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Stereotype Threat and STEM Self-Perceptions of Saudi College Women

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Stereotype Threat and STEM Self-Perceptions of Saudi College Women

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Biography

Ali Hadi Omair was born in Saudi Arabia. He received his Bachelor of Arts degree in Psychology from Muhammad Bin Saud University, Abha, Saudi Arabia. In 2007, he received his Master degree in Personality and Social Psychology from Umm Al-Qura University, Mecca, Saudi Arabia. Then, he obtained a scholarship from the Ministry of Education in Saudi Arabia to study Psychology in United State of America. In 2017, Ali received his Master of Arts degree in Psychology from DePaul University, Chicago. By approving this research dissertation, Ali will receive his Doctor of Philosophy degree (Ph.D.) in Psychological Science from the College of Science and Health (Department of Psychology), at DePaul University, Chicago, Illinois, USA.

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Abstract

Research shows that women's educational progress in scientific (STEM) fields is limited by negative stereotypes about their abilities in such fields. These negative stereotypes may be internalized by women and adversely affect their academic self-concept and progress in STEM fields. In the case of women in higher education who study in STEM fields, their knowledge that they are stereotyped as having less ability than men in those fields may result in a stereotype threat that reduces their performance in cognitive tests and reduces their academic self-perception in regard to STEM domains.

Most research on the negative female stereotype and stereotype threat in STEM fields has been conducted in Western countries. Little research has been conducted on women studying in STEM fields in universities in Saudi Arabia. It is important that such research be conducted because of Saudi Arabia's unique cultural limitations on women and the strength of the country's female stereotypes. Due to these circumstances, Western research results may not be applicable to Saudi women. Western results may also not be applicable to Saudi women because women higher education in Saudi Arabia occurs mostly in women-only institutions, unlike in the West. This study aimed to contribute new research to fill the gap in the literature regarding gender stereotypes about women in science majors in academia within Saudi society by examining how exposure to types of stereotype about women's science ability (stereotype threat vs. positive stereotype) impact academic performance (in terms of math test results) and self-perceptions in science (in terms of science identity, science self-efficacy, belief about science, and overall academic science self-perception) for women STEM/medical students in different types of gender classrooms (classes only for women vs. mixed gender classes) at university in Saudi Arabia. In addition, the study investigated the interaction between the

types of gender classrooms and the types of stereotype about women's academic science ability on math performance and self-perceptions in science.

These questions were tested by using the data that were collected from 634 Saudi women college students. The results found that students who were exposed to stereotype threat had lower math test scores and lower academic self-perception than women who were exposed to a positive statement about their STEM abilities. The study also found that women in mixed-gender classes had higher math test scores and academic self-perception than women in women-only classes. In addition, the results showed that in stereotype threat experiment condition women scored equally low in the math test regardless the type of gender classrooms. However, in the positive stereotype experiment condition, women in mixed-gender classrooms scored significantly higher in math test score compared to the women in single-gender classrooms. For the academic science self-perceptions, the results also showed a significant interaction effect of gender classroom type and stereotype about women's academic science ability; indicating the effect of stereotype depended on the type of the classroom. In the threat experiment condition, women were significantly lower in academic self-perceptions both types of gender classrooms. However, women who were exposed to positive stereotypes in mixed classrooms scored significantly higher in academic self-perceptions compared to women who were exposed to positive stereotypes in single gender classrooms.

These findings provide evidence that female Saudi students in STEM fields were above the midpoint of the scales on science self-perception (averaging on the positive ends of the scale), which may indicated to good level of academic self-perception in science. More specifically, when they are in mixed gender classrooms, the positive message support them to buffer themselves against negatives stereotypes to define their capabilities, and thy see themselves as being very capable in STEM subjects.

Introduction

Widespread negative female stereotypes limit the educational and occupational progress of women throughout the world (Mertus & Flowers, 2017; Trauth, Quesenberry, & Huang, 2008). One main result of the existence of negative female stereotypes is that in the fields of science, technology, engineering, and mathematics (STEM fields) the educational and occupational opportunities available to women lag behind those available to men. This result is harmful for societies, as a society's potential for advancement cannot be fulfilled when half of the population is hampered by stereotypes that limit their education and employment possibilities (Gates, 2014).

One limitation created by negative stereotypes comes in the form of stereotype threat, which occurs when people who belong to a group face the possibility of confirming a negative stereotype about their group by their actions (Grand, 2017; Steele, 2010). In such a situation, researchers have found that members of the stereotyped group often tend to produce results poorer than they would if the stereotype threat did not exist (Hively & El-Alayli, 2014; Kaye & Pennington, 2016; Rydell, Rydell, & Boucher, 2010). Research also suggests that the adverse effects of stereotype threat may be reduced by countering the stereotype with a positive message before the group engages in a cognitive test (Ngoma, 2018; McGlone and Aronson, 2007; Wheeler & Petty, 2001).

Studies have shown that the existence of a stereotype threat can negatively affect women's academic performance in STEM fields (Cadaret et al., 2017; Woodcock, Hernandez, & Schultz, 2016). However, most research on the impact of stereotype threat and of countering the threat with a positive message has been conducted in Western culture. It appears that no research to date has specifically investigated how stereotype threat may affect the views of women in higher education institutions in the Kingdom of Saudi Arabia. It is important that such research be conducted because Saudi Arabia is a male-dominated and gender-segregated society in which gender stereotypes are strong. The practice of gender segregation encompasses much of Saudi education in schools and universities, and limitations on women's higher education opportunities that result from negative female stereotypes are evident for women in Saudi Arabia (Alghamdi, 2017; Omair, 2017). While there have been some recent changes in Saudi Arabia that have created opportunities for women for better education and jobs, men with STEM (science, technology, engineering, and mathematics) and medical degrees who have gone on to careers in those fields far outnumber women (Islam, 2014).

The present study addressed the issue of how stereotypes may affect Saudi women who were enrolled in STEM and medical fields in Saudi institutions of higher education. In particular, the study examined the effects of stereotype threat on the academic STEM self-perceptions and academic performance of Saudi women enrolled in science or medicine tracks at Saudi universities. The study compared these effects to the condition of the women being given a positive message to counteract the stereotype threat. In addition, since Saudi women in some majors and cases need to be in the same classroom with men and interact with them directly, and this mixed-gender environment may have an effect on women students' academic self-perception, this study also examined how studying in a mixed-gender versus a single-gender classroom is related to Saudi women's academic self-perception and academic performance.

Because of the unique nature of female's educational position and opportunities within Saudi society, it is important for research to be conducted that provides a better understanding of how gender stereotypes in Saudi Arabia affect women's higher education. Furthermore, there is a gap in research on how the existence of gender stereotypes may affect Saudi women higher education students, and especially on how stereotype threat may affect the self-perceptions of women Saudi tertiary students who are pursuing a degree in a STEM or medical field. Thus, the research question for this study was the following:

> What is the impact of stereotype about women's STEM performance (the same or worse than men's) on math performance and academic self-perception of Saudi women who are pursuing a degree in a STEM or medical field and who study in mixed-gender compared to single-gender classrooms?

Overview of Gender Stereotypes

In social perception, individuals use concepts to classify individuals into groups (Fiske, 1998). This classification process can result in stereotypes, which are concepts used by social perceivers to process information about others (Hilton & von Hippel, 1996). A stereotype links a social group with some attribute that members of the group are alleged to have (Cox & Devine, 2015). Once a group is categorized, characteristics believed to be associated with the group are attributed to individuals who belong to the group.

Stereotypes may be positive or negative (Hoyt & Murphy, 2016); however, stereotypes are often pejorative and are typically learned by people in one social group (the in-group) as being applicable to people who belong to a different social group (the out-group) (Corrigan, Larson, & Rüsch, 2009). Stereotypes occur in racial, ethnic, national, age-defined, and gender categories, reflecting concepts that supposedly describe the nature or typical behavior of people who belong to groups within each category.

Examples include the common stereotypes that males are agentic and females are communal (Carli, Alawa, Lee, Zhao, & Kim, 2016). A person may learn a pejorative stereotype about an out-group but may not believe the stereotype is true. However, there are often those who accept the stereotype as accurately describing members of the out-group. If a person accepts the accuracy of a negative stereotype supposedly describing an out-group, then the stereotype may foster discrimination by affecting his or her perceptions, interpretations, and judgments about out-group members (Hilton & von Hippel, 1996).

