Improving Diversity in Engineering Education: The Subtle Effects of Stereotypes

D. G. Blasko
Department of Psychology
Penn State Erie, The Behrend College, Erie, PA 16563

J. J. Hodge
Department of Psychology
Penn State Erie, The Behrend College, Erie, PA 16563

ABSTRACT- *A major question in psychology and education asks why men outnumber women in science, technology, engineering, and math (STEM) related fields. In the current paper, we discuss the pervasive problems of explicit and implicit cultural stereotypes and how they might decrease performance in an engineering graphics classroom. Stereotype threat is the anxiety of knowing that one is a potential target of prejudice and stereotypes (Steele & Aronson, 1995). Implicit stereotypes are prevalent in our culture, reinforcing the idea that women and other groups such as African Americans have less ability in areas such as math and spatial reasoning. We will review research from our lab and others that show that stereotype threat is a situational phenomenon, and that educators can reduce the impact and occurrence of stereotype threat by following some basic quidelines.*

I. What are Stereotypes?

Each time we walk into a new class, we carry our preexisting stereotypes with us and research has shown that these stereotypes influence both our behavior and our students' performance. A stereotype is a mental representation of a social group. Stereotypes contain information about a group of people: "men," "women," "blacks," "whites," or "engineer" based on our cumulative experience, whether that be actual experience, or experience from the media, newspapers, movies, music, or our grandfather's stories. Stereotypes can contain positive as well as negative information. For example, "mother" might be associated both with "nurturing" and "nagging," but it is the negative characteristics of a stereotype that can be most harmful. When teachers, students, and employees hold stereotypes about women or other minorities that are inconsistent with their perception of a competent engineer, this becomes a self-fulfilling prophecy; fewer students will choose to pursue that career and those who go into training may show performance decrements which then reinforce the initial negative stereotype. Stereotypes are difficult to escape because they are largely outside of our conscious awareness, although some experimental procedures can make them more apparent (Greenwald, McGhee, & Schwartz, 1998). For example, the Implicit Association Task (IAT) that we use in some of our research simply asks people to group words into categories. On average, people are faster to group together women's names and family words and men's names and career words, compared to when those categories go against the stereotype (e.g. Mary, Engineer). This measure of implicit stereotypes has been shown to be a better predictor of actual behavior than most explicit survey measures (Nosek, Greenwald, & Banaji, 2007). If you think you don't have these stereotypes, you can test yourself at: *https://implicit.harvard.edu/implicit/demo/.* Unfortunately, the vast majority of us do.

We tend to use stereotypes most when we are in new or ambiguous situations, so they play the largest role early in a class. Unfortunately, it has been long known that first impressions, whether a teacher's impressions of his or her student, or a student's of his or her teacher, carry much more weight than later ones (Asch, 1946). Stereotypes can be very resistant to change because they build up over years, and because we pay selective attention to evidence that fits our views over that which refutes them. As a result, we might view the white women in our class who is quick to learn a solid modeling software such as Pro/Engineer and the Asian man who is very slow to catch on as exceptions to the rule. The good news is that understanding how stereotypes work to influence attitudes and behavior can, to some extent, inoculate us and our students from their effects.

II. What is Stereotype Threat?

We all have stereotypes of our own group, as well as stereotypes of other groups. Stereotype threat occurs when we are at risk of confirming, with our own behavior, a negative stereotype about our group. For example, in one classic experiment Black students performed more poorly on standardized tests than White students, but only when race was emphasized (Steele & Aronson, 1995). This can be as subtle as asking students to check off whether they are black or white, or male or female before taking a test (Shih, Pittinsky, & Ambady, 1999). Research has also demonstrated that women reminded of their ascribed status (i.e. woman) perform worse on a mental rotation task than when they are reminded of their achieved status (i.e. elite private college student; McGlone & Aronson, 2006). Hundreds of other experiments have confirmed that stereotype threat can harm performance in academic settings. The questions that have been studied more recently are: 1) Who is most vulnerable to stereotype threat? 2) What are the consequences of stereotype threat? 3) What situations are most likely to lead to stereotype threat? The answers to these questions can allow us to train teachers of all age groups to avoid the situations that are most likely to create threat, and to some extent, inoculate students to the influence of threat.

