

# Women in Science and Testing; or, Why Does Context Matter?

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*March 28, 2005*

# Overview

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- Under-representation of women in science
- Reasons for this under-representation
- Effects of context on student response

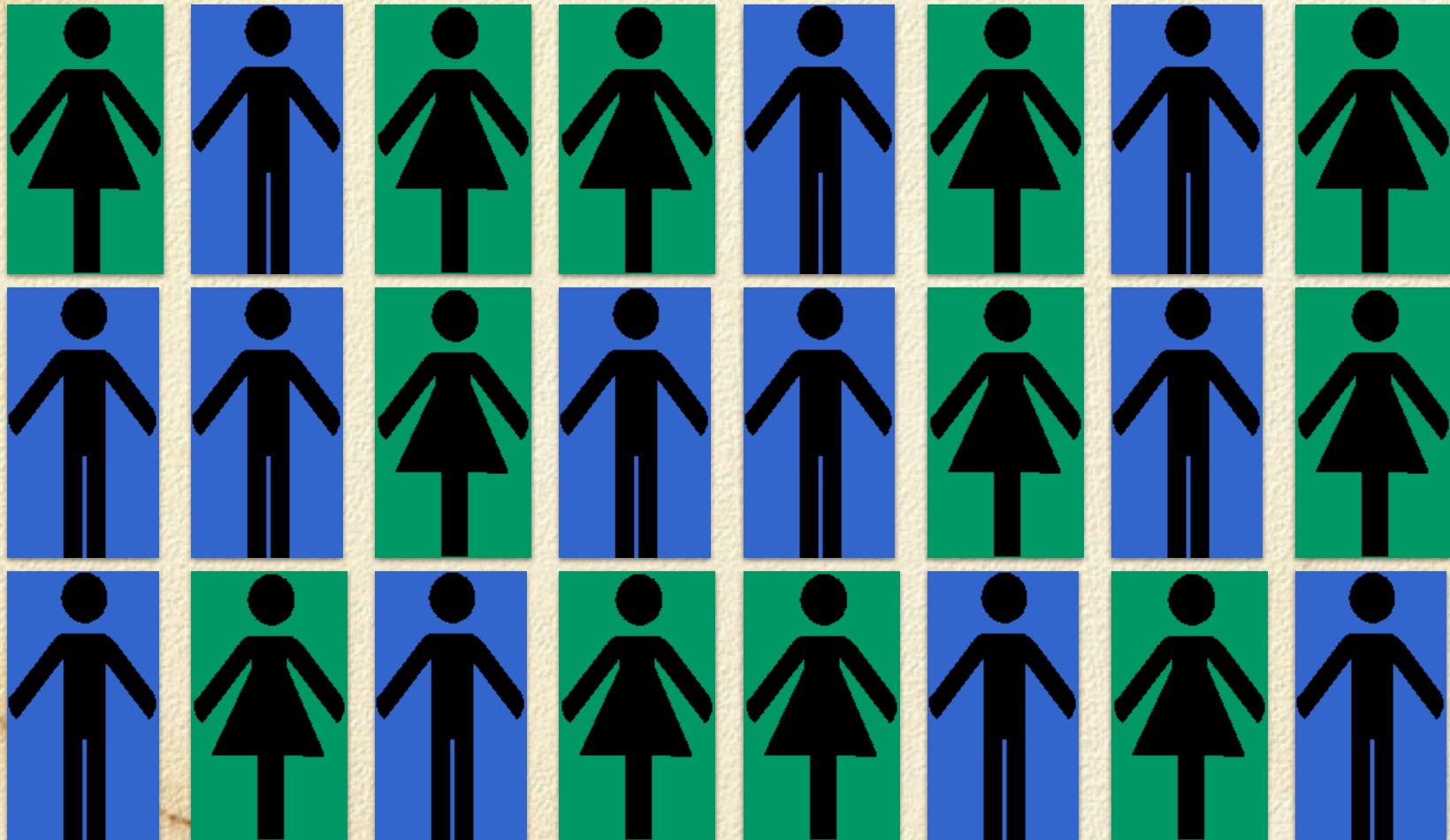