Some of the most widespread stereotypes are ideas about differences between the two genders (Lueptow, Garovich-Szabo, & Lueptow, 2001). The term “gender” has a meaning distinct from a person’s “sex.” The latter term is normally used to designate physiological differences between females and males, including primary sexual characteristics such as their reproductive anatomy and secondary sexual characteristics such as degree of facial hair. The term “gender” refers to social distinctions and roles that are associated with being male or female (Helgeson, 2012; Little & McGivern, 2016). These social distinctions may begin at birth and continue throughout life, with boys and men encouraged to be strong, competitive, and even aggressive in their behavior, while girls and women are encouraged to be non-aggressive and nurturing (Helgeson, 2012). Thus, gender stereotypes do not refer to anatomical sex differences between women and men but rather to alleged differences in their natures or abilities.

Common stereotypes for men appear to be mostly positive. Men are often viewed as more rational and more likely to have leadership qualities when compared to women. Other common stereotypes attributed to men include their being more active, autonomous, and self-assured in comparison to women (Kite, Deaux, & Haines, 2008).

Common stereotypes about women are that they are more emotional, weak, and mild than men, and that they are poor at mathematical, scientific, and logical reasoning in comparison to men and thus have less academic ability than men in STEM fields (Cadaret, Hartung, Subich, & Weigold, 2017; Kite et al., 2008). These stereotypical ideas of the nature and ability of women are widespread globally and are held by different age groups and by men and women alike (Kite et al., 2008).

There are some positive stereotypes about women and girls. These include the idea that women are more nurturing and sensitive than men and that they tend to be interested in fields such as languages and the arts (Koenig, 2018). Research suggests that the effects of negative female stereotypes on women's views of their academic capabilities in STEM fields can be counteracted by purposely introducing positive ideas about their abilities in the field (Ngoma, 2018). Such positive ideas may help counter the negative stereotype about the academic performance of women in STEM fields and thereby reduce stereotype threat. McGlone and Aronson (2007) found that when female students were given a difficult mathematics test, their grades improved when, before the test, they were provided a positive stereotype message specifically designed to counter any negative stereotypes. In general, it has been suggested that providing a message to stereotyped students that decreases a stereotype's applicability may increase performance on an academic test (Wheeler & Petty, 2001).

Academic Effects of Female Stereotypes in STEM Domains

Negative stereotypes about females' natural abilities in STEM domains can have an adverse effect on women's academic pursuits (Kahn & Ginther, 2017). The widespread female stereotype that women do not have as much natural ability as men in STEM fields leads societies to provide fewer educational and career opportunities for women in those fields (Mertus & Flowers, 2017). A global study by UNESCO (2017) found that women account for only 35% of higher education students enrolled in STEM-related fields across 70 countries. The particular areas in which women were most under-represented were information and communication technology, engineering, manufacturing, construction, natural sciences, mathematics, and statistics.

Reasons for fewer women entering STEM-related fields as they pursue higher education include the different socialization patterns girls experience in comparison to boys (Tiedemann, 2000). Though self-selection to enter or not to enter a STEM-related educational pathway is held to be a significant factor in determining females' lower rates of STEM involvement, girls' choices are determined by the ways they are socialized, including their becoming aware of stereotypes applied to females in comparison to males. These stereotypes include the idea that girls do not have as much ability as boys in STEM fields and that STEM fields are "masculine" rather than "feminine" subjects. Beginning in their early years, girls are often led to believe, both explicitly and implicitly, that females' abilities are inferior to boys' abilities in STEM subjects and that such subjects are better suited to males than females (Nosek et al., 2009; UNESCO, 2017).

Girls and women may assimilate and internalize female stereotypes about their intellectual ability in STEM fields, which may adversely affect their academic pursuits (Bonnot & Croizet, 2007; Eccles, 1994). This assimilation process can be understood in terms of self-identity theory and self-categorization theory. According to self-identity theory, individuals have both a personal and a social identity (Tajfel, 1978; Tajfel & Turner, 1979). A person's social identity consists of the groups that the individual perceives that she or he belongs to. Self-categorization theory holds that by categorizing themselves as belonging to one or more groups, people develop their social identity

(Turner, 1978). Women who strongly self-categorize themselves as belonging to the group of females develop a strong social identity as a woman and may view themselves in terms of stereotypes that are commonly applied to women (Turner & Reynolds, 2012). In the case of women who internalize female stereotypes about their capabilities in STEM fields, the self-stereotyping may influence one or more of their cognitive constructs, including their academic self-concept, sense of self-efficacy, academic resilience, and sense of belonging. The following three subsections discuss each of these important ideas.

Women's Academic Self-Concept in STEM

A female student's academic self-concept in STEM fields refers to her beliefs about her capabilities to excel in those domains (Jansen, Scherer, & Schroeders, 2015; Simpkins, Davis-Kean, & Eccles, 2006). Academic self-concept is important because it can affect the academic achievement of an individual (Marsh & Scalas, 2011). Those who have a stronger belief about their academic capabilities in a field tend to have greater achievement in the field over time. A stronger academic self-concept within a field of endeavor tends to increase expectations of successful outcomes in the field and result in greater motivation to study and do well in the field (Eccles et al., 1983; Fishbein & Ajzen, 1975).

Though academic self-concept is a subjective evaluation, it is typically at least partly based on feedback from objective measures of ability or achievement in the domain, such as examinations and grades. The student uses various comparisons as she develops her academic self-concept. An external comparison consists of comparing what she achieves with what her peers achieve in the domain. Internal comparisons include comparing what she currently achieves in the domain versus what she formerly achieved in the same domain or what she achieves in the domain versus what she achieves in other domains (Ertl, Luttenberger, & Paechter, 2017).

Additional factors, not based on such relatively objective comparisons, often help shape a female student's academic self-concept. These other factors may include parents', teachers', and other people's assessments of her ability in a particular domain (Dresel, Schober, & Ziegler, 2007; Tiedemann, 2000; Viljaranta, Lazarides, Aunola, Räikkönen, & Nurmi, 2014). These assessments may be at least partly based on whether the influencers do or do not endorse stereotypes about female ability in the domain (Jansen et al., 2015).

Evidence suggests that young women have as much actual ability as young men in science and mathematics. In the U.S., high school girls are just as likely to take advanced mathematics courses as boys, and they score higher math grades than boys. Yet, the academic self-concept that females are not as capable as males persists among these young women (Wang, Degol, & Ye, 2015). Research also shows that girls evaluate their math capabilities as lower than boys who have similar math grades (Correll, 2001). Furthermore, unlike males, females do not tend to attribute successes in a STEM field to their ability in the field, whereas they tend to attribute any lack of success to a lack of ability (Dickhäuser & Meyer, 2006; Kessels, 2014).

Assimilation by a young girl of the stereotype that females do not have as much ability as males in regard to STEM areas can weaken her academic self-concept regarding her general ability in STEM subjects, erode her self-confidence in regard to enrolling in such subjects, and lead her to lose interest in and willingness to educationally pursue such subjects (Dresel et al., 2007). The stereotype may affect a female's career choice, and those who do enter a STEM area of study or later enter a STEM career may subsequently be more likely than males to leave the area of study or the career (Block, Hall, Schmader, Inness, & Croft, 2018; Schuster & Martiny, 2017; UNESCO, 2017).

A study investigating how female students' academic self-concept in regard to STEM fields was related to gender bias found that women who reported experiencing gender bias had a lower academic self-concept regarding STEM subjects, indicating a lower belief in their capability to excel in those subjects (Robnett, 2016). The researcher surveyed 108 high-school girls from two U.S high schools who were interested in pursuing a career in a STEM subject, 124 undergraduate females from a single university who were majoring or pre-majoring in a STEM field, and 102 female graduate students from the same university who were majoring in a STEM-related field. Robnett (2016) found that 61% of the participants had experienced gender bias during the past year. The group most likely to experience gender bias were undergraduate women who were in math-intensive fields. The main source of this gender bias, as reported by the undergraduate women, was male peers who were in their major field of study.

Women's Academic Self-Efficacy in STEM

Gender stereotypes may also have a substantial influence on a girl's or woman's sense of academic self-efficacy, which consists of how she rates her cognitive and physical ability to deal with whatever demands may be required for successfully performing a task in a certain domain or to reach a goal in that domain (Jansen et al., 2015; Sweida & Reichard, 2013). Researchers have found that women's awareness of being negatively stereotyped in regard to certain academic domains can adversely affect their sense of academic self-efficacy in those domains as it does their academic self-concept. Because academic self-efficacy is thought to affect students' motivation, including what tasks and goals they set for themselves (Jansen et al., 2015), a female student's assimilation of a negative stereotype about the capability of girls and women in an academic area may adversely affect her setting of goals for herself in that area. Communicating stereotypical ideas of females' capabilities in traditionally male-dominated fields such as engineering, science, and mathematics can reduce girls' self-efficacy in those fields early in their education (Dresel et al., 2007; Tiedemann, 2000; Viljaranta et al., 2014). This reduction in sense of self-efficacy occurs even though testing shows that young girls' aptitudes and capabilities in those fields are equal to boys' aptitudes and capabilities (Wang et al., 2015). As a result of a reduced sense of self-efficacy, many girls decide not to pursue academic tracks and careers in those fields, believing that they are inappropriate for females (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001).

