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ADDRESSING THE GENDER GAP IN MATH CLASSROOMS

EFFECTS AND TRIGGERS OF FEMALE STEREOTYPE THREAT

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During the past 40 years, male students have consistently received higher marks in mathematics than female students as demonstrated quite dramatically by the United States' 2015 Standardized Achievement Test (Perry, 2015). While on average, male and female students demonstrate similar math proficiencies, males are over-represented at higher levels of math achievement, thus expressing a gender gap which becomes more pronounced as the grade level increases (Hall, 2012; Perry, 2015; Smith & Hung, 2008).

Researchers initially questioned whether this mathematical gender gap is biologically determined, however since the 1970's, numerous studies have instead suggested the gap is socially constructed and that it is cultural influences, not ability, which drive the gender differences in mathematical achievement (Fennema & Sherman, 1977 [as cited by Hall, 2012]; Smith & Hung, 2008). The social construction of this gender gap is referred to as "stereotype threat", and consists of the following components: society strongly stereotypes females as being worse at math than males; females become aware of (but not necessarily believe in) the stereotype; females subconsciously fear that they will conform to the stereotype. Together, these components make female math students susceptible to the effect of female stereotype threat: a reduced ability to demonstrate their knowledge when completing a mathematical assessment (Steele, 1997 [as cited by Picho et al. 2013]; Spencer et al. 1999, Good et al 2003 [both as cited by Smith and Hung, 2008]).

Research has shown that stereotype threat can be triggered in female math students either overtly (explicitly) or covertly (implicitly). In the research reviewed for this paper, <u>overt</u> triggering was commonly used to activate the threat because of its ease of implementation. Specifically, the researchers would activate the threat prior to having female students write a

math test, by telling them (either verbally or via written text at the top of the test): "The test you are about to take has been shown to produce gender differences." (Spencer et al., 1999 [as cited by O'Brien & Crandall, 2003]). Despite no mention of gender in the statement, female math students assumed such statements were directed at them, and on its own would be enough to generate lower math assessment results. Picho et al. (2013) however, found that the effects of stereotype threat are even more pronounced when female students are covertly triggered. In their study, such seemingly benign activities such as "asking young girls to colour pictures of a doll or write a story about a day in the life of a female character prior to writing a math test, or requesting women to indicate their gender at the top of a math test," are capable of not only triggering the threat, but enhancing it.

It is necessary to note that triggering the stereotype threat in females, either overtly or covertly, does not automatically result in negative math performance. For example, O'Brien and Crandall (2003) found that when given two math tests (one easy and one difficult) that women's performance on the easy test was actually enhanced by the stereotype threat, while their performance on the difficult test was significantly diminished. Another influence of female math performance appears to be rooted in the purpose of the math assessment itself. Souchal et al. (2014) found that females tend to under-perform when the purpose of the math assessment is purely for "selection or ranking that emphasizes performance goals, which triggers a personal desire to outperform others" (i.e. competition). Conversely, they found that females thrive at mastery-oriented (i.e., non-competitive task completion) assessments which are designed to help the students learn the material. Their findings are supported by Hall (2012), who notes that while SAT scores (which are individual diagnostics used to rank students

for college and university entry) show a gender divide, other standardized results (such as PISA and EQAO testing, which are not individual diagnostics) show a statistically small difference between male and female achievement. Interestingly, Picho et al. (2013) found that this competition was not induced by the gender make-up of the assessment environment, as their results showed that "females did not benefit more from female-only testing situations, or testing contexts where they formed the majority."

Wen et al (2016) also researched female students' response to the stereotype threat in a competitive assessment environment (i.e., "where the action of an individual is intended to compete for a shared goal whose achievement will benefit only one side"), and compared it to their response in a co-operative environment, where "the action of an individual towards a joint goal whose achievement benefits both sides". While the performance effect of the stereotype threat was significant in the *competitive* context, it was completely neutralized in the *co-operative* context. The authors furthered their study by investigating the impact of self-regulatory styles on the female stereotype threat. Specifically, they compared the following:

- Promotion-focused individuals (i.e., "the fulfillment of their aspirations, ideals, and wishes, and the potential benefits from behaviours")
- Prevention-focused individuals (i.e., "those who care more about satisfying their need for security and potential losses in behaviours and activities.").

The questions and activities used to prime female students berfore taking a math test are included here to more effectively describe the differences between "promotion" and "prevention" focus:

> *Promotion question: What do you aspire to attain in college?*
> *Prevention question: What do you think you should obtain through a college education?*
>
> *Promotion activity: Help the mouse complete this maze to find a piece of cheese.*
> *Prevention activity: Help the mouse complete this maze before an eagle circling overhead eats it.*

Wen et al. found that prevention-focus did nothing to help alleviate the female stereotype threat, and that promotion-focus eliminated it.

