

Gender, Math and the FCI

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Does math background interact with gender on FCI scores? A sample of 300 non-physics students were given one of two versions of the Force Concept Inventory, along with a brief demographic questionnaire. This paper examines how math background may interact with gender on this assessment instrument. The trends suggest a preliminary conclusion that math preparation has little effect on FCI score.

Introduction

The Force Concept Inventory (FCI) [1] is one of the most widely-used assessment instruments in physics education. Unfortunately, this popular test has shown a persistent gender gap favoring males [2,3]. What is causing the gender gap? Is it the men and women taking the test? Is it something about the test itself? There are many reasons the gender gap might exist: men might be better at physics or at conceptual physics; women might be worse test-takers; the test might have a gender bias; or women might have poorer preparation in physics or math. The explanation I am examining in this study is the possibility that women have worse math backgrounds than men and this is causing women to do more poorly on the FCI. This paper will examine the possible connections between math background, FCI score and gender.

Rationale

Women are significantly under-represented in physics [4, 5]. In our technological society, we cannot afford to turn away any interested individual. We need to promote the participation of women and minorities in physics. One way to do this is to study the reasons behind women's under-representation; in physics classrooms as well as other areas [6]. The gender gap on the FCI is one area that deserves examination. One consideration is the context surrounding the test and its administration. The test has contexts that appear stereotypically male; it is administered in the male-dominated social context of the physics classroom. What if these contexts were changed to be less male-oriented? What if the test was

given in non-male-dominated milieus? What if the test had stereotypically female contexts? Another question is a possible math-dependence of the test, again a male-dominated area. It is possible that a greater background and confidence in math might confer an advantage even on conceptual tests, perhaps due to increased science confidence. How does math background affect FCI performance in non-male-oriented situations?

Methodology

312 non-physics students at UW-Stout were asked to complete one of two versions of the FCI, the original or a gender-oriented version (GFCI) [7]. The GFCI maintains the physics of the original test while changing the contexts of the questions to be more female oriented. Students were in English or sociology classes and were told that the test was ungraded, anonymous and voluntary. Students were told only that their responses would be appreciated in helping with a research study. Very few students chose not to take the test. After students finished the test, they were asked to complete 9 demographic questions about their academic background.

The Sample

Forty-five percent of the sample were first-year students, 32% were sophomores, 13% juniors and 10% seniors. Fifty-nine percent were women, 41% were men. The students came from over 30 different majors; 14% of students were undecided. In terms of physics background, 64% of female students and 53% of male students had no previous physics experience. Thirty-four percent

of women and 30% of men had high school physics. Nine percent of males and 2% of females had college physics.

Math background

What effect does math background have on FCI score? Does math background interact with gender or with the version of the test? Three different math questions were asked on the demographic questionnaire: (a) What is the highest level math course you have taken? (b) How many years of math did you have in high school? (c) How many semester classes of math have you had in college?

Math level

Since physics and mathematics are often closely related, the level of a student's math preparation may have an effect on their physics understanding. Table 1 shows the average score on the FCI for males (M) and females (F) for each version of the test (GFCI or FCI), by the highest level of math class taken. The number of students in each cell is listed in parentheses.

Table 1.
Math level and average score

Level of math preparation	GFCI		FCI	
	M	F	M	F
	Avg. % score			
Pre-algebra	22 (6)	31 (4)	34 (6)	20 (12)
Algebra	25 (7)	21 (7)	27 (6)	19 (20)
Geometry	26 (30)	22 (42)	31 (19)	20 (48)
Calculus	33 (20)	21 (18)	33 (16)	23 (16)
Differential Eq.	59 (2)	38 (1)	60 (1)	N/A
Other	25 (4)	23 (6)	33 (2)	25 (2)

Math level & score: From Table 1 we see that level of mathematics does not strongly influence the average score on the FCI. Nor does math level appear to interact with the version of the test. This is good, since it suggests that the two samples were not significantly different in math

background. The gender gap is quite striking here, particularly for the original FCI. Readers should note that though the overall sample size was large, the number of categories used requires that any results drawn should be considered preliminary until further studies can be completed.

High School Math

How does the number of high school math courses taken affect FCI score? Given that many high schools require math each year, and for students interested in college, math each year is a wise course choice, my hypothesis would be that the number of high school math classes does not affect the average score. Table 2 shows the average score for males and females taking either version of the test, broken down by the number of reported math courses in high school. (Several students reported half-courses.) Keep in mind that most UW-Stout students are drawn from Minnesota and Wisconsin high schools, which are a mix of three-year and four-year high schools (9th through 12th or 10th through 12th grade). For some students, three years of math means math every year.

Table 2.
High school math and average score

Number of high school math courses	GFCI		FCI	
	M	F	M	F
	Avg. % score			
1		13 (1)		7 (1)
2	28 (6)	14 (2)	27 (2)	19 (6)
2.5				10 (1)
3	26 (30)	24 (24)	30 (17)	20 (45)
3.5		27 (2)		27 (4)
4	29 (30)	21 (49)	34 (29)	21 (37)
4.5	59 (1)			
5	44 (2)	25 (1)	30 (1)	33 (2)
5.5				27 (1)

High school math courses & score: The number of math courses taken in high school has no effect on the average score for this group of students. This makes sense given that a typical college prep curriculum will include math every year whether or not it is required, so most college students have similar math backgrounds. Males average a better score than females at each level shown; the gender gap persists. And again, many cells in the table have very few students in them, so conclusions are preliminary; one can only draw out trends in the data.

College Math

The last math question asked about the number of college math courses taken. Given that a large number of students were in freshman English 101, this question is unlikely to provide useful numbers of students from which to draw any conclusions. UW-Stout requires 6 credits (about 2 classes) in analytic reasoning, one course of which must be from the Math, Statistics, and Computer Science department. Table 3 gives results for the number of college math courses by gender and test version.

Table 3.
College math and average score

Number of college level math courses	GFCI		FCI	
	M	F	M	F
Average % score				
0	25 (21)	24 (36)	29 (12)	21 (35)
1	28 (26)	20 (28)	36 (21)	22 (30)
2	29 (12)	21 (11)	27 (10)	19 (22)
3	31 (7)	23 (2)	28 (2)	20 (8)
4	43 (4)	33 (2)	42 (3)	20 (2)
5			13 (1)	13 (2)
6			40 (1)	10 (1)

College math and score: Not surprisingly, the number of college math classes has little effect on score. There is a slight jump for males taking 4 classes, but the numbers are so small as to make any solid conclusion meaningless. One sees in this data as well that males are tending toward a better score.

Conclusion: Math and FCI score

This preliminary study suggests that for this population, math preparation has little effect on FCI scores. Nor is there any perceived interaction between math preparation, gender, and FCI score. The trend suggests that math background does not explain the gender gap seen on this test.

References

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- See, for instance, the papers presented at the session "PER: Gender Equity in Physics Education" at the American Association of

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7. McCullough, L. (2001). "A Gender Context for the Force Concept Inventory." Paper presented at the American Association of Physics Teachers Meeting in San Diego, CA. January 2001. Available at <http://physics.uwstout.edu/staff/mccullough/physicseduc.htm>.

Sample Question

Example of one question from the original FCI and the related question from the GFCI:

Question from FCI:

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?

Question from GFCI:

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?