In a study of variables affecting men and women university students' career orientation to the field of computer and information sciences, Rosson, Carroll, and Sinha (2011) found that men's' sense of computer self-efficacy was less than males' sense of computer self-efficacy. Furthermore, they found that while lower self-efficacy among males was significantly related to lower peer-based social support, this was not the case for female students. Many of the women who reported having low computer self-efficacy at the same time reported having a high degree of social support from their peers. This finding suggests that variables other than social support affected the computer self-efficacy reported by the female students. Rosson et al. (2011) also found that for both the men and women students, having high computer self-efficacy was positively related to intention to enter the career field of computer and information sciences.

The results of a study by Förtsch Gärtig-Daugs, Buchholz, and Schmid (2018) also suggested that females' sense of self-efficacy in the field of computer science may be lower than males' due to stereotypes. The researchers examined 103 graduates, 17 of whom were female, of the Faculty of Information Systems and Applied Computer Sciences at Bamberg University in Germany to determine the relative academic achievement, self-perceptions of professional skills, career ambitions, and career opportunities of male and female computer science graduates. The researchers found no significant difference between males and females in regard to their academic achievement, with 38% of both genders graduating from the university with a record of high achievement. However, a significantly higher proportion of the male graduates assessed their computer skills at a higher level compared to the female graduates. In particular, 92.5% of the male graduates assessed their computer science skills at a high level, while only 72% of the female graduates did so. Förtsch et al. (2018) also found that the men generally had a high self-assessment of their computer skills whether they did or did not have high academic achievements. The researchers noted that these findings could be due to the internalization of stereotypical ideas that men are naturally better at computer sciences than women.

Women's Academic Resilience in STEM

Women's academic resilience may also be affected by negative stereotypes. The concept of resilience refers to an individual remaining positively adapted to a situation or challenge despite having experiences indicating considerable adversity (Luthar, Cicchetti, & Becker, 2000). A resilient response by an individual to an academic or social challenge is one that furthers the individual's development. Examples of resilient responses to an academic challenge include making a greater effort and searching for fresh strategies to address the challenge. Non-resilient responses are ones that do not further the individual's development, such as giving up and feeling helpless (Yeager & Dweck, 2012). The academic resilience of girls and women in STEM fields such as mathematics of engineering may be compromised if they accept the gender stereotype that females' abilities in those subjects are less than men's.

One way stereotypes that females are not as capable as males in STEM areas may limit women's academic resilience is by reducing their sense of socially belonging in a STEM academic track they wish to pursue (Shafei & Al-Shami, 2015; Walton & Cohen, 2011). A female student's sense of socially belonging in a STEM academic track can positively influence her academic resilience in the track; a sense of not socially belonging in the STEM track may decrease her academic resilience (Nowicki, 2008; Roffey, 2017).

Women's academic resilience in STEM fields can be promoted and stereotypes can be countered by leading students to believe that their intellectual abilities are not fixed by stereotypical ideas but can be developed (Dweck, 2006; Good, Rattan, & Dweck, 2012; Yeager & Dweck, 2012). Students with a fixed mindset may lose their confidence in dealing with a challenging subject matter because they believe that if they were smart, the subject would not be so difficult. If they instead accept the theory that their intelligence can be developed, they will be more likely to want to learn and accept learning challenges. As they encounter challenges and exert effort to overcome them, their confidence in their ability to learn a subject matter tends to increase (Hill, Corbett, & St. Rose, 2010). A study that examined the academic resilience and achievement of female students who were taught that their intellectual abilities can be developed and grow found that the students showed higher achievement in challenging situations and had greater rates of course completion in challenging mathematics courses (Yeager & Dweck, 2012), increasing their academic resilience.

Another way to help girls and women overcome negative gender stereotypes and increase their confidence in their ability to succeed in STEM fields is through their being influenced by female role models who are already situated in a STEM career. This idea is supported by Bandura's (1986) social cognitive theory, which holds that observing other people with similar characteristics who are skilled at a kind of task fosters the individual's confidence in her or his ability to perform similar tasks. Therefore, one way to foster girls' entrance into STEM fields is to expose them to female scientists who care about the girls' success and who can act as role models (Buck, Plano, Leslie-Pelecky, Lu, & Cerda-Lizarraga, 2008).

Stereotype Threat

A stereotype threat is present when a person who belongs to a particular group is called on to perform some action or series of actions, and the person believes that his or her performance may serve to confirm some negative stereotype that is held about the group (Grand, 2017). More specifically, stereotype threats arise when members of a group are (a) engaged in a difficult task that they believe is evaluative of some ability, (b) the group as a whole is negatively stereotyped in regard to that ability, (c) the members are aware of the stereotype, and (d) they want to perform well in the task (Steele, 2010). Research has shown that individuals who perceive that their performance may confirm a negative stereotype attributed to their group produce results lower than they would be if the stereotype threat did not exist (Hively & El-Alayli, 2014; Kaye & Pennington, 2016). Research also indicates that the poorer results may occur because when cues of stereotypes are presented to individuals in a stereotyped group, the cues function as stressors to undercut the individuals' performance (London, Downey, Romero-Canyas, Rattan, & Tyson, 2012). For example, when members of a stereotyped group take a standardized test to measure their abilities, they may underperform on the test if they are exposed to a relevant negative stereotype before or while they are taking the test (Nguyen & Ryan, 2008).

In a meta-analysis of studies on stereotype threat, Pennington, Heim, Levy, and Larkin (2016) found that research indicates that an individual experiencing stereotype threat can result in several effects that may undermine performance. These effects include increased anxiety, negative thinking, and mind-wandering, all of which may reduce the cognitive resources that are required for performing a task. Encountering a stereotype threat may also lead an individual to make an effort to suppress negative thoughts, which can further undermine cognitive performance on the task at hand. A distinction can be made between individuals who experience a stereotype threat as directed toward their social group and those who experience it as directed toward themselves. The former perceive that their underperformance on a task will confirm a negative stereotype about the capabilities of their social group. The latter perceive that a poor performance on a task will be considered to reflect on the capabilities of themselves (Pennington et al., 2016).

The cues that are held to trigger a stereotype threat may be blatant, somewhat explicit, or indirect (Nguyen & Ryan, 2008). An example of a blatantly explicit cue would be for a test taker to be explicitly exposed at the time of the test to a stereotype that the individual's group is deemed to typically produce inferior results in such a test. An example of a somewhat explicit cue would be for a test taker to be exposed to a statement that there are typically subgroup differences in taking such tests, but it is not explicitly stated which subgroups do better or worse, with this being left to the individual's interpretation. An example of an indirect cue would be for a test taker to be asked to state their subgroup membership before taking the test or for it to be emphasized that the test is diagnostic. Blatantly explicit and somewhat explicit cues are held to have their stereotype threat effect through the test taker's conscious mechanisms, while indirect cues are held to have their effect through the test taker's unconscious mechanisms (Nguyen & Ryan, 2008).

Psychological results from stereotype threat include disengagement from an area or activity as a psychological defense that enables a person to avoid being evaluated and possibly confirming a negative stereotype. Stereotype threat can also decrease individuals' aspirations, leading them to lower their goals and even their performance, and can result in self-handicapping as an explanation of poor results in a competitive situation (Kray & Shirako, 2012).

In the case of women in academia, a stereotype threat may occur when they are examined on some subject that is stereotypically held to not be well-suited to their natural capabilities, such as mathematics. Since skill and knowledge in mathematics is a typical requirement for doing well in STEM subjects, the idea that women are not as good as men at mathematics can cause doubt that women can be as good as men at any STEM subject that requires mathematics. Though this stereotype was disproven by an investigation of females' and males' abilities in mathematics in grades 2 through 11 that ranged over 10 geographically diverse states in the U.S. (Hyde, Lindberg, Linn, Ellis, & Williams, 2008), the stereotype persists. Thus, for women who seek to be educated in a STEM or medical field, it is possible that negative stereotypes about women's natural capabilities in mathematics or in some other intellectual field may result in a stereotype threat that depresses women's scores on tests and exams in the field. As a result, stereotype threats could limit women's entrance into the field.