# Background

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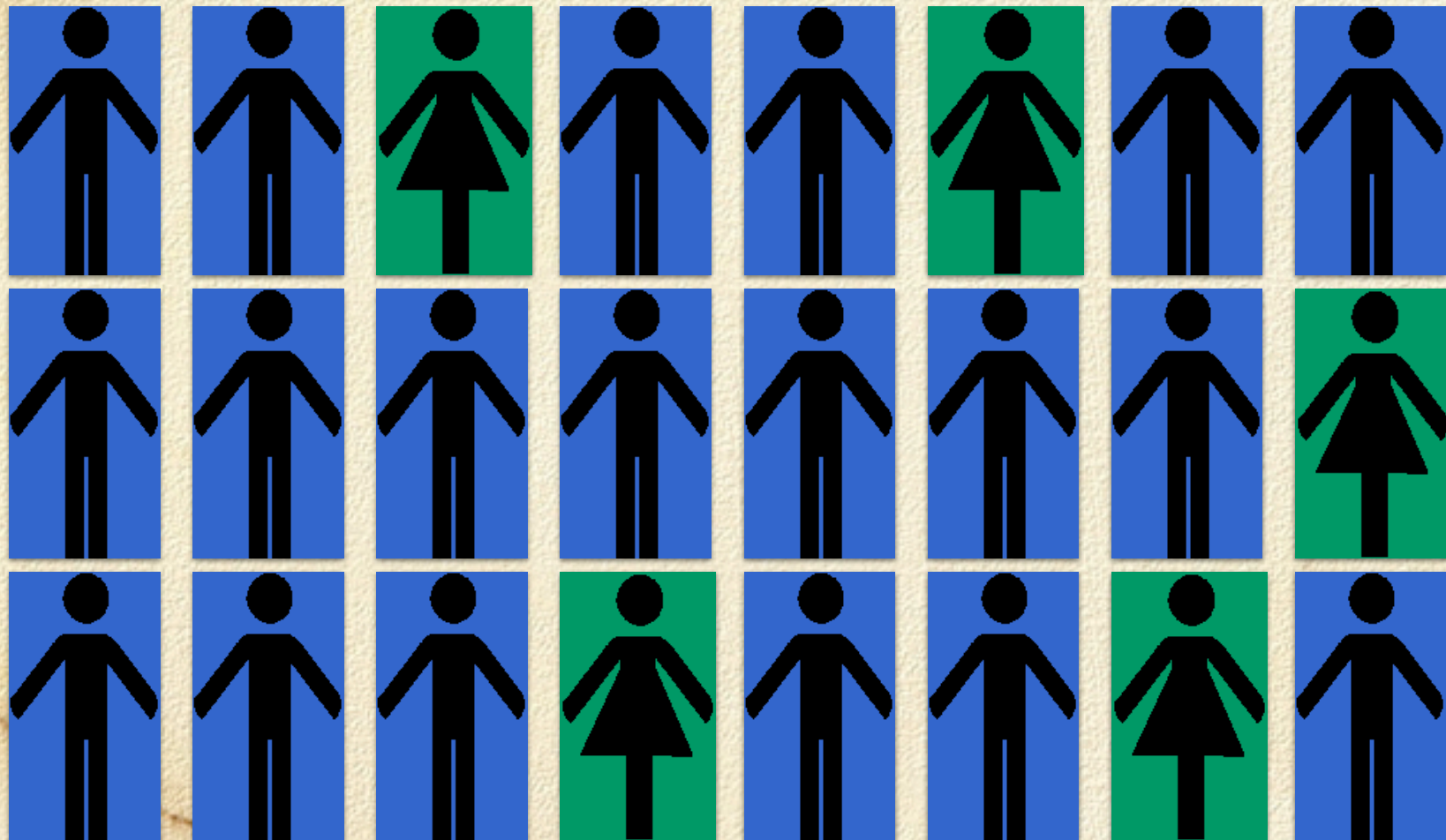
- Though women get about half of all degrees overall, women are underrepresented in physics and other sciences

# High School Physics

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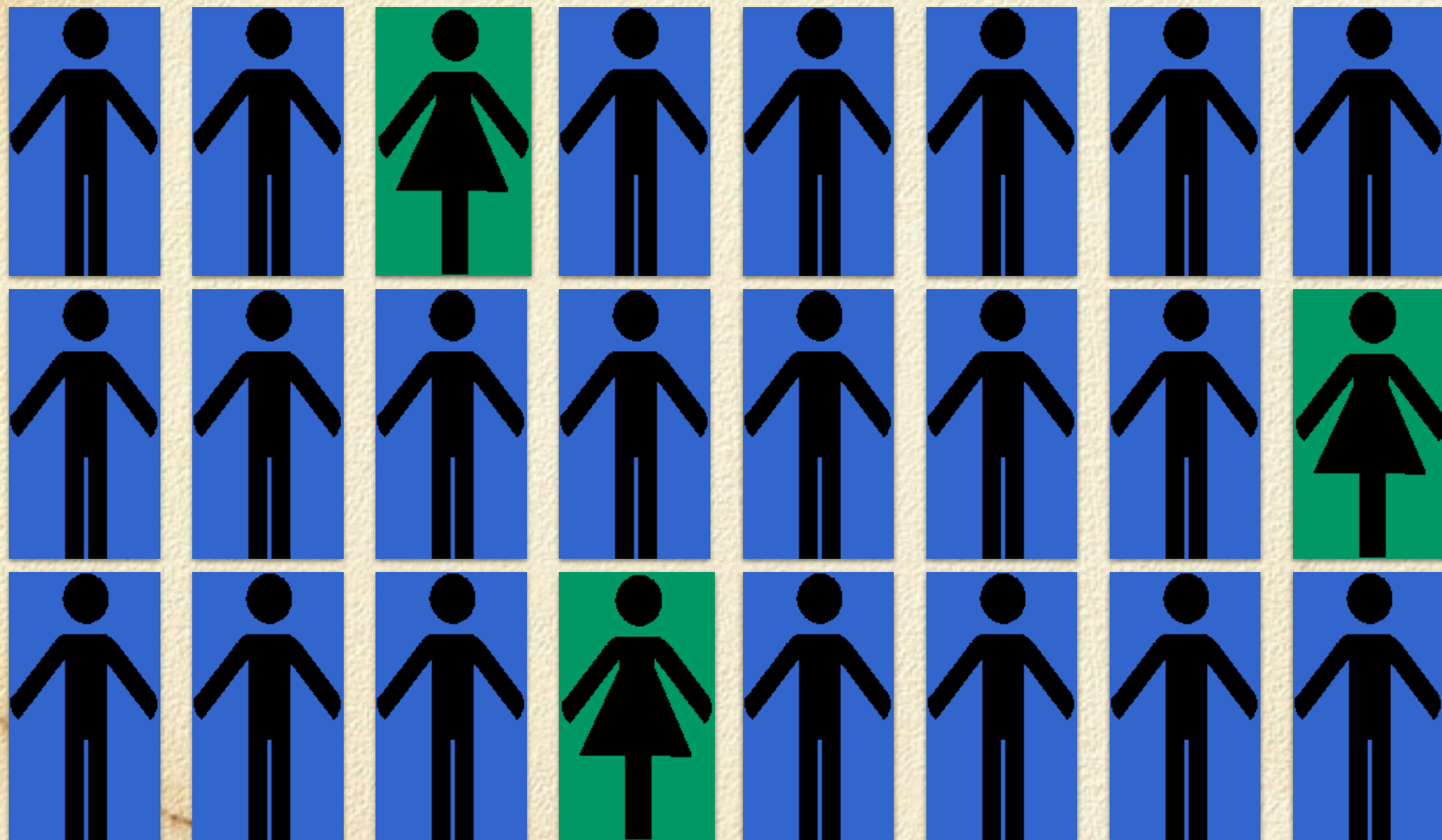


