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Stereotype Threat in the Engineering Classroom

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Abstract

Recent research has demonstrated that stereotype threat—the concern that others will judge one negatively due to a stereotype that exists about one's group—interferes with women's performance on standardized math and engineering exams. The current research elucidates stereotype threat in the classroom; in particular, the study investigates how an instructor's behavior and language induces stereotype threat and affects performance. A 5-minute video of an engineering classroom scene in which a male professor portrays or does not portray subtle sexist behavior is first shown to the group of participants. The participants then complete a difficult engineering exam comprised of 18 math and engineering questions taken from a Fundamentals of Engineering Exam. The "high" stereotype threat condition for the women occurs when: (i) the questions are difficult; *and*, (ii) the instructor exhibits subtle, sexist behavior. It is in this high threat situation that differences between women's and men's performance should emerge; differences are not expected if either the questions are easy *or* the instructor does not exhibit sexist behavior.

The results indicate that on the 6 math questions—which all of the students found easy—there was no significant performance difference between women and men. The 12 engineering questions were more challenging for the students; here, the men performed significantly better than the women. The data reveal that the significant differences occur between men in the sexist instructor condition and the women in both the sexist and non-sexist instructor conditions. Moreover, men in the sexist instructor condition performed marginally better than men in the non-sexist instructor condition. There was no significant difference between women's performance in the sexist instructor and non-sexist instructor conditions. The results do not depict that women in the sexist instructor (high stereotype threat) condition underperformed all other gender/instructor combinations; instead, the results indicate that the men's performance was enhanced in the sexist instructor condition over the other three instructor/gender combinations. Thus, the conclusions are only partially in line with the expectations based on previous stereotype threat research. The surprising conclusion regarding men's enhanced performance in the sexist instructor condition underscores the importance of instructor behavior and language.

Introduction

Research on stereotype threat examines the experience of being in a situation where one risks being judged negatively due to a commonly held devaluing stereotype that exists about one's group[1-8]. The primary hypothesis of stereotype threat research is that when one is in a situation in which a negative stereotype exists about one's group, then the concern with being judged or of self-fulfilling the stereotype interferes with one's performance. This predicament of being in a situation in which one faces judgment based on societal stereotypes begins with a prejudice that is widely known—even among people who do not believe the stereotype. For instance, our society alleges women have inferior math abilities compared to men. So when a woman finds herself in a situation in which her math skills are being tested (e.g. a formal test or answering a question in math class), she experiences a pressure that may degrade her performance. This is a predicament that others, not stereotyped in this way, do not face.

The strength of stereotype threat varies with the situation; for instance, a woman may suffer from its effects in her math class, but not in her elementary education class. Stereotype threat is not an internalized belief in the stereotype or a fear that it may be true. Nor is stereotype threat a belief that others will be prejudiced against you. It is a threat that is "in the air[6]." Stereotype threat can be experienced even if one does not believe the stereotype or worry that the stereotype could be true about oneself. A person can have high self-confidence and still suffer from the effects of stereotype threat; indeed, past research indicates that stereotype threat effects are largest among the best students who are most identified with the subject matter[3,7].

The present research evaluates the impact of stereotype threat in an engineering classroom environment on women's performance on standardized engineering tests. The Background Section outlines the previous germane research on stereotype threat and gender. The Methods and Hypotheses Section describes our new study on stereotype threat in engineering classrooms: the design, participants, procedure, scoring, and expectations are presented. The Results Section presents the new results and the Conclusions Section discusses their implication.

Background

Previous research has demonstrated the impact of stereotype threat on women's performance on math tests[3,4]. From a stereotype threat perspective, a student's concern about being stereotyped by others should be highest when two factors are at play: (i) the student is performing poorly (e.g. the questions are difficult); and, (ii) a stereotype might be applied to the student (e.g. the stereotype that women are not good at math). Based on previous research, it is in this situation that differences between men and women's performance should emerge.

One study examined the performance of highly selected women and men on a difficult math test when the relevance of the stereotype was manipulated by how the test was characterized. In the "relevant" stereotype threat condition, participants were told that the test had shown gender differences in the past (what the gender differences were was not described). Conversely, in the "irrelevant" stereotype threat condition, participants were told that the test had never shown gender differences. The results showed that men significantly outperformed women in the relevant stereotype condition and women and men performed equally well in the irrelevant

stereotype condition[3]. Since the women's performance improved and equaled the men's when the difficult test was characterized as having shown no gender differences in the past, it suggests that there was something in the testing situation that was responsible for the difference.

Similar to the prejudice that women are inferior to men in mathematical ability, there exists a societal stereotype that women are less capable than men in engineering ability. In previous studies, we showed that stereotype threat undermines women's performance on engineering exams[1,2]. In one study[1], 29 women and 54 men took an engineering test; it was comprised of difficult questions from the general portion of the standardized Fundamentals of Engineering Exam (FEE)[9]. We only selected participants for the studies who indicated that they had a relatively high grade point average (GPA) in engineering, and who stated that they were good in engineering and that it was important for them to be good in engineering.