A number of studies have investigated how stereotype threat may affect women academically. Kapitanoff and Pandey (2017) undertook a study in which they examined 451 students in 11 semester-long Introduction to Statistics for the Social Sciences courses in a large urban California community college. Approximately 63% were women. The researchers submitted a statement to the students that expressed a common gender stereotype that men are better in mathematics than women and usually do better in mathematics classes. The researchers found that those women who endorsed the stereotype statement significantly underperformed compared to women who did not endorse the stereotype. Anxiety about the class and mathematics anxiety were greater in endorsers than non-endorsers and were considered indicators of stereotype threat. This threat was reduced for endorsers by the end of the semester for female students who had female instructors.

Deemer, Thoman, Chase, and Smith (2014) conducted a study to determine how facing a situation of stereotype threat was related to female students' sense of self-efficacy, their intent to undertake undergraduate research, and their intent to make a career in the STEM fields of either physics or chemistry. The researchers surveyed 439 female university students enrolled in chemistry and physics lab classes in universities in different regions of the United States. Findings revealed that perceptions of facing a stereotype threat decreased female students' sense of science self-efficacy and their intention to undertake undergraduate research in either physics or chemistry. Deemer et al. (2014) suggested that this result may have been because the perception of stereotype threat may have reduced the females' self-efficacy to a level that was sufficiently low as to undermine their decisions on a career path.

In a meta-analysis of 116 studies, Nguyen and Ryan (2008) found that in studies that examined women's underperformance in math due to stereotype threat, the underperformance was greater for indirect than for direct cues. They also found that explicit stereotype threat removal practices for women, such as explicitly stating that a math test was devised with no gender bias, had a greater stereotype-threat-reducing effect than indirect threat removal practices such as stating that the performance on a math test would not be evaluated.

Gender identity is the importance a person places on their gender as being part of their overall self-concept (Witt, & Wood, 2010). There is evidence that the negative effect of stereotype threat on female students' achievement in STEM subjects depends on the strength of the student's gender identity. Casad, Hale, and Wachs (2017) conducted a study to determine how adolescent girls' strength of gender identity may affect their performance in a mathematics task when they are placed in conditions of stereotype threat. The 498 girls in the study ranged in age from 12 to 14 years and were in one of five Southern California middle schools. Forty-five percent of the girls were taking honors math classes, with the remainder in standard math classes. Casad et al. (2017) found that for the girls in honors math classes, strength of gender identity protected them from several negative results of stereotype threat. In particular, strength of gender identity buffered them against disengagement, discounting math test results as being invalid, and negative attitude.

The results of the Casad et al. (2017) study suggest that in examining how stereotype threat regarding STEM fields affects female students, it is important to measure the strength of the students' gender identity, as this variable may modify the effect of the stereotype threat. In addition to identity, it is important to examine how stereotype threat may affect female students in different regions of the world and countries. This is because despite the fact that negative female stereotypes about STEM academic ability are widespread globally, there can be differences in such stereotypes between different countries and cultures. A study by Dumdell, Haag, and Laithwaite (2000) compared the relation of gender to computer self-efficacy in Scotland and Romania. The researchers found that in each country, males were more confident of their computer skills than females. However, both genders in Romania were more confident of their computer skills than their counterparts in Scotland. In another study, Japanese students were found to believe more strongly than Swedish students that computers and mathematics are male domains (Makrakis & Sawada, 1996). The fact that negative female stereotypes may vary in content and strength from country to country suggests that the effects of stereotype threat regarding STEM subjects may also differ for different countries. To date, most of the research on stereotype threat has been done in Western countries. Little research on how gender stereotypes and stereotype threat are related to female students' STEM endeavors in colleges and universities in Saudi Arabia has been conducted. For decades, Saudi woman faced extreme gender segregation and negative stereotypes. However, more recently, the Saudi government is seeking to make some changes that would make Saudi women more active and to engage more positively in positions that were limited to men such as STEM fields. As a result, Saudi women are in the middle between the two different types of messages—negative and positive. The negative message that has deep cultural roots, and the positive message that just start to create new future for women. Thus, it is appropriate for this study to specifically focus on how stereotype threat may affect female Saudi Arabian university students enrolled in STEM tracks.

Women and Female Stereotypes in Saudi Arabia

Women in Saudi Arabian Culture

The Kingdom of Saudi Arabia is a monarchy located in the Arab Gulf region. It is a prosperous country with large reserves of oil and natural gas. Over the past 70 years, Saudi Arabia has experienced great changes economically, socially, and politically since the country's oil reserves were discovered and extraction began in the 1940s. The oil production has resulted in the country enjoying immense gains financially, which is reflected in the incomes and lifestyles of Saudi citizens (Aldegether, 2017).

The country's national religion is Islam, and virtually all native Saudis practice that religion. The culture is largely traditional and very conservative, with the society being almost completely male-dominated (Abdul Razzak, 2016). In the Saudi Kingdom, the family is a very strong social institution. Women are required by Saudi culture to always consider themselves first as members of a family—as a wife, mother, daughter, or other close relative (Aldegether, 2017)—with her main role being that of a housewife and loving mother (Alsuwaida, 2016). However, as opposed to Western countries, in Saudi society the extent of women's participation in decision-making related to marriage is restricted to family matters. It has been suggested that the restriction in family decision-making means that Saudi women suffer from being excluded from participating and playing critical roles in their society and are thereby deprived of their human rights (Alhareth, Alhareth & Al-Dighrir, 2015). Therefore, it is possible that the limited say women have in decision making in the family then extends to limited decision making in other domains of society such as in the workplace and education (Juhn, Ujhelyi, & Villegas-Sanchez, 2014).

One of the key rules in Saudi society that depicts women as dependent on men is the male guardianship system which commonly practiced in Saudi families. It is a requirement that every woman in Saudi society must have a male guardian, her "*mahram*," whether it is a father or a husband or brother, who has the authority to make all critical decisions on her behalf (Manning et al., 2014). For example, in order for women to get married (or divorced), permission from her "*mahram"* is required. Also, adult women in Saudi Arabia are not allowed to travel abroad, leave prison, obtain consent of work, or access healthcare without the permission of a male guardian (Van et al., 2016). In other words, in Saudi Arabia, a woman must have a male guardian throughout her life. If married, her guardian is usually her husband; if unmarried, her guardian is her father or a brother; if widowed, her guardian is normally a son or sons if she has any. For entering an occupation, getting married, divorced, or travel a Saudi woman needs the permission of her guardian.

The traditional stereotypical view in the Saudi culture is that females are relatively weak and necessarily dependent on males in almost all aspects of life. In the Saudi culture, the expectation is for females to be submissive and to support males rather than to take an active leadership role (Ahmad, 2011). These stereotypical views of women were reflected in the results of a study by Omair (2017), who surveyed 841 Saudi university students to determine whether the students held stereotypes about Saudi females and what these were. The participants were approximately evenly divided between females and males. The researcher found that both males and females held stereotypes about Saudi females, with the men having a stronger overall affirmation of Saudi female stereotypes than the women. Men affirmed Saudi female stereotypes of being submissive and less competent than men, while women supported stereotypes of Saudi women being virtuous and isolated.

Stereotypical ideas about the nature and proper place for Saudi women are supported by strongly held conservative religious beliefs that promote continued adherence to traditional gender roles, activities, and a dress code for women. Another conservative aspect of the Saudi Arabian culture is that the mixing of men and women in public, called "*Ikhtilat*," has long been discouraged. The tradition of no mixing of the sexes restricts women's activities in several ways, including their occupational opportunities. While the prohibition on mixing has been claimed to follow from the Islamic religion, some Saudis argue that the restriction is not rooted in Islam but is rather based on Saudi social traditions (Alwedinani, 2017) and that in the past, Muslim Arabic women participated in all aspects of life (Hamdan, 2005). Though traditional Saudi culture has rooted in people's minds that a man's declaring the name of his daughter, sister, mother, or wife in public is disgraceful, this social practice results in a great injustice to women. The concealment of the woman's name contributes to the concealment of many of her rights thereafter. This reflects a kind of respect for men who do not accept that their women relatives (wives, daughters, sisters, and mothers) should be known by strangers. Because of this practice, career opportunities for women may be limited (e.g., in STEM), which may affect self-exploration, self-identity, and feeling independence.

According to Al-Rasheed (2013), in the 1980s especially restrictive religious interpretations of women's activities started being developed, requiring gender separation in education and occupations. This change was partly due to Saudi Arabia's enormous oil wealth, which has made women's salaries less necessary for financially supporting families. The widespread acceptance of traditional stereotypical views about women has resulted in Saudi females being kept socially, politically, and commercially restricted. The powerful conservative tradition in Saudi Arabia favors continuing restrictions on women's activities (Abdul Razzak, 2016).