# Undergraduate Physics



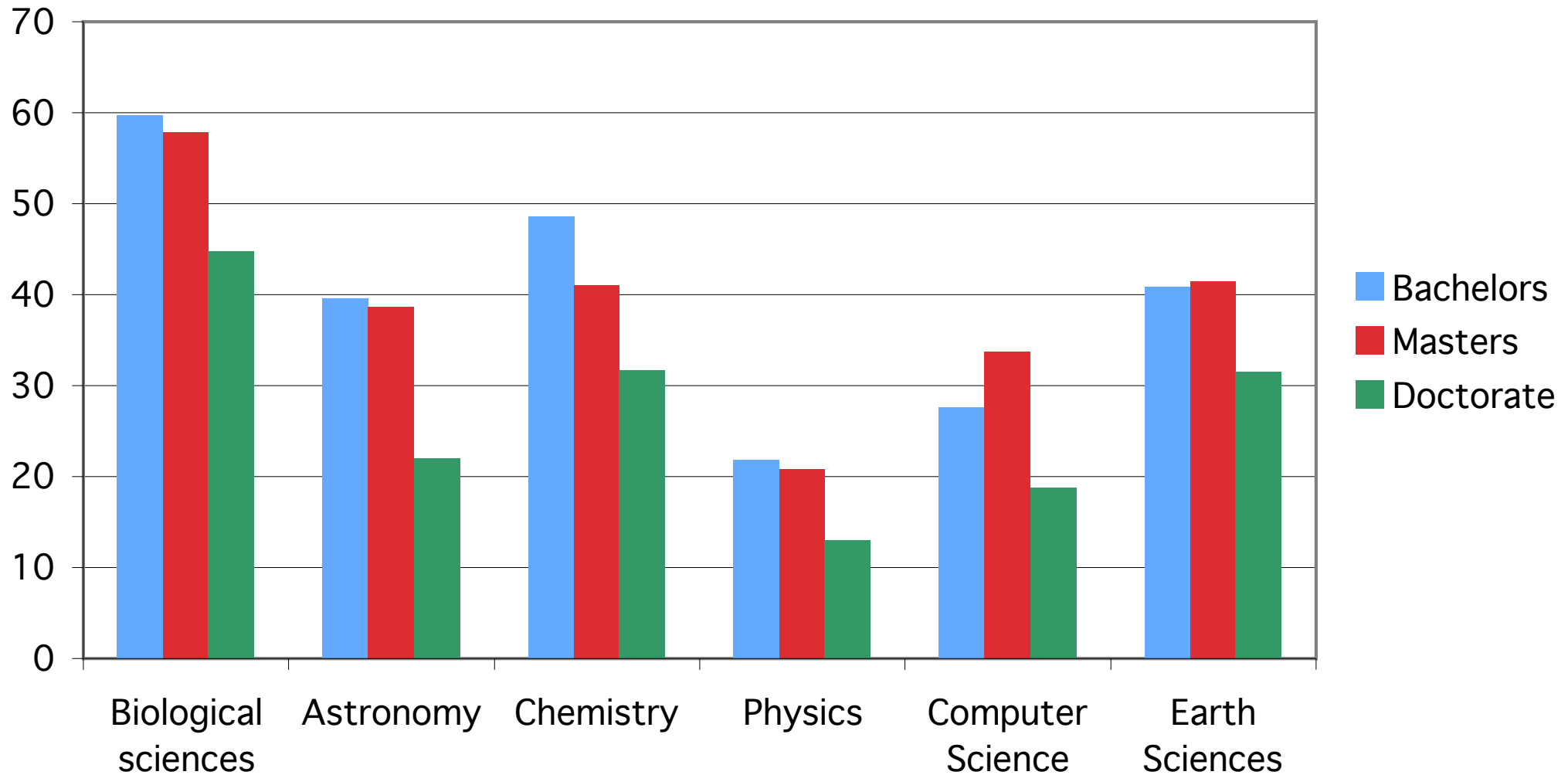
# Graduate Physics

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# Women in Science—by degree

% of degrees awarded to women



# Yes, there is a problem

- Severe under-representation of women in physics and most of the physical sciences
- Need to be encouraging women
- Need to stop discouraging women
- What's causing women to leave?



# The Problem: Primary and Middle School

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- By 5th grade, boys and girls have significantly different in-school and out-of-school science experiences
- By 6th grade, girls' attitudes towards science are more negative than boys'
- By 6th-8th grade, girls score lower on science achievement tests than boys do

# The Problem: High School

- Barriers:
  - Peer culture
  - Peer harassment
  - Bad counseling and advice
  - Sexism from administrators and teachers
  - Classroom culture of sexism
  - Lack of female teachers/role models (25%)
  - Parental influence

# High school science lab

- Lab and hands-on experiences are some of the most effective teaching techniques in science; but only if students participate
- In mixed-sex classes and groups, male students tend to dominate equipment and materials; female students are often relegated to role of note-taker and recorder

# The Problem:

## Undergraduate science

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- Barriers:
  - Peer harassment
  - Outright sexism in the classroom
  - Poor advising
  - Lack of mentors and role models
  - Poor pedagogy

# The Problem: Industry and Academe

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- Barriers:
  - Parallel tracking: “lab technician”
  - Harassment
  - Sexism
  - Lack of role models
  - Cultural expectations
  - Family/work conflicts
  - Two-body problem

# There is a Problem

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- Discouraging women at every stage
- Many societal and cultural barriers

# How about Larry Summers?

- Are there inherent biological differences between men and women? *Yes*
- Are men biologically better at science than women?  
*No*

Women in Science: Comparisons across Cultures. (1994). *Science*, 263, 1467-1532.