Other potential mechanisms for preventing the effects of stereotype threat include the influence of role models; one of the reviewed studies suggested a strong correlation between females' math performance and the presence of positive female math role models in the classroom. Prior to having students write a math test (after the stereotype threat had been induced), Marx et al., (2013) asked some of the students to read a newspaper article about either a male or female student who was very successful at math (i.e., positive math model exposure). The other students were asked to read the same article which included the following quote attributed to the successful student: "Throughout school I was worried that if I failed people would assume it was because someone like me could not be good at math." (negative math model exposure). As a result, female students exposed to the positive female role model performed 10% better (on average) than those exposed to either the negative female role model, the positive male role model, or the negative male role model. Based on these results, the authors argue that positive female math role models neutralize the effects of stereotype threat from women's math performance. As their results also demonstrated that negative female role models permit the female stereotype effect, the authors further argue that "female role models should avoid expressing doubt about their math abilities".

While all of the research discussed to this point relies on psychological remedies to stereotype threat, Chalabaev et al. (2016) built upon research which linked an individual's sensory experiences and motor movements with higher-order cognition (for example, "people evaluate groups as powerful if those groups' names are presented high rather than low in the visual field [paper cited Schubert, 2005]; people imbue objects with importance if those objects feel heavy [paper cited Jostmann, Lakens, & Schubert, 2009]). Interestingly, the researchers found that the math performance of right-handed female students significantly improved if they clenched their left fist while taking a math test, or if the test was presented on the left side (versus the right sight) of a computer screen.

Both Picho et al. (2013) and Keller & Dauenheimer (2003) warn that research into how best to alleviate stereotype threat is still in its early stages, and that it would be premature to attempt to disrupt this phenomenon with specific actions. However, the hypotheses, test methods, and conclusions of the various research initiatives reviewed for this paper do suggest potential strategies and approaches for diminishing the effects of stereotype threat in the math classroom. Since none of the reviewed research activities were found to negatively impact the performance of male math students (i.e., males' math performance remained unchanged despite the induced psychological manipulations within the research), the risk associated with implementing any such measures seems low.

Thus for mathematics educators, the following serve as potential remedies to the female stereotype threat in the math classroom. Note that the ethics of deliberately manipulating student behaviour in these ways, despite being well-intentioned, likely warrants some discussion.

- Avoid math activities and math assignments which reinforce the female stereotype (e.g., asking females to code a program in the Scratch application which sketches a picture of a dress, asking female students to calculate a mathematics money-problem involving the purchase of make-up). *(Based on the findings of Picho et al., [2013])*
- Ensure female math teachers exude confidence in math (and mute any misgivings or doubt they might have, including verbal and non-verbal expressions) while in front of their students. *(Based on the findings of Marx et al. ,[2013]; Beilock, Gunderson, Ramirez, and Levine (2010) [as cited by Marx et al., (2013)])*
- Exclude female characters from math word problems (e.g., Mary and Joanna went to the store). *(Based on the findings of Picho et al., [2013])*
- Reduce the amount of direct competition within the math classroom as much as possible. Avoid activities which divide the class into teams of "male versus female", as well as comparisons of "males versus females" math performance at the conclusion of an assessment. *(Based on the findings of Souchal et al., [2014]; Hall [2012])*
- Explicitly define assessments as being "mastery-oriented", and set students' learning mindset by alerting them at the start of class that an assessment is forthcoming:

  > ***"Mastery statement example**: At the end of today's lesson, you will take a test. On the basis of this test, you will receive a grade. This test will help you memorize and understand the lesson well. You will see that, even during the test, you will continue to learn. You have to know that this grade will count in your final semester grade."*
  >
  > *(Souchal et al., [2014])*

- Include the following statement at the beginning of each diagnostic or summative assessment which will be used to rank or judge individual student performance *(Based on the findings of Jamieson and Harkins [2010])*:
    - *"The task you are about to complete is a test of math ability. Previous research has demonstrated that gender differences exist on some math tests, but not on others. The test on which you are about to perform has NOT been shown to produce gender differences."*
- Include or tell a positive math story of a female role model prior to the start of a math test. *(Based on the findings of Marx et al.,[2013]; Beilock, Gunderson, Ramirez, and Levine (2010) [as cited by Marx et al., (2013)])*
- Provide students with a squeeze toy to activate the motor movements of their non-dominant hand during assessments. *(Based on the findings of Chalabaev et al., [2016])*

In conclusion, while male and female students have similar abilities in mathematics, female math performance lags that of males due to stereotype threat, especially at the higher grade levels. For the benefit of their female students, it is important for math teachers to be aware of this phenomenon and its triggers. Such knowledge will inform the development of classroom environments which help ensure that diagnostic assessments of female students provide a true indication of their math ability.

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