Pushing against this conservative force, there is a strong progressive force that has arisen in Saudi Arabia. This progressive influence encourages the Saudi government and society to depart from some ultra-conservative viewpoints, including those demanding gender separation and restrictions on women (Abdul Razzak, 2016). Defenders of increasing Saudi women's rights argue that the interpretation of the Qur'an as demanding segregated gender roles is based on Saudi cultural practices and reflects a patriarchal interpretation rather than what is actually contained in the text of the Qur'an (Alsuwaida, 2016). The progressive element has had some notable success in its efforts, including the fact that the government has lifted some of the restrictions on the settings in which women are allowed to work with men. This relatively new gender mixing in some areas of Saudi Arabian culture often results in women acting in ways that falsify traditional stereotypes. Men are sometimes put into situations where they have to replace old stereotypes about women with new viewpoints and expectations, and in some cases, they find themselves competing with women (Abdul Razzak, 2016).

In recent years, some initiatives for changing women's family roles to allow some freedom were started by King Abdullah before his death. In 2017, a royal decree loosened somewhat the guardianship rules (Alsubaie & Jones, 2017). These included an immense government-sponsored study-abroad program that included women. According to Manea (2013), King Abdullah is widely recognized as the major contributor to efforts to change Saudi family relationships and mitigate gender inequalities. For instance, the program of issuing national identity cards to women in 2006, allowing single women to rent hotel rooms without the approval of a "*mahram*" in 2008, and decrees allowing women to open their own business without permission from their relative men made in 2011 are key changes that provide some liberation for women from traditional family roles in Saudi society. As a consequence of these changes, the domination of men over women is currently somewhat reduced, with some females having a greater say in the running of their families. These changes have also affected decades-long restrictions in education.

Saudi Arabian Women in Education

One reason that Western studies concerning female STEM stereotypes and stereotype threat may not be totally applicable to Saudi Arabia is the unusual strength of female stereotypes in the Saudi culture. Traditional stereotypical views of women and their proper place in Saudi Arabian society has led to many limitations on their participation in Saudi public life and their opportunities in both education and work (Omair, 2017). For instance, the prohibition against the mixing of men and women in public includes the mixing of the sexes in education. Thus, at the primary and secondary levels, females and males are taught in separate schools (Alwedinani, 2017).

However, Saudi women were not exposed to any kind of education until 1956. In that year, after many attempts to formulate a law requiring education for both genders, females were finally brought into the light of education, though the education system was not the same for women and men (Yizraeli, 2012). Prior to the mid-1950s, Saudi females received only informal education. This generally consisted of girls being educated at home or at religious schools (Alharbi, 2014). The religious schools sometimes included other subjects in their curriculum consistent with girls learning skills to help them prepare for family life. In 1956, the first primary schools for girls were formed. From the beginning of formal education for girls in Saudi, teaching was based on traditional gender stereotypes that serve to justify systematic discrimination toward females that relegated them to learning only subjects compatible with their expected role in the family and society. These stereotypes were established from early childhood education, with males and females differentially treated within the context of primary education. From the first grade, female students in Saudi Arabia are told that it is the mother's job to cook and care for the family, for it is in the kitchen she can express her nobility as a woman (GPGE, 1981). To appease opposition to the decision to open early education to females, King Faisal named the Saudi head of religion to preside over a new institution dedicated to the education of girls. This institution was separate from the Ministry of Knowledge, which focused on the education of boys only (Alharbi, 2014). In 2002, these two educational ministries were combined. Even after, girls' education was severely limited, with classes focusing on gender-defined issues such as how to be a good wife and mother (Alsuwaida, 2016). Girls' classes were more narrowly defined and did not have the quality or range of boys' classes. In the years between 1990 and 2006, the percentage of girls relative to boys, across all levels of education (primary, secondary and tertiary), rose from 85.1% to 95.4%. The incidence of literacy in 15-24 year-old women also rose from 73.7% to 92.7% in the same period (UNDP, 2009).

In regard to higher education and beyond, women in Saudi Arabia have historically been limited by traditional stereotypes in the academic tracks and careers they are allowed to, or likely to, enter. For the most part, gender segregation continues at the college and university level. Institutions of higher education in Saudi Arabia were restricted to men only until 1979 (Altami, 2016). The focus on gender segregation in education, as in other aspects of Saudi life, is viewed by many as being derived from Sharia law and is justified as a requirement for keeping women safe (Al-Hariri, 1987). In the Saudi Arabian education system, women are segregated into certain educational pathways and are expected not to participate fully in the education sector (Bowen et al., 2015). This discrimination toward women in education is manifested by the existence of an educational philosophy that tends to favor the gender binary, with the society resisting virtually any change that might improve women's educational prospects by constantly applying a conservative argument that compatible with the religious and political ideological movement called "Al-Sahwa" that means "Awakening" in English; which emphasizes traditional institutional norms and beliefs. At the university level, the majority of women graduate with degrees in education, social science, and Islamic studies, with fields related to engineering and science considered to be primarily for males (Al-Munajjed, 2006; Hassan, 2000). This restriction to certain educational fields limits the occupational opportunities available to women. Based on survey data from 220 managers located across four cities in Saudi Arabia, Calvert and Al-Shetawi (2002) found that women's lack of training in technology-related subjects was limiting their job opportunities more than their personal preferences were.

However, in recent years, progress has been made in the opportunities for women to engage in higher education. In 1979, King Saud University in Riyadh was established as the first Saudi university for women. The university had colleges that offered courses in education, public administration, medicine, nursing, and dentistry (Alyami, 2016). In 2004, Princess Nora bint Abdul Rahman University for women was established in Riyadh, along with several other all-women universities in other regions of Saudi Arabia. Several co-educational universities have also been established, although in such universities men and women are still separated into two different campuses and have separate studies. The only fully gender-integrated university in Saudi Arabia, where women and men study and learn side-by-side, is King Abdullah University of Science and Technology, which began operating in 2009 (Alsubaie & Jones, 2017). Gradually, more schools were developed for girls and women, but it was not until the reign of King Abdullah bin Abdul Aziz from 2005 until his death in 2015 that more rapid progress in women's education began (Alsuwaida, 2016).

Today, the literacy rate for Saudi females is high, with Islam (2014) reporting the 2013 rate as being 97% for females. Women outnumber men in Saudi universities, with 58% of all Saudi tertiary students being women in 2012. The proportion of women to men students in higher education was 1.5 in 2009, higher than the ratios in the U.S, France, Germany, and Switzerland, which were 1.41, 1.27, 1.0, and 0.93, respectively (Islam, 2014). However, men outnumber women in the pursuit of higher university degrees beyond the bachelor's degree and outnumber women in university education in STEM fields, architecture, and agriculture (Islam, 2014). Furthermore, while there is an abundance of female teachers at the elementary and secondary levels of education, this is not true of tertiary education (Mirza, 2008).

Saudi Women in STEM Fields

The prohibition against gender mixing limits what is available to women in the form of tertiary education. The prohibition has historically limited the types of classes that females were allowed to take and the career tracks they were allowed to pursue in their education (Alharbi, 2014). For instance, there have been few female students pursuing a career in the engineering, manufacturing, or construction (EMC) fields in Saudi Arabia's public or private universities at either the undergraduate or graduate level.

El-Sherbeeny (2014) reported that EMC programs available to females at the undergraduate level number 12 in comparison to 114 such programs for males. At the graduate level, there were 20 EMC programs for females and 72 for males. During the span from 2007 to 2011, only 4,000 female engineers graduated from Saudi universities, compared to 66,000 male engineering graduates.

Due to the prohibition against gender mixing, a Saudi woman's ability to fulfill her desire to study in a certain field may depend on her father's view of "*Ikhtilat*" (Alwedinani, 2016, 2017). Some other Saudi women restrict their studies because they accept the prohibition against the mixing of sexes. Still others limit their studies because they feel uncomfortable around men due to their lack of experience in gender-mixed situations (Alwedinani, 2016).

Most Saudi women who graduate from university have a degree in education, social sciences, the humanities, or religion, and most female graduates are subsequently employed in the field of education, with teaching considered to be a very honorable profession in Saudi Arabia (Aldegether, 2017). However, the number of females enrolled in science and engineering has been increasing. In 2011, 72% of all tertiary science students and 9% of all tertiary engineering students were women (Islam, 2014). Yet, Saudi job openings for women in science and engineering fields remain relatively few, as these areas remain dominated by men. Partly as a result, female university graduates in Saudi Arabia experience high unemployment, with the rate for unemployed Saudi women being 34% in 2013. Over three-quarters of these unemployed women had university degrees. The main employer of women in Saudi Arabia continues to be the government, which hires women mainly in education. In contrast, the private sector employs only 5% of working Saudi women (Islam, 2014).

