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Performance Gap among Male and Female College Students Measured With the Force Concept Inventory

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Abstract: *In this article we present our results on a study of performance gap among our male and female college students. Our choice for the study tool for this work was the force concept inventory (FCI). We gave the test to our students twice; before and after our instructions on force and motion. The overall performance of male and female students in both tests along with details about individual questions is reported. The mean percentage scores showed a gender gap in favor of male students. Male students outperformed female students in almost every one of the thirty questions of the inventory in both the pre and the post test.*

Keywords: *Gender gap. Force concept Inventory. Force and motion in physics. misconceptions. Physics education research.*

I. Introduction

There are a large number of reports in the literature confirming a gender gap in physics performance both in class and in assessment tests [1-6]. We used the force concept inventory (FCI) [7] as a measurement tool in this study by giving it to our students twice; once before any instructions on force and motion (pre-test) and once after (post-test). The results allowed us to make a direct performance comparison among males and females since they were all given the same test and received the same instructions. In section 2, we talk briefly about our methodology and how the data were collected and analyzed. Results and discussions are presented in section 3 and we finish with concluding remarks in section 4.

The work reported here is part of a bigger project we started to assist the whole physics teaching and learning process at our university. Our efforts so far resulted in three publications [8-10] on misconceptions and teaching language effects on students' performance. This paper is dedicated to report the results of the study of gender gap in performance among our students.

II. FCI Data collection

In this study, we used the revised version of the Force Concept Inventory (FCI) [7]. This version of the test (revised in 1995) contains 30 conceptual questions about force and motion usually used to detect different misconceptions held by students [9-14]. Each question comes with one correct answer and four distracters derived from certain misconception/s. No matter what answer students choose, there will be some information we can extract about their way of thinking. The FCI tests students' knowledge about Newtonian concepts in six different dimensions [7]: kinematics, Newton's first law, Newton's second law, Newton's third law, superposition principle and kind of forces. Every incorrect answer in the inventory is carefully chosen to test a certain misconception; therefore, the authors included a taxonomy of misconceptions in their original paper [7].

We gave the FCI test twice (before and after instructions) to six different sections including on average sixty students each. All students who participated in this study were in their first year of college. Their physics background coming to this class is based entirely on their high school experience since this is their first physics class in college. The results included in this report came from students attending both tests and the rest were ignored with a final count of 341 students (177 females and 164 males). There is a different class setup in our university that we should mention, we have female students in separate sections than male students and have female instructors for female students and male instructors for male students. This is part of university policy that we had to follow and had nothing to do with any research plan. Because of this particular classes-setup policy, one might question the validity of comparisons made in this study between male and female students after receiving instructions. Since there was a female instructor for female students and a male instructor for male students, there might have been a gender gap not only in learning but also in teaching. To minimize this effect and enhance the validity of this part of the study, there were huge coordination efforts between instructors to make sure that the class environments were equally effective and each topic was dealt with equivalently using the same power point and discussing the same examples.

III. Results and discussion

We start our discussion by comparing students' scores in pre and post tests as shown in Table 1. The first thing one notices from the table is the weak overall performance of all students even after instructions. Weak performance on the FCI by our students is of no surprise to us as similar results have been reported before in many studies around the world [15-18]. It's not in the scope of this study to try to explain this weakness or suggest solutions for it but its part of our future planned projects and therefore there will be no farther discussion on this here. In this paper, we're just trying to report a gender gap in performance among our students which is clear in Table 1. The difference in the mean FCI scores between male and female students is 7.6 % in the pre-test (about two questions from the FCI) and 13.4 % in the post-test (about four questions from the FCI). The gap has doubled after instructions which can be due to two different factors. One of the factors (even though we tried our absolute best to minimize it) might be due to different instructors. The other one must be related to the way of understanding on instructions by males and females, therefore; this number is a good measure of performance gap.

Evidence of performance gap is also supported by results of calculating Hake's normalized gain <g> [19], for male students it was 15 % where for female students it was only 6.4 % suggesting that males' improvement were more than double that of females. These low gains also suggest that there is little difference made by our instructions in students' performance which is similar to results reported by Hake (1998) and Viiri (1996) [18,19]. This result by itself deserves more attention and efforts are ongoing to start the next stage in this research project. Our ultimate goal is to improve our way of teaching to help students overcome recorded misconceptions about physics and hopefully also reduce (or even eliminate) the gender gap in performance reported in this paper. Final conclusions and the stage of start suggesting solutions for found problems will require more research and will take some careful planning to adjust our instructions and the way we deliver them to students.

