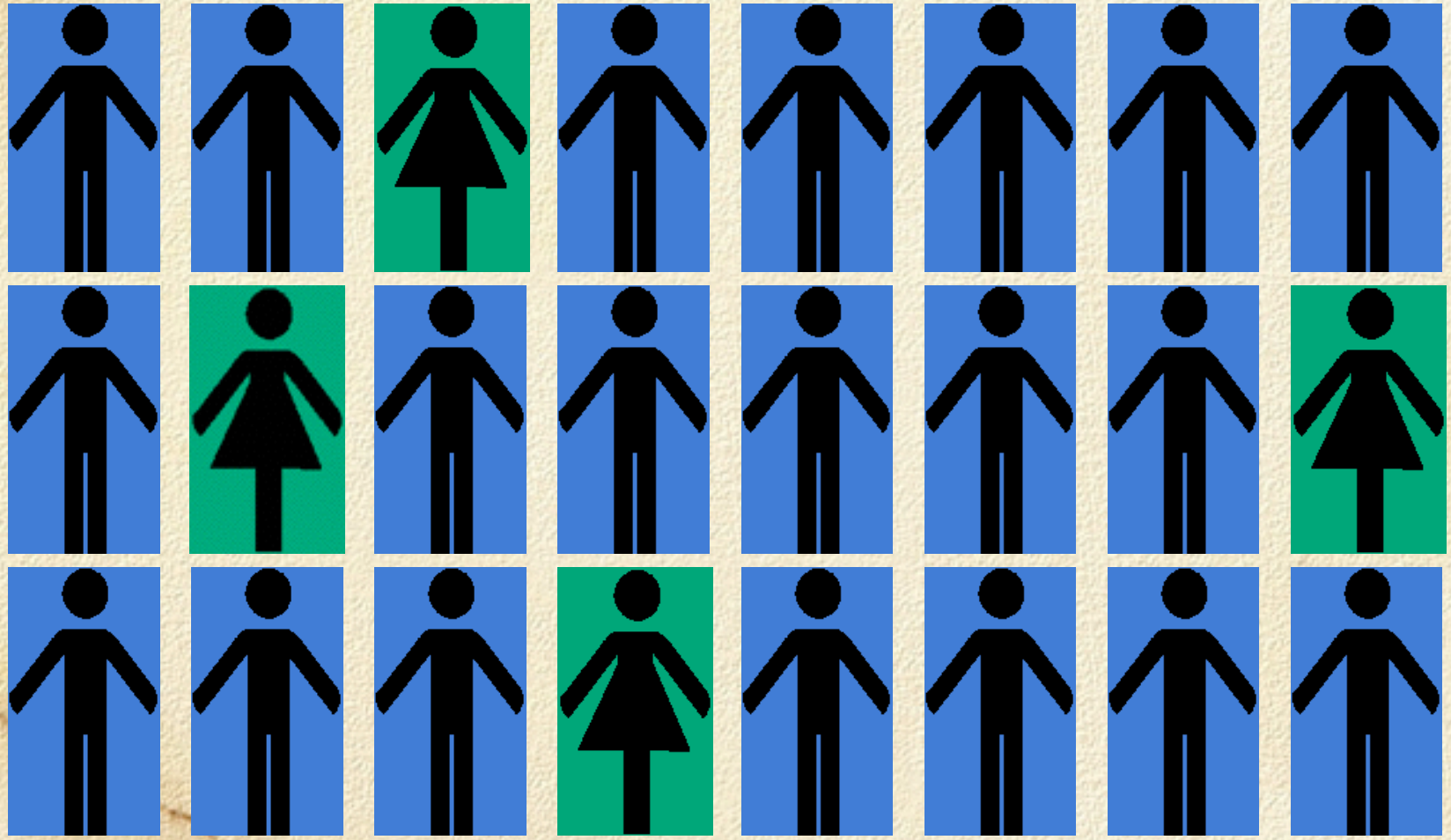


Undergraduate Physics

- Women make up ~31% of two-year college physics students*
- Among 25-year old college attendees who have had physics, 37% are female**
- Women receive 22% of physics bachelors degrees***