In a study to determine female Saudi university students' perceptions of how gender is associated with different categories of professions, Reda and Hamdan (2015) surveyed 80 female students from two Saudi universities and then conducted follow-up interviews. The results of the survey showed that most of the students associated males with most professions requiring a great deal of education, including being a scientist, a professor, and an expert of any kind. An exception to this trend was that only 3% of the students associated being a doctor with being a male, while 80% associated being a doctor with being female, and 17% indicated they associated being a doctor with both genders. The researchers explained the finding about the students' assessment of gender in the case of doctors to their experience of being treated by female, rather than male doctors. It seems that it is preferred for females to be treated by female nurses and doctors due to avoid mixing with men. This preference is not based on competence, but it is rooted in social and religious norms. Socially, it is not easy for women to communicate with men outside their families, and so they do not feel comfortable explaining their health problems and symptoms to male professionals. Religion also prioritizes women's modesty, and instructs that it is an important obligation. Reda and Hamdan (2015) suggested that the social experience of gender stereotyping present in a society in which there is a hierarchy of males over females played a larger part in the students' assessed organization of professional categories than their actual experiences in regard to the gender-makeup of various professions.

Recently, changes have occurred suggesting that there is a growing opportunity for Saudi women in STEM areas. El-Sherbeeny (2014) reported that in 2012, a public engineering program for females was instituted at King Abdulaziz University and that Effat University had established a partnership with Duke University in the U.S. to establish the first engineering program at a women’s university in Saudi Arabia. Also, the Saudi ARAMCO oil company was recently actively recruiting female engineers (El-Sherbeeny, 2014). Other indications of change include the fact that the percent of Saudi women in comparison to men studying the STEM subject of computer science in Saudi universities is greater than for the United States, the United Kingdom, and Sweden (Alghamdi, 2016, 2017). Women made up 45.8% of the computer science university students in Saudi Arabia in 2014, whereas the percentages for the other three countries were 14%, 16%, and 14% respectively. The relatively high proportion of women in computer science in Saudi Arabia compared to some other countries suggests that the stereotype that women are not as talented as men in STEM subjects may be weakening in the Saudi Kingdom at least in regard to the subject of computer science. This is also suggested by the finding that there were no significant differences in attitudes toward computing between male and female students in the capital city of Riyadh and that females were more positive than males about computers in outlying regions of the country.

Alghamdi (2017) conducted a study examining why females in Saudi Arabia enter computer science in their studies and as a profession. The researcher interviewed 10 female Saudi students enrolled in computer science courses in three Saudi universities. Alghamdi found that Saudi females were partly motivated to enter a computer science track in their universities because of the rapid expansion of technology. In addition, for most of the women, their families encouraged them to enter the computer science field. Also, a main motivation for seeking a career in computer science was the educational and occupational computer science environment in which the women could choose whether they do or do not work with men. Based on 2013 data provided by the Saudi Arabia

Ministry of Commerce, Alghamdi reported that 53% of Saudi women prefer a workplace in which they work with other women only.

Another study whose results suggest a weakening of stereotypes about the capabilities of females in STEM subjects among some Arab populations and possibly in Saudi Arabia was conducted by Kohan-Mass, Dakwar, and Dadush (2018). These researchers surveyed and interviewed 50 high school students (21 boys and 29 girls) studying advanced physics in an Arab high school in Israel. The researchers found that girls in the school were competitive and high achievers. The girls considered physics a prestigious study track that accepted only students with high grade averages. In middle school, more girls than boys fulfilled this requirement. The girls viewed advanced physics as a way to promote their acceptance to higher education programs such as medicine and engineering. The girls confided that their parents are concerned for their success more than for boys, because they are more worried about the girls' future. The fact that girls are not allowed out late contributes to their having more time to work on their studies. One result is that the Arab girls' averages in physics were above the boys' averages, with the gap increasing with age.

There are now a number of Saudi universities providing opportunities for women to enroll in academic tracks leading to the medical professions. However, there is evidence that women may not be wholly satisfied with the medical education they are receiving. In a study conducted by Hasan, Ibrahim, and Ali (2013) at Jazan Women's Medical Faculty, 40 third-year students were surveyed using the Dundee Ready Educational Environment Measure (DREEM). Results showed an overall score of 91.36 out of 200 possible. The researchers noted that the low scores occurred even though material resources and delivery systems at the university were advanced. They also noted that the overall score was lower than DREEM scores for most medical institutions in other countries, including India, Sri Lanka, Trinidad, Nepal, Nigeria, and the U.K. Other Saudi medical schools have also shown poor scores using the DREEM instrument (Hasan et al., 2013).

Gender-Mixing in Saudi Universities

A reason Western studies on female STEM stereotypes may not be applicable to Saudi Arabian women in higher education is that most female university students in Saudi Arabia study in women-only institutions. It is only in recent years that some co-ed universities have been established, though with men and women segregated into different campuses. Only King Abdullah's University of Science and Technology allows the two genders to go to the same classes (Alsubai & Jones, 2017). Therefore, while in the West, mixed-gender higher education is common, it is a relatively new and rare occurrence in Saudi Arabia.

Some female university students learn about mixed-gender academic settings by studying outside the Kingdom, as a Saudi government scholarship program for international study allows both women and men to pursue a college degree outside Saudi Arabia. About 42,000 Saudi students studied in other countries between 2004 and 2008 (Islam, 2014). In 2012, 19,000 Saudi females were studying at U.S. universities and colleges (Young & Clark, 2017). Research evidence suggests that getting used to mixed-gender educational settings is a challenge for some Saudi international students. Young and Clark (2017) focused on the acculturation experiences of 11 Saudi female graduate students studying at a U.S. university. The researchers found that issues of gender norms, expectations, and prejudices related to traditional Saudi cultural identity for women significantly affected the experiences of living in a non-gender-segregated society and a mixed-gender academic setting. In another study, Macias (2016) interviewed 11 Saudi Arabian women studying in a U.S. university, finding major themes of religion, family, academics, and transformation. In regard to academics, the women reported dealing with challenges such as experiencing an education system different from home. In regard to transformation, the women's interviews revealed that they had made transformations since studying in the U.S, including increased self-confidence and the wish to become a source of change when they returned to their communities in Saudi Arabia.

How gender mixing in Saudi higher education may affect stereotypical beliefs about women is unclear. Western studies have shown diverse results in regard to how education with mixed genders versus single genders is related to gender stereotypes. There has been evidence that, in mixed-gender educational settings, attitudes to subject areas become more gender-stereotyped (Smyth, 2010). In addition, some research suggests that girls do better in mathematics and science in single-gender settings (UNESCO, 2007). However, other research suggests that there is no significant difference in single-gender and mixed-gender schools in regard to preparation for STEM careers (Sikora, 2014), and there is evidence that boys' stereotypical views of girls are increased by single-gender schools (UNESCO, 2017). In Saudi Arabia, even though there now exist some mixed-gender higher education courses, no studies on female higher education students appear to have been done comparing Saudi mixed-gender to female-only university academic settings. It is possible that how stereotypes and stereotype threat affect Saudi women differs between those who study in mixed-gender compared to all-female classrooms.

In addition, very little research has been done on stereotype threat as it may affect Saudi women in their education or professions. Only one such study was located, which was conducted by Abdalla, Akkurt, and Rasheed (2017), who compared Saudi female and male first-year university students to determine their relative exam anxiety when taking an examination on a computer instead of on paper. Participants were 700 first-year students in a public university located in Eastern Saudi Arabia. More than three-quarters (529) were females and 171 were males, with the mean age being 18.5 years. The greatest number of students (367) were in the science track at the university, with 194 being in the engineering track and 139 being in the health track. To measure computer exam anxiety, Abdalla et al. (2017) used the Computerized Exam Anxiety Scale (CEAS). The researchers found that the female Saudi students had significantly greater computer examination anxiety than the male students. The researchers explained this difference between genders by suggesting that while they were taking the CEAS, the female students experienced a stereotype threat in the form of increased pressure to perform well in order not to confirm the negative stereotype that computers are mainly a masculine rather than a feminine domain. However, Abdalla et al. (2017) also found that several other variables affected the scores of the students on the CEAS, including familiarity and experience with computers and the academic track the students were taking at the university.