# My background

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- Woman in physics → research on women in physics/science
- Physics teacher → research on physics classrooms
- My research area: Are there particular barriers in science education?
- Research on women in physics classrooms, such as research on student performance



# Research on student performance

- Commonly used physics questionnaire, used across the country in high schools, colleges, and universities
- Data from 5 years at UMN; look at gender breakdown

# The Force Concept Inventory

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- 30 question test covers topics usually taught in first term introductory physics
- No math/calculations
- “Wrong” answers (distractors) were carefully chosen from research on common student misconceptions

# FCI at UMN

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- Every semester at UMN, men outperformed women!
- Gap ranged from 10-15% higher for men
- Yikes! Was this special to UMN or was this more widespread?
- How to test? Get lots more data

# Gender and the FCI

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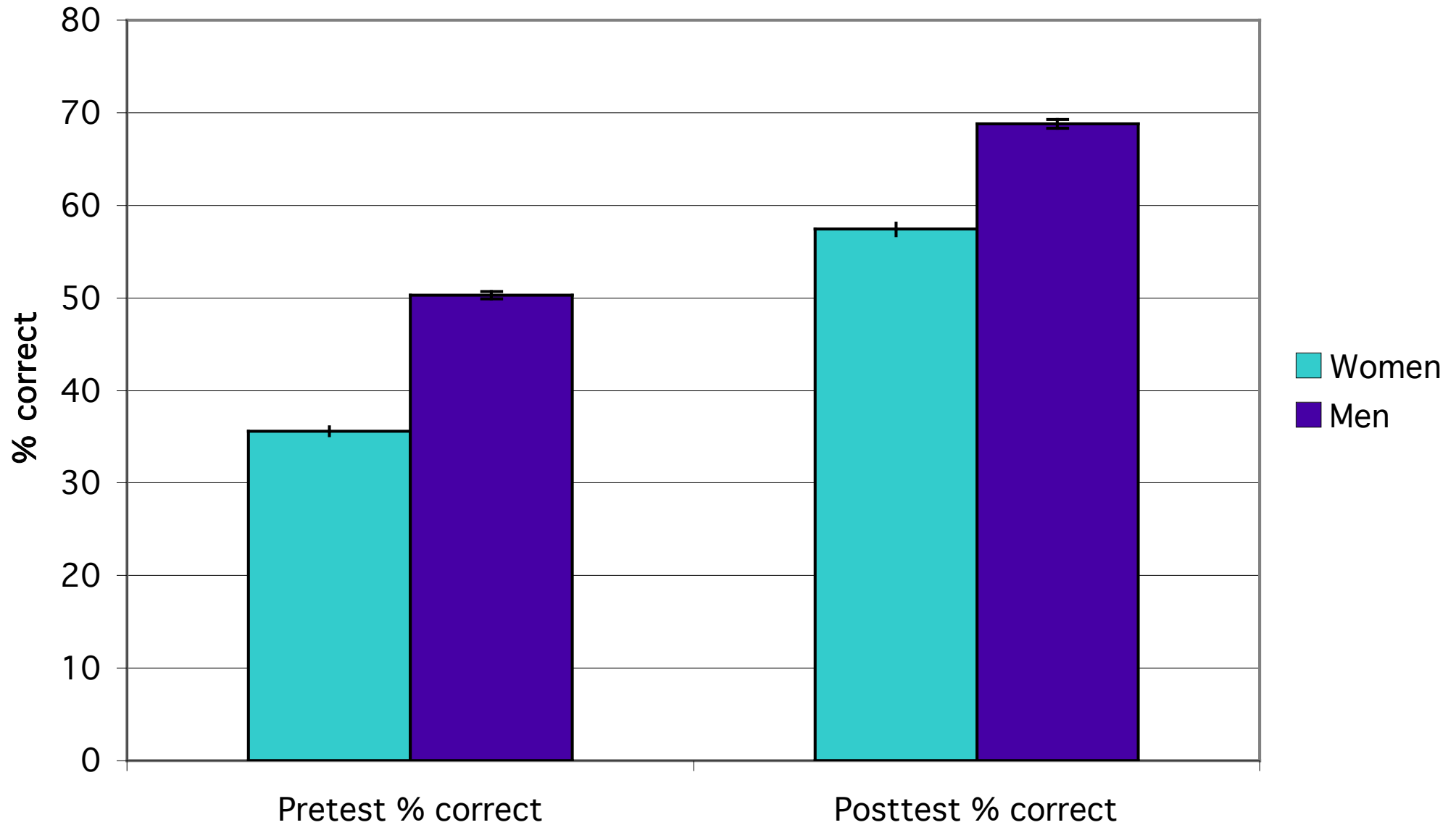
- Study with 8 different higher education institutions
- Men and women took FCI
- Collected data on pre-test score, post-test score, gender, and where possible, previous physics background

# Gender gap

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	Pre %	Post %
Women (N=780)	35.6 (se=.5)	57.4 (se=.7)
Men (N=1997)	50.3 (se=.4)	68.6 (se=.5)