*Ivie, Rachel, and Katie Stowe. 2000. *Women in Physics, 2000*. College Park, MD: American Institute of Physics.
**Ivie, Rachel, and Kim Nies Ray. 2005. *Women in Physics, 2005*. College Park, MD: American Institute of Physics.
***Data from http://caspar.nsf.gov (NSF and NCES sources)

Graduate Physics



Graduate Physics

- 21% of first-year graduate students are women*
- Women receive 21% of master's degrees in physics**
- 18% of physics doctorates go to women*

*Ivie, Rachel, and Kim Nies Ray. 2005. *Women in Physics, 2005*. College Park, MD: American Institute of Physics.
**Data from http://caspar.nsf.gov (NSF and NCES sources)

Teaching positions

- 29% of high school physics teachers are women*
- 16% of adjunct/instructors in physics are women**
- 16% of assistant professors in physics are women**
- 11% of associate professors in physics are women**
- 5% of full professors in physics are women**

*Neuschatz, Michael, and Mark McFarling. 2003. *Broadening the Base: High School Physics at the Turn of New Century.* College Park, MD: American Institute of Physics.
**Ivie, Rachel, and Kim Nies Ray. 2005. *Women in Physics, 2005*. College Park, MD: American Institute of Physics.

The Problem: Under-representation

- Severe under-representation of women in physics
- Need scientifically literate public and technological/ scientific workers
- Need to be working to keep women
- Need to be doing research on how to keep women

Gender gap in the physics classroom

- How do women fare in the physics classroom?
- In high school, girls tend to get higher grades than boys
- In high school science class, girls receive higher grades than boys

AAUW. (1992). *How Schools Shortchange Girls.* New York: Marlowe & Co.
AAUW (1999). *Gender Gaps.* New York: Marlowe & Co.

College grades

- Women in college tend to earn higher grades than their male counterparts
- Women's SAT/ACT scores tend to under-predict their college GPA

Mau, W-C. and Lynn, R. (2001). Gender differences on the SAT, the ACT, and college grades. *Educational Psychology* 21(2), 133-136.
Leonard, D. and Jiang, J. (1999). Gender bias and the college predictions of the SATs. *Research in Higher Education* 40(4), 375-407.

College physics

- What about college physics?

	Women (N=526)	Men (N=1293)
A	15	24
B	41	40
C	37	31
D	6	4
F	1.0	1.4

McCullough, L. & Crouch, C. H. (2001) "Gender, Educational Reform, and Instructional Assessment: Part I" AAPT talk Philadelphia, PA Winter Meeting 2002

College physics grades

- Women more likely to do better than men among students who had HS physics
- In university-level (calculus-based) physics, women receive lower grades than men
- Professor of same gender ➡ higher grade in college physics course

Sadler, P. and Tai, R. (2001) Success in introductory college physics: The role of high school preparation. *Science Education*, 85(2), 111-136.
Tai, R. and Sadler, P. (2001). Gender differences in introductory undergraduate physics performance; university physics versus college physics in the USA. *Int'l J. of Science Education*, 23(10), 1017-1037.