Interestingly, that gender stereotypes are so much more explicit in Saudi culture vs. mixed messages in Western cultures, and this could affect outcomes differently. For example, if women are more likely to internalize negative stereotypes about women abilities in Saudi culture, or if they are constantly exposed to overt stereotypes, exposing them to the negative stereotype might not be as threatening. Although some positive changes to women's empowerment that led by Saudi government, sociocultural roots that formed over decades in Saudi society may have a stronger psychological impact that limits the positive messages conveyed by the government to the new generation of women. It is likely that women's education in Saudi Arabia is influenced by the stereotypical image of women in the Saudi culture. Socially, women are dependents of the men who are close relatives in their families (father, husband, brother, and son). By socialization, Saudi women believe that mixing with men is heavily restricted. Therefore, segregation in schools and universities is socially acceptable. It is possible to say that with the gender socialization in Saudi society that supports and encourages the gender segregation, Saudi women may feel more comfortable to be in single-gender educational settings. In addition, it is likely this culture and the stereotypes within it have influenced women's choices of study majors—more female Saudi students opt for theoretical fields of study, where they do not need to interact with men in schools and work fields that are non-segregated environment. Although some changes to women's education, jobs, workplace, and policy have been observed in the country since 2004, the pace is very slow. One possible explanation for that is that education possibilities made accessible to women are in line with the norms of the tribal, male-dominated society, which are rooted and supported in strict, religious teachings that are difficult to overcome. As a result of these competing cultural factors, it is important to study the impact of positive and negative stereotypes about women in STEM classrooms based on whether the classroom is single or mixed gender to determine the best environment to promote women's success.

Hypotheses

The review of literature reveals that research has found stereotype threat to adversely affect female higher education students' performance in STEM subjects. The research suggests that this may be due to negative female stereotypes affecting women's self-perceptions, including their academic self-identity, self-efficacy, self-esteem, and sense of belonging. Studies also suggest that this threat may be countered by presenting a positive stereotype-relevant message to women. However, these studies were conducted primarily in Western cultures, and very little research has been conducted on how stereotype threat may affect females in Saudi Arabia. There are various important cultural differences between Saudi Arabia and Western countries, including the relatively collectivist instead of individualist society, the strong traditional and religious orientations of Saudi Arabia, the society's restrictions on the behavior of women, and the predominant single-gender system of education. Thus, the effects of female STEM stereotype may occur differently in Saudi Arabia compared to Western countries (Omair, 2017). Research is therefore needed on how stereotype threat affects females enrolled in STEM fields in higher education institutions in Saudi Arabia.

The purpose of this study was to determine how being exposed to stereotype threat is related to the academic science self-perceptions and academic performance (a mathematics test) of female STEM/medical students in a Saudi Arabian university. Possible correlations between stereotype threat and women's self-perceptions and academic performance were examined for both single-gender and mixed-gender classrooms. The study also examined how providing a positive statement discounting the female STEM stereotype affects female STEM/medical students' self-perceptions and academic performance.

The study have the following hypotheses:

Hypothesis 1a: (Main effect of reading a negative stereotype-threat, a positive stereotype about women's academic science ability on math performance): Due to some evidence showing that members of a stereotyped group performed poorer than they would if a stereotype threat was not present (Hively & El-Alayli, 2014; Kaye & Pennington, 2016; Rydell, Rydell, & Boucher, 2010), and due to some evidence showing that providing a group with a positive message before the group engages in a cognitive test counters the negative effect of a stereotype threat (Ngoma, 2018; McGlone and Aronson, 2007; Wheeler & Petty, 2001), I predicted that regardless of gender classroom type, participants will have the highest math scores after reading a positive statement on women's academic science ability, lowest scores after reading a negative statement on women's academic science ability.

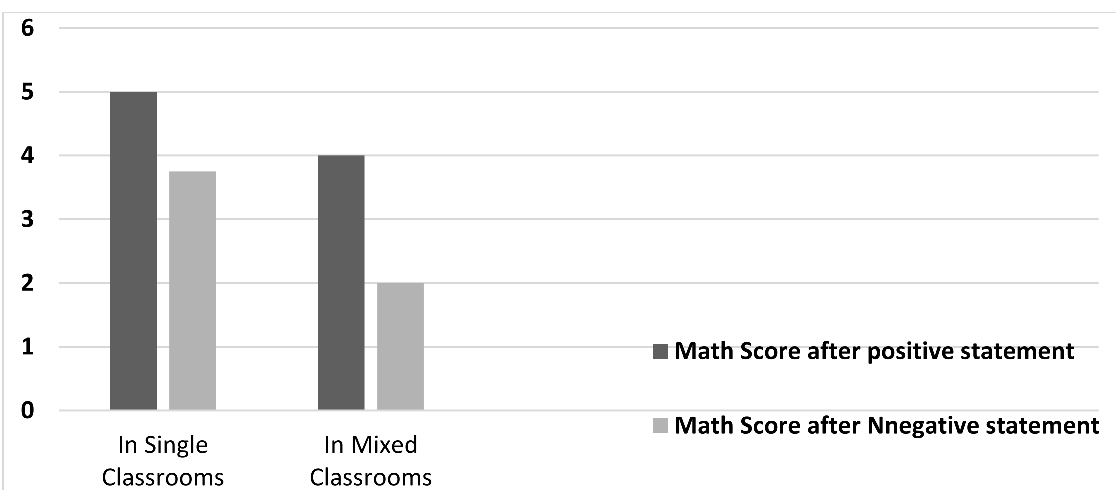
Hypothesis 1b: (Main effect of reading a negative stereotype-threat, a positive stereotype about women's academic science ability on academic self-perception): Given research suggesting that being exposed to stereotype threat may negatively affect women's academic self-perception (Deemer et al., 2014; Kray & Shirako, 2012), and given the common stereotype that asserts females have less academic ability than males in STEM fields (Cadaret, Hartung, Subich, & Weigold, 2017; Kite et al., 2008), I predicted that regardless of gender classroom type, women will have the highest level of academic science self-perceptions (science identity, science self-efficacy, beliefs about science, and overall science self-perceptions) after reading a positive statement on women's academic science ability, the lowest level of academic science self-perceptions after reading a negative statement on women's academic science ability.

Hypothesis 2a: (Main effect of gender classroom type on math performance): Due to some evidence showing that girls do better in mathematics and science in single-gender settings (UNESCO, 2007), and given to the stigma of gender mixing in Saudi Arabia, I predicted that regardless of statement read, women in single-gender classrooms will have higher math scores than women in mixed-gender classrooms.

Hypothesis 2b: (Main effect of gender classroom type on academic self-perception): given some evidence showing that students from single-sex schools are more gender-aware and more anxious in mixed-gender situations (Wong et al., 2018), I predicted that regardless of statement read, women in single-gender classrooms will have a higher level of academic science self-perceptions (science identity, science self-efficacy, beliefs about science, and overall science self-perceptions) than women in mixed-gender classrooms.

Hypothesis 3a: (Interaction between types of gender classroom and types of statement type on math performance): Because I expect single-gender classrooms to provide some protection from the effects of negative stereotypes, I predict that for women in single-gender classrooms, math scores will be high for those who read the positive statement, and moderate for those who read the negative statement. However, for women in mixed-gender classrooms, math scores will be high for those who read the positive statement, and low for those who read the negative statement. This pattern is depicted in Figure 1.

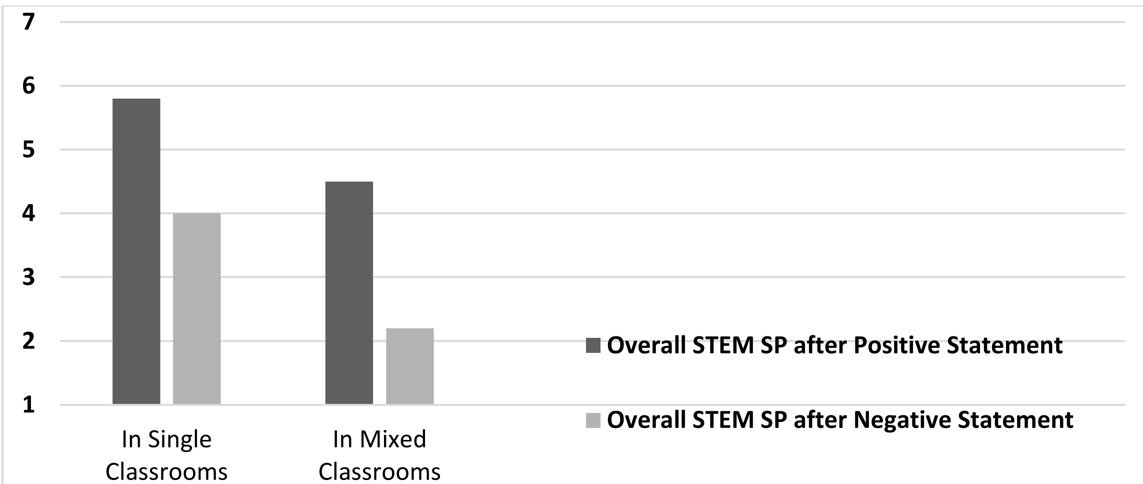
Figure *1: Hypotheses for math performance*



Hypothesis 3b: (Interaction between gender classroom and type of stereotype on academic science self-perception): For women in single-gender classrooms, level of

academic self-perceptions (science identity, science self-efficacy, beliefs about science, and overall science self-perceptions) will be high for women who read the positive statement and moderate for women who read the negative statement. However, in mixed-gender classrooms, academic self-perceptions will be high for those who read the positive statement, and low for women who read the negative statement. This pattern is depicted in Figure 2.