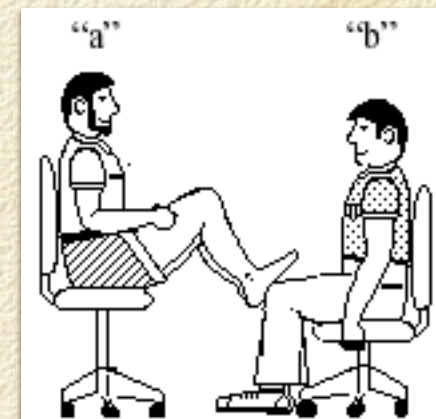
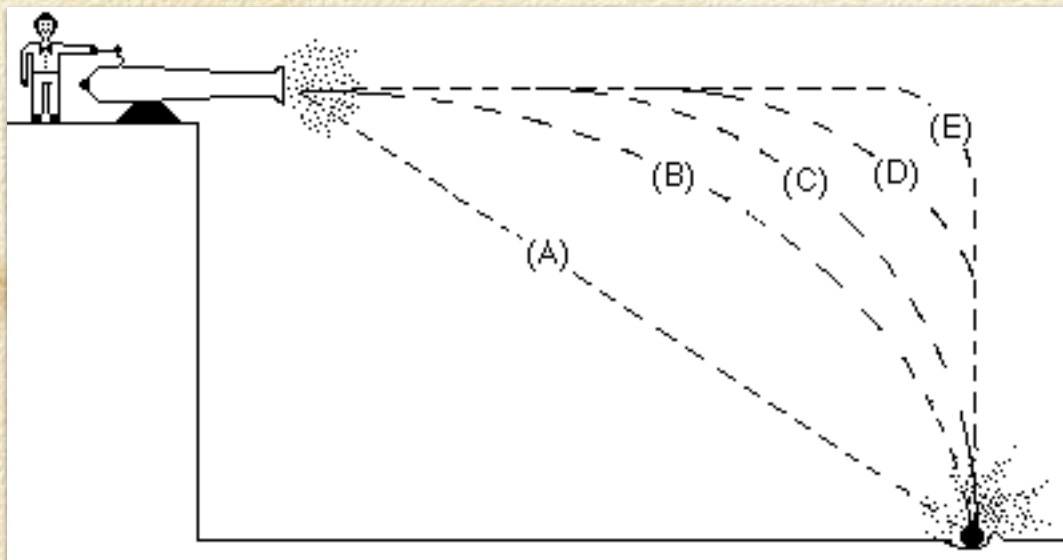
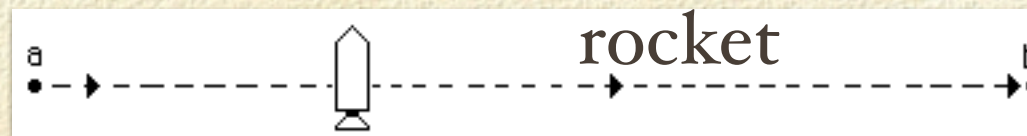
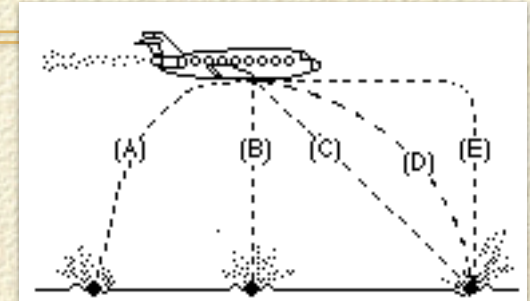
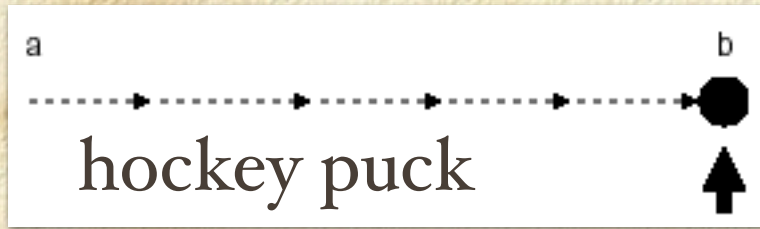
# % correct by gender pre/post



# Why the gender gap?

- What's up with this test?
- The men, the women, or the test?
- Possible test bias?
- Take a closer look...

# FCI contexts





# Test by males, for males?

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- Written by a team of male physics education researchers
- Tested on mostly male high school students
- Stereotypically male contexts
- Almost every person is a male

# Whoa...

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- Do all those male contexts actually hurt women's performance?

# The Impact of Context

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- Context makes a difference! Memory tests: men remember directions more easily and women remember a shopping list more easily (Hermann et al., 1992)
- We are more comfortable in familiar contexts, including in the classroom (science lab from job advertisement)

# Context & Response?

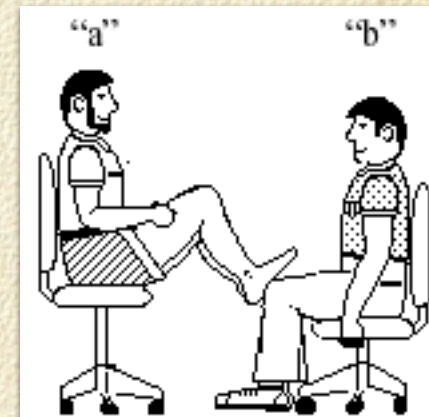
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- Rennie & Parker: changing context affected student response
- Students preferred real-life context questions
- More girls than boys preferred contextual questions (found the questions easier)
- Enderstein & Spargo: changing context from native to urban changed responses

# Evidence for Contextual Interaction

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- Translated version of the test in Thailand
- Students wouldn't answer this question!
- Cultural context completely blocked the science of the question
- Context affects performance!



# How to test context?

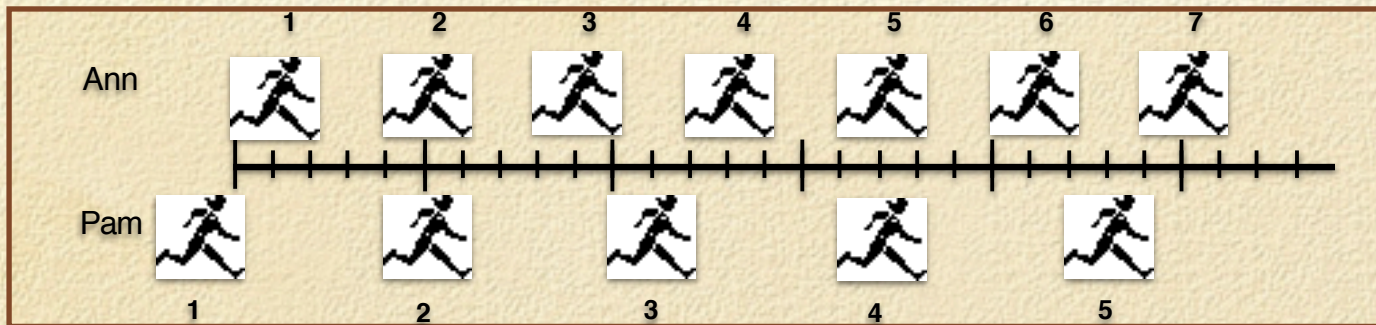
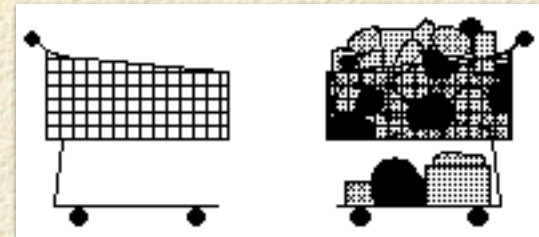
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- Change the context!
- New version of FCI with stereotypically female contexts
- As far towards a female bias as possible
- Also more daily-life situations

# What's a Female Context?

- What stereotypically female contexts can you come up with?