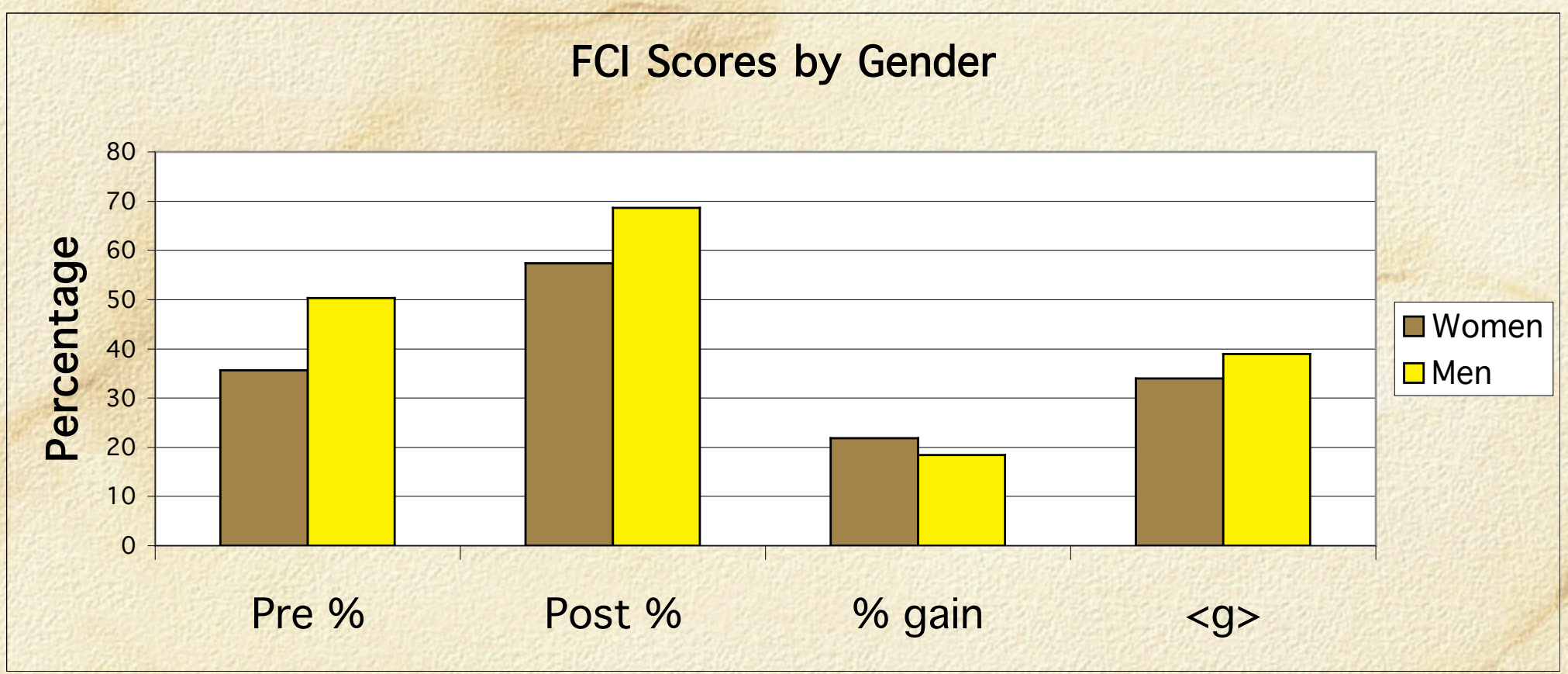
Conceptual testing

- Many multiple-choice conceptual tests are available for introductory physics courses; how do women fare on these tests?

Force Concept Inventory

- Women average lower scores on the FCI at all class levels; this gap does not seem to be dependent on previous physics background

From McCullough, L. & Crouch, C. H. (2001) "Gender, Educational Reform, and Instructional Assessment: Part I" AAPT talk Philadelphia, PA Winter Meeting 2002



	Pre %	Post %	% gain	<g>
Women (N=780)	35.6 (.5)	57.4 (.7)	21.8 (.6)	.34 (.01)
Men (N=1997)	50.3 (.4)	68.6 (.5)	18.4 (.4)	.39 (.01)

Test of Understanding Graphs-Kinematics

- 21 question test on kinematics graphs
- From the test author:
  - Males averaged 9.5/21 (45%)
  - Females averaged 7.2/21 (34%)
- Statistically significant gap favoring males

Beichner, R. (1994) Testing student interpretation of kinematics graphs. *Am. J. of Physics*, 62(8), 750-762.

DIRECT

- The DIRECT conceptual test on direct current circuits shows a gender difference at the university and high school levels; both differences were found to be statistically significant

	University mean score	High school mean score
Men	16	13
Women	12	11

Engelhardt, P. and Beichner, B. (2004) Students' understanding of direct current resistive electrical circuits. *Am. J. of Physics*, 72(1), 98-115.

Gender gaps exist

- Lower rates of participation of women in physics
- Conceptual tests show gap favoring males
- Physics classroom's effect on women?

Pedagogy and women in physics

- Belief that interactive/student-centered/ feminist/inquiry-based pedagogies are particularly helpful for women
- What data is there to support this?