Table 2. Comparison between female and male students' performance on the FCI test both before and after instructions

	Pre-test		Post-test	
	Male	**Female**	**Male**	**Female**
Mean percentage score	26.3 %	18.7%	37.3 %	23.9 %
Standard error of the mean	1 %	0.8%	1.2 %	0.9 %
Gender difference in the mean	7.6 %		13.4 %	

In Fig. 1 we show more details about the performance gap between our female and male students. It shows the number of students answering a certain item from the FCI test (normalized to the number of students) for all items in the inventory. Upon close examination of Fig. 1, one finds evidence of the outperformance of males over females in almost all of the items in the inventory in both the pre and post tests. There were some items where females outperformed males slightly (less than 2%) and the biggest outperformance of females showed up in ***Q1*** (28%), ***Q17*** (14%) and ***Q25*** (14%) in the post-test. These are the questions from the FCI test asking about the metal ball, elevator and the woman exerting a force on a chair. It's very hard to come up with a convincing explanation for this outperformance in these particular questions, our only guess is the way they were written, these questions might have communicated better with females than other questions.

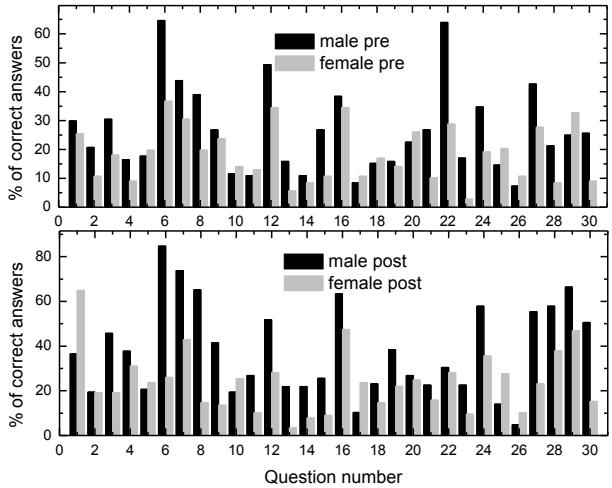

Figure 1. Percentages of correct answers for each of the questions in the FCI test for both female students (gray) and male students (black) in pre-test (up) and post-test (down).

The rest of the questions in the inventory showed performance gap in favor of male students. The largest gender gap is observed in the pre-test in questions: ***Q6*** (28%), ***Q22*** (26%) and ***Q27*** (25%) and in the post-test questions: ***Q6*** (59%), ***Q7*** (31%), ***Q8*** (50%), ***Q9*** (27), ***Q12*** (24%), ***Q27*** (28%) and ***Q30*** (36%). It seems like the performance gap have increased in the post-test reaching percentages close to 60% in ***Q6*** that is asking about the path the ball would follow after exiting a circular channel. There are reports about a big gender gap (>30%) in questions 14 and 23 [1,21], here we did find the gap in these two questions but it was lower than 30% (2 and 15 % pre and 14 and 13% post).The increase in the performance gap among both groups in the post test might carry many indications one of which is about the instructions themselves. Our instructions about force and motion did seem to have helped our male students improve their performance in the post test but not female students. Reasons might have to do with the way the instructions are presented and discussed with students. We shouldn't also forget about the special classroom setup that we have at our school which might have contributed to this increase in the gap after instructions. Even if this were the case, this particular effect should be very small because of the huge coordination efforts to minimize differences in classrooms environments and it should have no effects what so ever on pre test results. At the end, we find it very hard to come up with definitive explanation for the gap or for the increase in the gap after instructions and more work is still required to finalize our conclusions.

IV. Conclusions

Our goal for this report was to test for a gender gap in performance among our students. We used the FCI as our measurement instrument and gave it to our students both before and after they received instructions on force and motion. We reported percentages of correct answers for each of the 30 questions in the inventory for each group in both tests and were able to detect a gender gap in favor of male students. These results are not surprising because similar ones regarding gender gap were reported before [1-6]. Even though we tried to give some reasoning for the reported results in the previous section, we're still far from reaching a definitive final conclusion about possible reasons for these results or to suggest any measures to eliminate or reduce this gap, all of this is part of our next planned project. What is certain at this stage of our research is that more work is still needed and this is why our team is already working now on studying common misconceptions among female and male students in an attempt to get more insights on this performance gap.

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