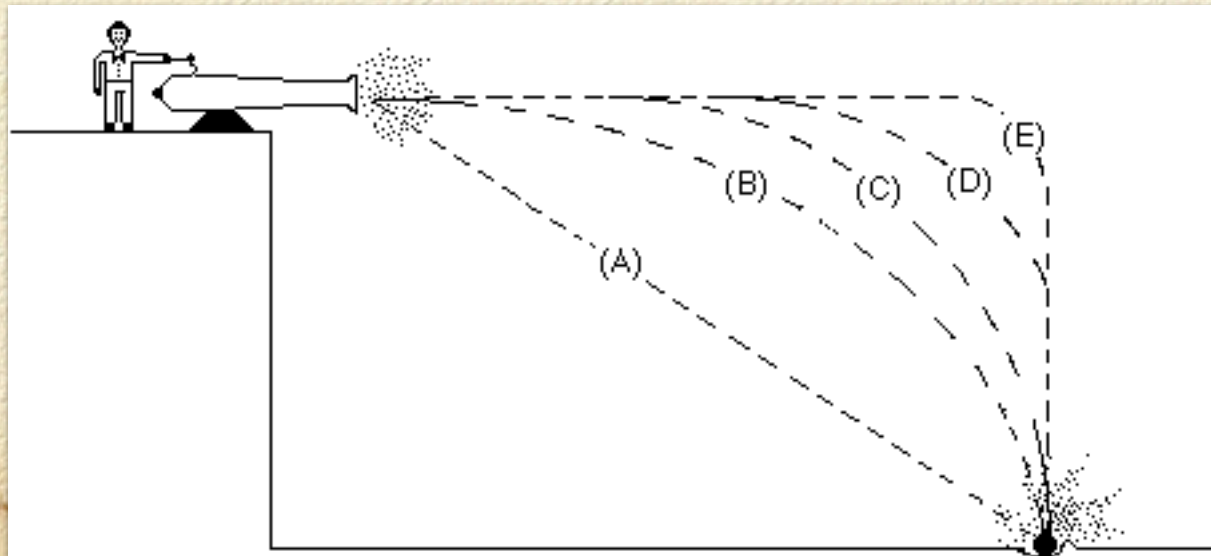
# New FCI contexts





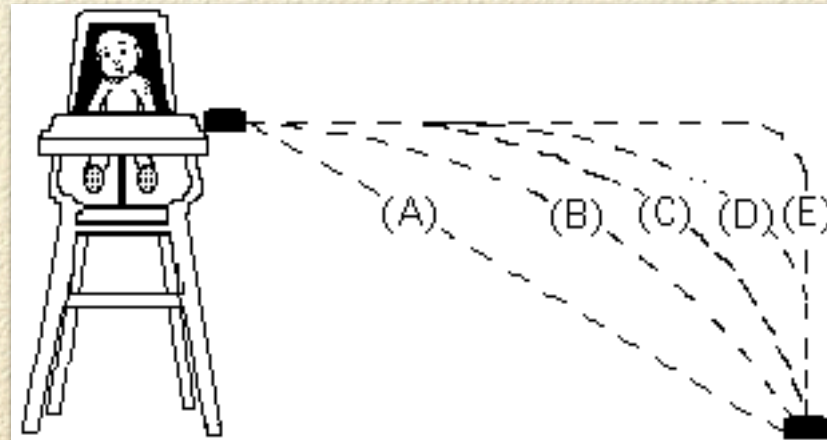
# Original question

- A ball is fired by a cannon from the top of a cliff as shown in the figure below. Which of the paths would the cannon ball most closely follow?



# Revised question

- A baby in a high chair slides her bowl of food horizontally off the side of her flat tray with a quick push. Which path below best represents the path of the bowl?



# Original question

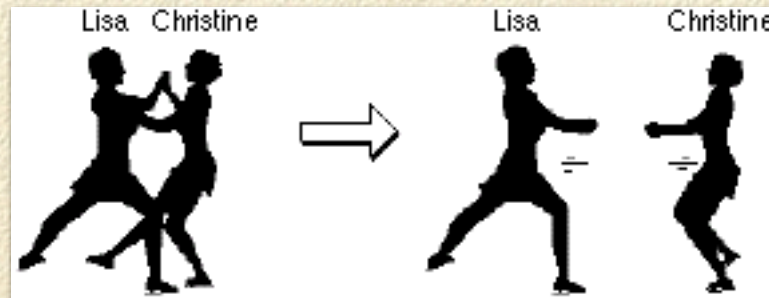
- In the figure, student “a” has a mass of 95 kg and student “b” has a mass of 77 kg. They sit in identical office chairs facing each other. Student “a” places his bare feet on the knees of student “b”. Student “a” then suddenly pushes outward with his feet, causing both chairs to move.



# Revised question

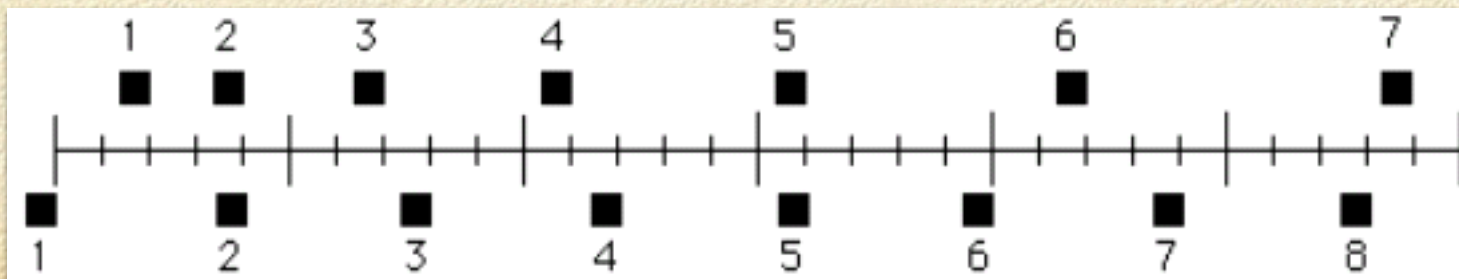
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- Two figure skaters, Lisa who has a mass of 95 kg and Christine who has a mass of 77 kg are standing on the ice with Lisa's hands braced against Christine. Lisa suddenly pushes off of Christine, causing them both to move.