We manipulated the relevance of stereotype threat with three sets of directions that characterized the test differently. In the "relevant" stereotype condition, the diagnostic directions represented the test as being able to discriminate between capable and incapable engineers; this induced a high stereotype threat condition for the women. In the non-diagnostic directions condition we reduced stereotype threat by characterizing the test as being unable to judge a person's engineering competence; this mitigated the stereotype threat for the women since the test is unable to judge their performance. Finally in the gender-fair directions condition we reduced stereotype threat by characterizing the test as one in which no gender differences have been found.

Our hypothesis was twofold. First, we expected that in the diagnostic instructions condition in which stereotype threat is high, women would under-perform compared to men on the engineering test. However, second, in the non-diagnostic instructions and gender-fair instructions conditions, we anticipated that the women would perform equally with the men. Our results indicated that women who took the test with diagnostic instructions performed worse than people in the other five conditions (women/non-diagnostic, women/gender-fair, men/diagnostic, men/non-diagnostic, men/gender-fair). In particular, women performed significantly worse than men in the diagnostic instructions condition. However, women performed about as well as men in the gender-fair instructions condition and women performed as well as men in the non-diagnostic instructions condition.

Methods and Hypotheses

The current research elucidates stereotype threat in the classroom; in particular, the study investigates how an instructor's behavior and language induces stereotype threat and affects performance. All participants took the difficult engineering test with non-diagnostic directions[1]; however, we manipulated the relevance of stereotype threat with two different 5-minute videos of the same engineering classroom scene: in one video the male professor portrays subtle sexist behavior and in the other video the same male professor does not portray subtle sexist behavior[10].

We developed the difficult engineering test from questions available as practice tests for the general portion of the FEE. We reduced the number of questions and shortened the duration, but maintained the proportions of questions for each of the various engineering areas. The

composition (and ordering) of the 18 questions were as follows: 6 math, 2 electric circuits, 2 statics, 2 chemistry, 1 thermodynamics, 1 dynamics, 1 material science, 1 computers, 1 ethics and 1 engineering economics. In scoring the answers we separated the math questions from the engineering questions. Our previous studies demonstrated that the difficult math questions were relatively easy for all of our participants.

The participants were recruited to take part in the study through email and in-class announcements. We only selected participants who indicated that they had a relatively high grade point average (GPA) in engineering, and who stated that they were good in engineering (we refer to this as Q6) and that it was important for them to be good in engineering (Q7). We selected participants using these criteria because previous stereotype threat studies have indicated that stereotype threat effects are largest among the best students who are most identified with the subject matter. A total of 58 students participated in the study: 13 women and 17 men took the test in the sexist instructor condition; 10 women and 18 men took the test in the non-sexist instructor condition.

The participants reported to each testing session in small, mixed gender groups; students were randomly assigned to the two test conditions. After viewing the video the students read the non-diagnostic test directions and took the difficult engineering test; they were given 30 minutes to complete it. Upon completion of the test the participants were reassured that no one was expected to do well since the advanced test material was beyond their current level. The participants were thanked for their time and paid $20.

The "high" stereotype threat condition for the women occurs when: (i) the questions are difficult; *and*, (ii) the instructor exhibits subtle, sexist behavior. It is in this high threat situation that differences between women's and men's performance should emerge; differences are not expected if either the questions are easy *or* the instructor does not exhibit sexist behavior.

Results

We evaluate the similarities between groups of the randomly assigned non-sexist and sexist conditions using two-way analysis of variance analysis for a number of variables which characterize the abilities and attitudes of the students. Scores on the FEE test, GPA, perceived skill at engineering (Q6) and perceived importance of skill at engineering (Q7) are all considered. Throughout the summaries provided, the p-value is shown for each comparison in parentheses; it indicates the level of statistical significance: $p<0.01$ leads to a conclusion of a highly significant difference, $0.01<p<0.05$ indicates a significant difference, $0.05<p<0.1$ is considered a marginally significant difference, while $p>0.1$ leads to a conclusion of no significant difference.

There is no significant difference between women and men with respect to GPA or Q6 ($p=0.24$ and $p=0.10$); nor is there any significant difference between participants in the non-sexist and sexist conditions with respect to GPA or Q6 ($p=0.98$ and $p=0.74$). Furthermore, no significant difference in relationship (interaction) between the responses and sexist conditions is noted between women and men for GPA and Q6. Although there is no significant difference between women and men with respect to Q7 ($p=0.67$), there is a significant difference between

participants in the non-sexist and sexist conditions with respect to Q7 (p<0.0001). Again, no significant difference in relationship (interaction) between the responses and sexist conditions is noted between women and men for Q7.

Based on our preliminary findings that compared the randomly assigned non-sexist and sexist conditions, we found it necessary to perform an analysis of covariance where comparisons between the genders and instructor conditions are adjusted for the differences in response to Q7. The results presented below are based on a two-way analysis of covariance with factors of gender and instructor condition adjusted for Q7. Individual pairwise comparisons between each of the four treatment combinations of gender and instructor condition (male & non-sexist, female & non-sexist, male & sexist, female & sexist) is also tested using the Least Significant Difference procedure.