Bad pedagogy

- "Reports of poor teaching in S.M.E. classes were by far the most common complaint of all switchers and non-switchers."
  Pedagogy was third-highest rated reason for leaving science
- Science teachers less likely to use active learning techniques; more likely to grade on curve

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.
Milem, J., & Astin, H. (1994). *Scientists as teachers: A look at their culture, their roles, and their pedagogy.* Paper presented at the NARST meeting, New Orleans, LA.

Good pedagogy?

- Good pedagogy helping women? Little research to support this
- Much discussion, many papers on how to change classrooms and teaching

High school pedagogy

- Deep and narrow pedagogy in high school helps achievement in college physics courses
- No mention if it helps females more

Tai, R. and Sadler, P. (2001). Gender differences in introductory undergraduate physics performance; university physics versus college physics in the USA. *Int'l J. of Science Education*, 23(10), 1017-1037.

Pedagogy to attract

- What Works? project:
  More than one student cited an innovative teaching approach as a reason to major in physics

- Grinnell College: Changing pedagogy in intro courses draws more women

Whitten, B., S. Foster, M. Duncombe, P. Allen, P. Heron, H. Zorn, L. McCullough, K. Shaw, B. Taylor. (2003) What Works? Increasing the Participation of Women in Undergraduate Physics. *J. of Women and Minorities in Science and Engineering,* 9(3/4), 239-258.

Schneider, M. (2001). Encouragement of women physics majors at Grinnell College: A case study. *Phys. Teacher*, 39, 280-282.

Pedagogy to retain

- Rutgers University:
  "Extended General Physics" course with more interactive pedagogy helps women stay in the course; 1% drop compared with 11% drop in regular course

- "Individual differences between students far outweighed gender differences"

Etkina, E., K. Gibbons, B. L. Holton, G. K. Horton. (1999). Lessons learned: A case study of an integrated way of teaching introductory physics to at-risk students at Rutgers University. *Am. J. of Phys.,* 67(9), 810-818.

Pedagogy helping women?

- Workshop Physics:
  Younger college women → positive experience
  More senior college women → more likely to feel negative about the interactive course structure

- SCALE-UP:
  Women were almost five times as likely to pass a SCALE-UP course than a traditional course

Laws, P., P. Rosborough, F. Poodry, (1999). Women's responses to an activity-based introductory physics program. *Am. J. of Phys.*, 67(7), S32-S37.
Beichner, R., J. Saul. (2003). *Introduction to the SCALE-UP Project.* Paper submitted to the Proceedings of the International School of Physics, Varenna, Italy.

Pedagogy and attitude

- Feminist pedagogy in physics classroom showed large positive changes in attitude (men and women)
- "Almost significant" effects on student anxiety (reduction of anxiety)

Davis, F. & Steiger, A.(1993). *Feminist Pedagogy in the Physical Sciences.* Report to the Quebec Department of Higher Education and Science.

Hot off the press

- FCI: Consistent pretest gender gap every year
- Traditional pedagogy: post-test gender gap
- First implementation IE course: reduced gender gap post-instruction
- Second implementation IE course: gender gap post-instruction reduced to statistical insignificance

Lorenzo, M., C. Crouch, E. Mazur, (2006) Reducing the gender gap in the physics classroom. *Am. J. of Phys.*, 74(2), 118-122.

Lorenzo et al. continued

- FCI normalized gain <g>
- More interactive course increased gain for both men and women
- Gender gap in <g> reduced to insignificance with more interactive course

Lorenzo et al. continued

- Reduced gender gap attributed to pedagogical changes (pretest constant)
- “No observed loss of achievement among the male students.”

Pedagogy's effect

- Little research available; suggestions that more interactive pedagogies help women in various ways
  - attitudes
  - recruitment and retention
  - interest
  - achievement

What else helps?

- Exposure to science from a young age
- Role models and mentors
- Support structure
- Supportive climate

Conclusions

- Women still under-represented in physics
- Gender disparities in physics classrooms
- Better pedagogy, while helping raise all students' achievement, may be particularly helpful to women; much more research needed