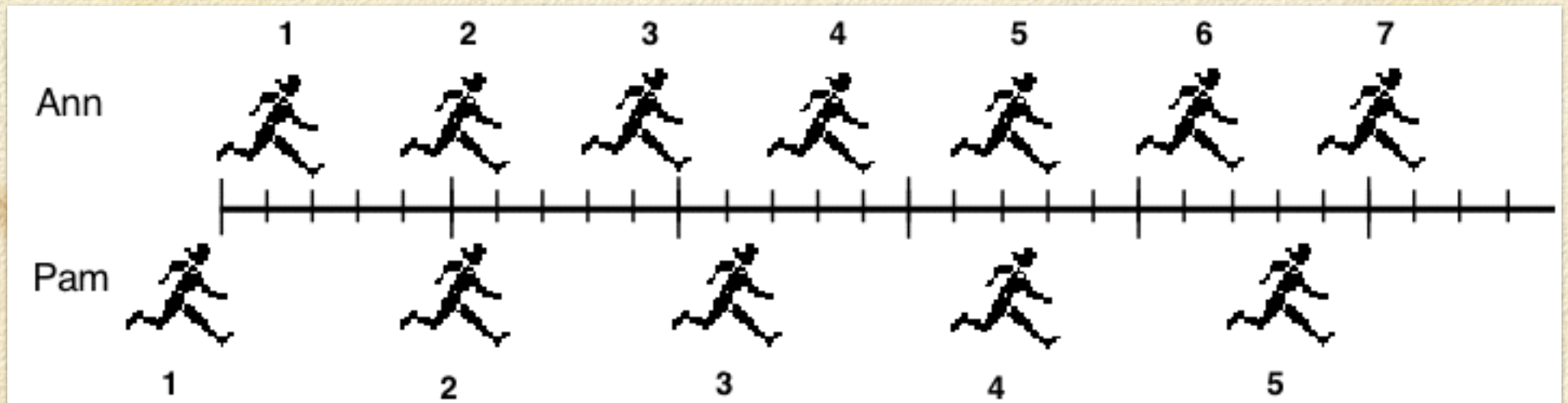
# Original question

- The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure. The blocks are moving toward the right.



# Revised question

- The positions of two joggers, Ann and Pam, are shown below. The joggers are shown at successive 0.20-second time intervals, and they are moving towards the right.



# Does context matter?

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- We can change contexts to have any sort of gender or culture or neutral orientation
- But does changing the context affect student response to the question?
- Give both versions to students and see...

# Overall comparison

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% correct on pretest

	Original	Revised
Women	23.5 (N=99)	29.4 (N=92)
Men	34.3 (N=184)	39.4 (N=132)



# Overall comparison

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% correct on post-test

	Original	Revised
Women	35.0 (N=65)	38.4 (N=113)
Men	47.6 (N=92)	48.7 (N=136)

# Pretest Comparisons

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- Overall, the scores did show statistically significant difference between the versions on the pre-test
- Women → 18 questions show increase in percent correct, 4 show decrease
- Men → 13 questions show increase, 1 shows decrease

# Post-test Comparisons

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- Overall, the scores did not show statistically significant difference between the versions on the post-test
- Women → 11 questions show increase in percent correct, 3 show decrease
- Men → 7 questions show increase, 7 show decrease

# What does it mean?

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- There is an increase in overall score for both women and men on the pretest
- There is no real difference for either women or men on the posttest
- How can we start to make meaning of this?

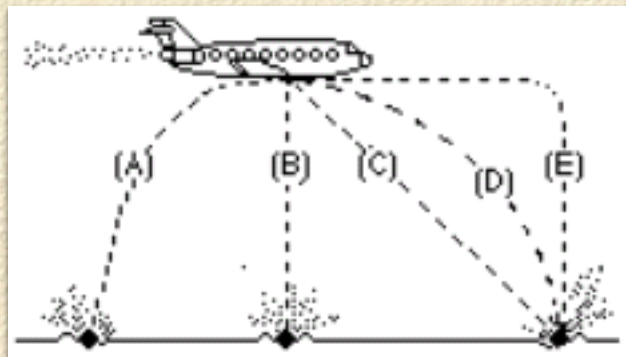
# Item by Item

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- Look at particular questions:
- Office chair → diary
- Boy on swing → girl on swing
- Plane/Bowling ball → eagle/fish

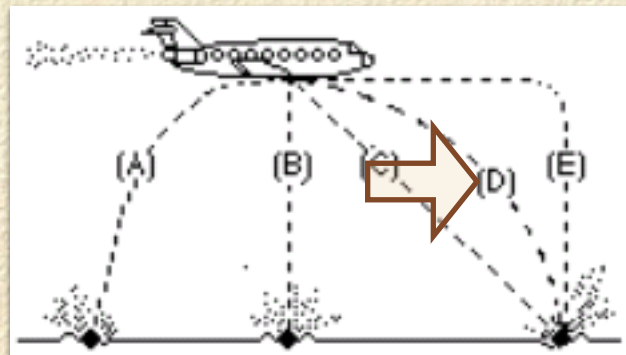
# Original Question

- A bowling ball accidentally falls out of the cargo bay of an airliner as it flies along in a horizontal direction. As observed by a person standing on the ground and viewing the plane as in the figure, which path would the bowling ball most closely follow after leaving the airplane?



