## Gender Interactions with the Force Concept Inventory

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#### Overview

Gender gap in physics, gender gap on FCI

Item differences on original FCI by gender

Context an issue?

Changing context = changing responses
Conclusions

Women in physics: underrepresented Women receive ~22% of bachelor's degrees in physics

Classroom and educational variables play a part in the lack of women in physics

Many variables to look at: assessment is one

Can assessment be gender biased?

#### Gender & testing



ACT/SAT show gender gaps, particularly on math section N. Cole (1998) The ETS gender study Navarro (1989) Ethington (1987)

#### The FCI, Women and Men

FCI shows a gender gap on pretest & posttest scores and normalized gains\*

Gap is independent of physics background and instruction

\*McCullough & Crouch, 2002 AAPT meeting Philadelphia PA

#### Significance

FCI used as measure of educational effectiveness

Gap demonstrates possible test issues for female test-takers

Need to determine how different audiences interact with the assessment

What if the FCI isn't completely suitable for women?

#### Further questions

Could reform courses and activeengagement instruction be working for men but not for women?

Could we be under- or over-estimating women's performance?

#### Gender & the FCI

Many possible reasons for gap; one may be that women understand and interpret the questions differently than men

#### How to check?

Overall gap: examine how men and women respond on individual items

Different responses?

different facets? different p-prims?

#### Interesting examples

Several questions show interesting patterns of response

Pretest different than post-test

## Question #24: Rocket's speed no acceleration

Rocket thruster turned off, how does rocket's speed change?

# #24: % of gender choosing each answer

	Women (N=99)	Men (N=184)
A: Constant speed	42	63
B: Increasing speed	2	3
C: Decreasing speed	38	24
D: Increases then constant	4	3
E: Constant then decreasing	13	7

# #24: % of gender choosing each answer

	Women (N=99)	Men (N=184)	
A: Constant speed	42	63	
B: Increasing speed	2	3	
C: Decreasing speed	38	24	
D: Increases then constant	4	3	
E: Constant then decreasing	13	7	
(Yes, it's the pretest)			

#### Question #15: N3L Car/truck

A car pushes a truck and is accelerating. How does the force of the car on the truck compare to the force of the truck on the car?

# #15: % of gender choosing each answer

	Women (N=65)	Men (N=93)
A: $Fc = Ft$	26	26
B: $Fc < Ft$	18	2
C: Fc > Ft	54	68
D: Fc > 0; no Ft	2	3
E: no forces; truck moves b/c in the way	0	0

#### Post-test

## Question #29: Forces on an office chair

An office chair sits at rest on a floor. What forces act on the chair?

Gravity

Normal force

Air pushing down

## #29: % of gender choosing each answer

	Women (N=65)	Men (N=93)
A: Gravity	5	5
B: Gravity and normal	58	74
C: Normal and air	2	0
D: Gravity, normal, and air	32	20
E: no forces since at	3	1

#### Post-test

#### FCI for whom?

Men and women respond differently
 FCI serving men and women equally?
 Originally tested on high school students at a time when most physics students were male

Distractors optimized for men?

#### Another issue-context

Many contexts of questions are stereotypically male
Does context affect response?

#### Context & Response

Rennie & Parker (1993, 1996, 1998): changing context affected student response

- Students preferred real-life context questions
- More girls than boys preferred contextual questions (found the questions easier)

Enderstein & Spargo (1998): changing context from native to urban changed responses

#### Female contexts for FCI

To test context, make them stereotypically female (Gender FCI or GFCI)\*

See how the changed context affects response patterns

\*McCullough, Jan 2001 AAPT meeting San Diego

#### FCI contexts

b

#### hockey puck

а



"b"



#### GFCI contexts











#### Overall score-pretest

	FCI	Gender FCI
Women	23.5% (N=99)	29.4% (N=93)
Men	34.3% (N=184)	39.4% (N=132)

#### Pretest % correct by gender and test version



#### Overall scoreposttest

	FCI	Gender FCI
Women	35.0% (N=65)	38.5% (N=113)
Men	47.8% (N=93)	48.8% (N=136)

#### post-test % correct by gender and test version



#### Context & Gender

Context-gender interaction?
 Small on overall score
 Item by item?

#### #24 Rocket speed

Context changed from a rocket with a thruster experiencing no outside forces to a person on "frictionless" ice with a fire extinguisher

Changed from external perspective to internal perspective

# #24 pretest: rocket speed no acceleration % correct by gender and test version

	FCI		GF	CI
	Women	Men	Women	Men
(N)	(99)	(184)	(93)	(132)
A: Constant speed	42	63	37	70
B: increasing	2	3	1	2
C: decreasing	38	24	49	21
D: increase then constant	4	3	3	2
E: constant then decrease	13	7	10	5

#### Stout matched sample

Students who took both the FCI and the GFCI within a few weeks

Can match to see when they changed answers

Compare to pattern of whole population

#### #24 pretest

Women:

Solution State Stat

I changed from wrong to right (4%)
→ from E

Men:

Solution Solution States Solution States Solution So

#### #29: forces on chair

 Context changed to forces acting on a diary at rest on a nightstand
 Office chair has air under the seat; diary has "no" air under it

#### 

	FCI		GF	CI
	Women	Men	Women	Men
(N)	(65)	(93)	(113)	(136)
A: Gravity	5	5	7	7
B: Gravity & normal	58	74	73	65
C: Normal & air	2	0	Ø	1
D:Gravity, normal & air	32	20	17	28
E: no forces/at rest	3	1	3	1

#### #29 post-test

Women: 3 of 14 women changed answers (21%)
I changed from the correct answer to a wrong answer (7%)→ to D

3 2 changed from wrong to right (14%) → from D

🍯 Men:

5 of 29 men changed answers (17%)

 $\stackrel{\scriptstyle \circ}{\scriptstyle \circ}$  2 changed from correct (7%)  $\rightarrow$  to D

 $\overset{\circ}{\rightarrow}$  3 changed to correct (10%)  $\rightarrow$  from D, A

#### What's Happening?

Men and women treat the FCI differently

Changing the context produces different responses from the two genders

Men and women think about different aspects of questions?

#### Student Models

Men & Women accessing different pprims/facets?

Do men and women have different mental models of physics?

Are p-prims gender-dependent? Culturally dependent?

Do we know what a female physics student's mental model looks like?

#### Conclusions



Women and men interact with the FCI differently

- Not just a gender gap in physics understanding
- Different proportions on distractors Changing context can affect men and women differently

#### Implications

Need to think about gender when assessing using the FCI

When creating assessment, need to consider the population

Biomedical research

Don't treat male and female physics students the same way; they don't treat physics assessments the same way





## Question #17: The Elevator

Elevator lifted up at constant speed by cable. Forces on the elevator are such that:

# #17: % of gender choosing each answer

	Women (N=99)	Men (N=184)
A: Up force > gravity	53	68
B: up force = gravity	3	4
C: up force < gravity	5	1
D: up force > gravity + air force	17	21
E: no upward force	22	7

Pretest