III. Vulnerability to Stereotype Threat

To some extent we are all vulnerable to stereotype threat. All of us belong to some group that is characterized by a stereotype, and any social identity that is highlighted before a task can cause threat if one's performance has the possibility to confirm a negative stereotype about that identity. To this end, members of a socially "dominant" group are also vulnerable to stereotype threat in some cases. For example, White males may perform more poorly on a sports task in comparison to Black and Hispanics when race is made salient (Stone, 2002), and White males may score lower on math tests when they are compared to Asian males (Aronson, Lustina, Good, Keogh, Steele, & Brown, 1999). However, those most vulnerable are people whose group status is made salient and whose self-stereotypes are inconsistent with positive performance. For example, if you are the only women in your engineering graphics class, your female status is obvious. If you are then asked to perform a task such as learning a new solid modeling program, the multiple stereotypes of males being more likely to be engineers, males being better at computers, and males being better at spatial visualization can create an environment where our female engineering student is at a particularly serious disadvantage.

Those who are more likely to endorse the stereotype are more susceptible to the effects, so

women who agree with the stereotype that men are naturally better at math are more susceptible to stereotype threat. Those who believe that intelligence is fixed and largely genetic also perform more poorly under threat than those who believe that intelligence is changeable and can be improved with practice (Dweck, 1999). In one rather surprising study, women who were most proactive (likely to act instead of remaining passive) were more susceptible to stereotype threat. They indicated less interest in pursuing careers in a field where success supposedly required stereotypical male attributes (Gupta & Bhawe, 2007).

Excellent preparation and high ability don't necessarily protect us. High ability individuals might actually be most susceptible to stereotype threat because they care deeply that their performance counteracts the stereotype. The high achieving female engineering major also personally values achievement in her domain and this can lead her to become more susceptible to stereotype threat. In one counterintuitive finding it was the racial minority students who highly valued academics who were most likely to withdraw from school (Osborne & Walker, 2006). Sadly, one or more experiences with prejudice can also lead to hypervigilance and the tendency to be looking for bias everywhere. This exacerbates stereotype threat based performance decline and can lead the individual to have inaccurate and inconsistent views of their own skills (Brown & Pinel, 2003).

IV. Consequences of Stereotype Threat

The consequences of stereotype threat for our own classrooms should by now seem clear. Students who are capable of performing well show poorer performance if the academic environment creates stereotype threat. However, another consequence is that stereotype threat may lead individuals to use self-handicapping strategies to avoid damaging theirself-esteem. They may withdraw from involvement in class, not do homework, and put less time into studying in order to implicitly justify the poor performance. If I study my hardest and fail the exam, I must be stupid, but if I drink too much at a party the night before the exam, then I have a reason to do poorly.

A recent meta-analysis combining data from 18,976 students in five countries found that under conditions that reduce stereotype threat, students from the stereotyped group can actually perform better than those from the non-stereotyped groups (Walton & Spencer, 2009). The authors suggested that the standard measures of academic performance are biased against women and non-Asian ethnic minorities in the quantitative fields.

Stereotype threat does not only occur in the academic environment. Even if students do manage to get their degrees, they are still likely to face challenges in the work environment where there is more pressure, more competition, and where bosses and co-workers are less educated about the influence of stereotypes. Inoculating students now to the pervasive influence of stereotype threat can help them resist it later in their careers.

V. Avoiding Stereotype Threat

When group identity is made salient, stereotype threat is most likely to occur. In some cases that might be inevitable such as when there is only one women or African American in the class. But teachers can avoid emphasizing group identity especially in testing situations. For example, it is common to place name, age, gender, and even ethnicity at the beginning of some assessments, but these questions, no matter how innocuous, make group identity more salient in the unconscious mind. For example, one study suggested

that simply moving the demographic information from the beginning to the end of the test would allow an additional 4700 women students to receive credit for the AP calculus exam each year. (Danaher & Crandall, 2008).

Even interacting with a member of another group thought to be superior can induce stereotype threat. For example, in one study Blacks felt more threatened and performed worse when the person giving the test was White instead of Black, but White students were unaffected by race of the administrator (Marx & Goff, 2005). We don't have control over our own race or gender but we can consider such issues in picking graders and teaching assistants.