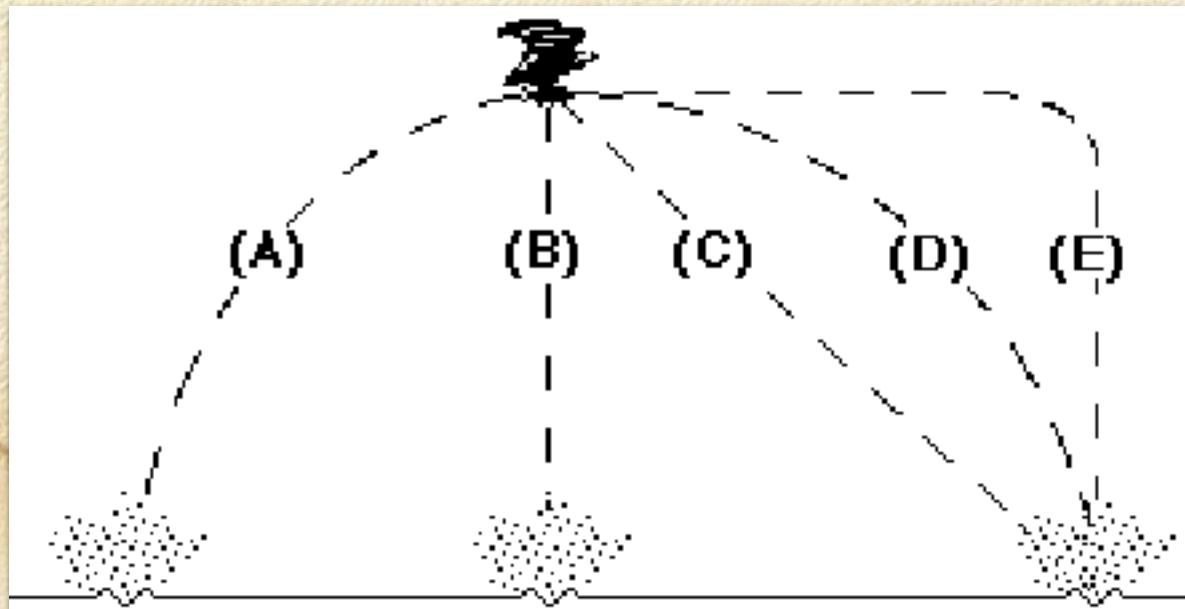
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# Revised Question

- A bird is carrying a fish in its claws as it flies along in a horizontal direction above a lake. The bird accidentally drops the fish. As seen from the lakeshore, which path would the fish most closely follow after leaving the bird's claws?





# Results-plane/bird

% correct by gender	Original	Revised
Women	25	38
Men	62	65

Women did much better, men did the same on the revised version.

# Original Question

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- The figure shows a boy swinging on a rope, starting at a point higher than A. Consider the following distinct forces:
  - 1. A downward force of gravity
  - 2. A force exerted by the rope pointing from A to O.
  - 3. A force in the direction of the boy's motion.
  - 4. A force pointing from O to A.



# Original Question

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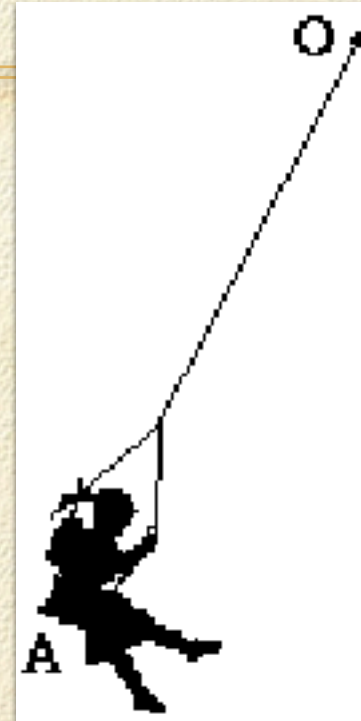
● The figure shows a boy swinging on a rope, starting at a point higher than A. Consider the following distinct forces:



- ➡ ● 1. A downward force of gravity
- ➡ ● 2. A force exerted by the rope pointing from A to O.
- 3. A force in the direction of the boy's motion.
- 4. A force pointing from O to A.

# Revised Question

- The figure shows a girl swinging on a swing, starting at a point higher than point A. Consider the following distinct forces:
  - 1. A downward force of gravity
  - 2. A force exerted by the rope pointing from A to O.
  - 3. A force in the direction of the girl's motion.
  - 4. A force pointing from O to A.



# Results-swing

% correct	Original	Revised
Women	12	35
Men	23	34

Women did much better on the revised version, men did better on the revised version. This revision removed the gender gap.

# Original Question

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An empty office chair is at rest on a floor. Consider the following forces:

- 1. A downward force of gravity.
- 2. An upward force exerted by the floor.
- 3. A net downward force exerted by the air.

Which of the forces is (are) acting on the office chair?

- (A) 1 only
- (B) 1 and 2
- (C) 2 and 3
- (D) 1, 2, and 3
- (E) none of the forces. (Since the chair is at rest there are no forces acting upon it.)

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# Revised Question

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A diary is at rest on a nightstand. Consider the following forces:

- 1. A downward force of gravity.
- 2. An upward force exerted by the nightstand.
- 3. A net downward force exerted by the air.

Which of the forces is (are) acting on the diary?

- (A) 1 only
- (B) 1 and 2
- (C) 2 and 3
- (D) 1, 2, and 3
- (E) none of the forces. (Since the diary is at rest there are no forces acting upon it.)



# Results-chair/diary

% correct	Original	Revised
Women	58	73
Men	74	64

Women did better on the revised version, men did worse on the revised version. This revision reversed the gender gap!

# Patterns?

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- No obvious patterns emerge
- Every combination possible seen
- Need to look further at combinations
- Overall score changed, but within questions was less obvious

# Implications

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- Need to be aware of context in problems, assignments, tests
- Changing the gender to female creates its own problems with inclusiveness
- Need alternative methods of being inclusive
- Need to study cultural contexts as well

# Conclusions

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- Women are under-represented in physics
- Many cultural and societal barriers for women in science
- Definite interaction between gender, context and score
- FCI may have test bias in favor of males
- Continued study in this area will help us understand one possible source of problems; understanding leads to solutions