Similar to our previous research, the data indicate that on the 6 math questions—which all of the students found easy—there is no significant performance difference between women and men (p=0.34). Moreover, there is no significant difference between participants in the non-sexist and sexist conditions (p=0.99); nor is there a significant difference in relationship (interaction) between the responses and sexist conditions between women and men (p=0.33).

The 12 engineering questions were more challenging for the students, but the data do not fulfill our expectation that women would perform worse than men in the high stereotype threat condition (engineering score and sexist instructor). On the engineering questions men did perform marginally better than women (p=0.06); however, there is no significant difference between the average performance of participants in the sexist instructor and non-sexist instructor conditions when averaged over gender.

Table 1: Engineering questions test score averages by gender and instructor condition combination. The same letter (A, B, C) within a column indicates equivalence at the given level of significance (* indicates testing was done adjusting for Q7 score differences).

	Mean	Equivalent at 0.05 level*	Equivalent at 0.1 level*
Male Sexist	52.94	A	A
Male Non-Sexist	42.59	B	B
Female Sexist	41.88	B	C
Female Non-Sexist	40.00	B	C

The pairwise comparisons reveal that significant differences occur between men in the sexist instructor condition and the women in *both* instructor conditions: p=0.03 for women/non-sexist and p=0.05 for women/sexist. Moreover, men in the sexist instructor condition performed marginally better than men in the non-sexist instructor condition (p=0.09). There is no significant difference between women in the sexist instructor and non-sexist instructor conditions

(p=0.65). Figure 1 shows the interaction plot for the engineering questions of the gender by instructor condition interaction; Table 1 summarizes the pairwise comparisons.

Figure 1: Interaction plot of engineering questions test score by gender-instructor condition
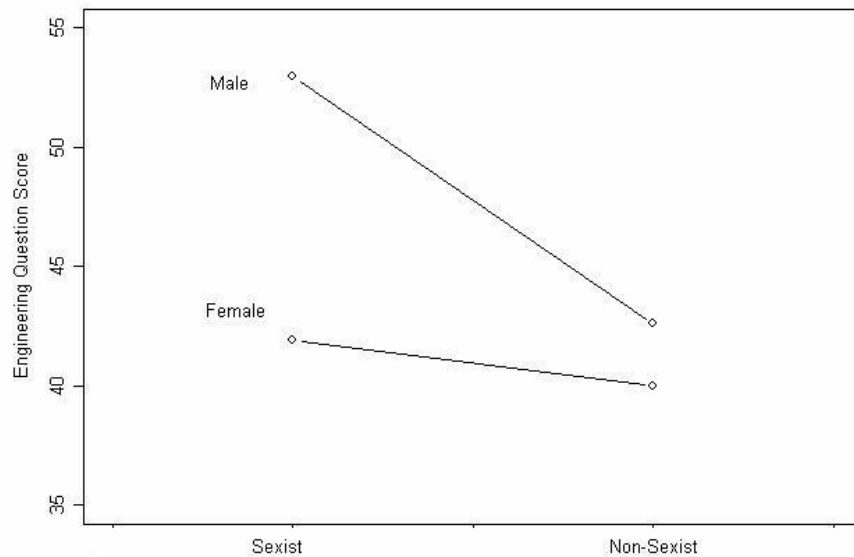
Conclusions and Discussion

The results are only partially in line with our expectations based on previous stereotype threat research. The results do not depict that women in the sexist instructor (high stereotype threat) condition underperformed all other gender/instructor combinations; instead, the results indicate that the men's performance was enhanced in the sexist instructor condition over the other three instructor/gender combinations. The surprising conclusion regarding men's enhanced performance in the sexist instructor condition underscores the importance of instructor behavior and language.

This conclusion is particularly germane in light of a recent, comprehensive study that collected and analyzed data from students, faculty and administrators at 53 universities. One of the primary conclusions of the study was that the classroom and department climates were significant factors in the women students' persistence in engineering[11]. The results of our research further support the idea that engineering educators play a critical role in creating these environments.

Fortunately, there are tractable ways to improve the climate, reduce stereotype threat and increase women's success. In creating classrooms and learning environments low in stereotype threat and warm in climate, it is not enough to just avoid negative behaviors—positive efforts must also be made. When stereotype threat is the remaining barrier for a student, Steele has suggested several "wise" strategies that a teacher can employ to mitigate the impact of threatening stereotypes[6]. Hall and Sandler have provided a comprehensive list of action items for administrators, faculty and students on warming up the climate for women students[12].

Further investigation of women's underperformance relative to men on difficult engineering exams is required to better elucidate the most important factors that are responsible for this difference. One of the most intriguing avenues of future investigation suggested by our current results is the impact of the men's "stereotype lift" versus the women's stereotype threat. However, the wise strategies and action items suggested above can be implemented even before the exact correlative and/or causal relationships are fully understood. Indeed, these strategies are effective at creating better learning environments for all students—thus, everybody benefits.

Acknowledgments

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