One issue that teachers can control is to be careful when first describing challenging new topics. On the one hand, it is tempting to introduce a task or topic by directly refuting the stereotype than one group is better than another, but that may also backfire by making the group stereotype even more salient. Therefore, it might be better to have discussions intended to reduce stereotypes separately from the introduction of new topics and separate from assessments.

In addressing stereotypes it is also useful to provide positive role models of the stereotyped group that affirm that individuals can be successful in the field. This can be done in person or by watching films and reading stories of a variety of people that have worked hard and succeeded. During these discussions it is important to deemphasize the role of innate, genetic factors and emphasize that the brain continuously changes with practice and more practice means better performance. Sports analogies can be useful here. No-one expects to be able to run a marathon without long hours of gradual conditioning and training, Muscles become stronger after challenging workouts and, in a similar way, the brain get rewired and connections are strengthened when difficult mental tasks are practiced.

Evaluations can be particularly tricky. As instructors we want students to study hard and be well prepared, so we tend to emphasize that the test or assignment is important and diagnostic of their ability. However, stereotyped individuals, especially those who have had bad experiences, can become hypervigilent and determined to perform well in order to disprove the stereotype. This can lead to high motivation but also higher stress, anxiety, and intrusive thoughts that use up the mental capacity needed for complex reasoning.

Time limits are also something to be used with caution. Knowing that there is limited time to perform a task can increase evaluation anxiety and that may be particularly detrimental to the stereotyped group. For example, in one study we found when women were under threat in a spatial visualization task (mental rotation) they performed quite accurately but very slowly, but when a time limit was imposed the women (but not men) performed more quickly but suffered a large decline in accuracy (Blasko, Hodge, Schubert, & Jerome, 2008). This suggests that some proportion of women may be more sensitive to time pressure because in attempting to disprove the stereotype, they are highly focused on accuracy.

In a second study, we found that women performing a mental arithmetic task performed only slightly worse under threat but when one group had a time limit imposed, their performance was 13% lower than the group without the time limit even though both groups had plenty of time to complete the task (Hodge, Blasko, & Rufenacht, 2009). This effect was not observed for men where the group stereotype supported higher performance. Therefore, in class assignments and in exams, it is important to consider whether explicit time limits are really necessary. In cases where

time limits are needed (such as standardized tests) practicing under those constraints with successful outcomes can be helpful.

Research has shown that individuals who use humor as a coping mechanism are more resistant to the influence of stereotype threat (Ford, Ferguson, Brooks, & Hagadone, 2004). As an instructor, finding ways to reduce performance anxiety by using humor in the classroom may be a very effective strategy. However, it is important to make sure that the stereotyped group members are not the brunt of the joke. In male dominated domains, gender relations are often the topic of jokes and this may increase stereotype threat.

Education can also be very helpful. Taking time out of class to explain to students what stereotypes are, and how they work below the level of conscious awareness is enough in some circumstances to create resistance to the negative effects of stereotype threat. This discussion is most powerful if it is reinforced throughout the class. If you are not comfortable doing this yourself, invite a colleague with knowledge of the topic and let the students know it is very important to you, your institution, and to your profession to enhance diversity and reduce the influence of stereotypes. Mandatory diversity training is often unsuccessful because it is often one session given by an outsider who is foreign to the culture and therefore, not taken seriously. Educating colleagues in teaching discussions is also important because students may receive one message in your class and another more negative message in another class leading to self-defeating hypervigilence and ultimately poorer performance and higher drop-out rates.

Listed below are five simple ways supported by empirical research to reduce stereotype threat in your classroom. By adopting these pedagogical practices, you will create a more productive learning environment for women and minorities in the engineering discipline.

VI. Five simple ways to reduce Stereotype Threat

1. Reframe the task so that it is gender neutral.
2. Avoid time limits when possible.
3. Explain what stereotypes are to your students and how it can affect their performance.
4. Provide positive role models for women and minorities whenever possible.
5. Emphasize that intelligence is not fixed and that students can always increase their knowledge through practice.

For an in-depth description of stereotype threat and how to reduce it, visit: http://reducingstereotypethreat.org/

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