Figure *2: Hypotheses STEM self-perceptions*



Methods

Research Design

This research study employed a cross-sectional, between-groups, quantitative design to investigate how stereotype is related to the math performance and academic STEM self-perception of female Saudi university students. Variables included type of stereotype-relevant statement read by participants (a negative statement about women's science ability meant to trigger a stereotype threat, a positive statement meant to challenge stereotypes), type of classroom (single-gender only for women, or mixed-gender) in which participants study. Data were collected via a brief math test and a survey scale for academic science self-perceptions (science identity, science self-efficacy, beliefs about science).

Participants and Procedures

The sample size of the participants in this study were 634 female students. The participants were drawn from a population of undergraduate female students from STEM/medical majors from 4 universities located in the southern, western and central parts of Saudi Arabia (all large urban areas). These universities are different in type of gender classrooms and gender campuses. The first type of university accepts both genders to enroll in a variety of academic majors including STEM, but men and women study in separate campuses. That means male students attend campuses and classrooms that are only for men, and women attend campuses and classrooms that only for female students. However, in some majors such as medical sciences and health care, and in some introductory courses, men and women can be in mixed gender classrooms for academic training purposes. In some situations, is due to limited investment, the college's capacity, or the numbers of faculty in such majors. The participants from the first type of universities (two universities) were 383 women students. The second type of university accepts only women to enroll. That means the campuses and the classrooms are only for women and no men are allowed. The second type of the universities includes STEM majors and other different academic majors. There was one university from the second type and the number of the participants were 127 women students. The third type of the university accepts both genders to enroll, and the campuses and classrooms are totally mixed-gender. The third type of the university includes only STEM majors. There was one university of the third type and the number of participants were 124 women students.

The age range of study participants was between 19 and 26 years (*M* = 21.49, *SD* = 2.04 years). Participants' class ranks included freshmen, sophomores, juniors, and seniors. Participants from single classroom-type were 320, and 324 female students were from mixed-gender classrooms. Participants from each classroom-type group were randomly assigned to two statement-reading groups: a stereotype-threat statement, and a positive stereotype statement.

Data were collected in a classroom context. The data-collection for each classroom used the same procedures.

First, a request to do the study was sent to the target university's administration. After approval, the study conducted in mixed-gender and single-gender university classrooms.

The data-collection procedures for each classroom started with an explanation to the participants the nature of the study, and asked them for voluntary consent. Students took an opportunity to read the Consent Form and then the main points summarized to them by the investigator. The researcher then asked questions regarding the procedure and their rights to insure they understand the research (see Appendix A, B). The type of the survey is paper and pencil. Therefore, all the participants received a paper version of the survey.

Second, the researcher randomly distributed the negative and positive versions of the anonymous surveys within the gender groups. In each classroom (only women vs. mixed gender), the investigator brought an envelope that includes 40 corners clipped surveys. All the envelops were already prepared by putting a survey that contains negative statements followed by a survey that contains positive statements. Thus, each envelop contains similar numbers of the two types of the surveys (20 negative, 20 positive) that arranged within each envelop one by one. All the surveys include the same information and same amount of pages. The only deference is that some surveys were with same text of negative statement about women's stereotype in STEM, and some surveys were with same text of positive statements about women's stereotype in STEM. Extra envelopes were available in case any class has more than 40 students. In the mixed gender classrooms, the same operation has been used to distribute the surveys. However, because there are male students in the mixed gender classrooms, other envelopes for men includes the same surveys have distributed to male students. Although men students are not the target sample for the study, however; asking them to participate in the study were an important condition for the quality of the experiment. Asking men students in the same mixed gender class to participate were required to achieve the goal of the experiment by exposing women to a stereotypical image of their ability in science compared to men (same, or worse) in a mixed classroom, and then ask them to answer the same math question.

The participants were asked to read the statement (negative or positive) in the first page. These statements included manipulated information about the academic performance in STEM of men and women in Saudi Arabia to trigger positive or negative stereotypes for the purpose of this research. Each student was given a summary of "research" that has been conducted regarding gender in STEM fields (with findings fabricated for the purposes of this research). In each classroom, half of the classroom received a summary that I created showing that women are not as good as men in STEM fields, and the other half read a summary that I created showing that woman are just as good as men in STEM fields. After reading the statements, the participants turned the page; then they were asked to answer some questions related to the statements to ensure that those who received the negative and the positive statements actually read it.

Third, all participants were asked to answer six math questions in ten-minute only. Using the stopwatch, students have only ten minutes to answer the math test.

Fourth, a brief survey was administered to all participants in all classrooms to measure academic STEM self-perception with three subscales (science identity, science self-efficacy, and science beliefs), and basic demographic questions. In the last page, administered to all participants in all classrooms a demographic questionnaire (gender, academic major, GPA, academic year/university rank.

Fifth, at the end of the survey, participants were completely debriefed about the nature of the research, the experimental manipulation (that false information was provided to trigger stereotypes), and the benefits of the research. In addition, participants were encouraged to ask any questions that they might have. They also received a debriefing sheet with the researcher's contact information in the event they have further questions (see Appendix C).

Finally, the investigator collected the completed questionnaires and surveys. The entire data-collection procedure took approximately 30 minutes for each class.

The entire procedures, scales, and materials (including info sheet, instructions and debriefing) were given in Arabic.

Measures

Independent Variables

There were two independent variables for the study. One of the independent variables was the type of classroom participants study in. There are two values for this variable: single-gender and mixed-gender. The second independent variable were stereotype statement type. This variable have two values: stereotype threat and positive stereotype. The stereotype-threat statement was be the following:

> "In this study, we are investigating academic performance in STEM fields. Research has been carried out in many countries across the world (America, Europe, and Asia) regarding the academic ability of women in scientific fields (science, engineering, technology, mathematics, medicine, and health sciences) (Global Gender Gap Report, 2007). The results are not positive. Research indicates that women appear to have less ability in these fields. They are more likely to evaluate the difficulty level of these fields as "challenging" (76.70% for women, and 42.23% for men), and women are less likely than men to successfully complete degrees in scientific and medical majors (53.25% for women, and 71.23% for men). These global results are consistent with studies that were carried out very recently (2014-2018) in Saudi society. Despite the opportunities and encouragement given to women in Saudi Arabia to engage in scientific fields, research in Saudi Arabia shows that women are more likely to perceive scientific majors and classes as "difficult" than men, and more likely to drop out or change majors, and less likely to complete degrees in scientific and medical majors, than men in Saudi Arabia (Al-Gahtani, 2015). Also, the results show women need extra training to develop their academic skills and abilities".

The positive stereotype statement was the following:

> "In this study, we are investigating academic performance in STEM fields. Research has been carried out in many countries across the world (America, Europe, and Asia) regarding the academic ability of women in scientific fields (science, engineering, technology, mathematics, medicine, and health sciences)

(Global Gender Gap Report, 2007). The results are very positive. Research indicates that women appear to have equal ability in these fields. They are just as likely to evaluate the difficulty level of these fields as “challenging, but can be achieved” (68.18% for women, and 70.42% for men), and women and men are equally likely to successfully complete degrees in scientific and medical majors (82.41% for women, and 79.23% for men). These global results are consistent with studies that were carried out very recently (2014-2018) in Saudi society. After the opportunities and encouragement given to women in Saudi Arabia to engage in scientific fields, research in Saudi Arabia shows that women are equally likely to perceive scientific majors and classes as “less difficult” as men, and equally likely to stay in science majors, and successfully complete degrees in scientific and medical majors, as men in Saudi Arabia (Al-Gahtani, 2015). Also, the results show women have good academic skills and abilities in scientific fields.”

Dependent Variables

The dependent variables of the study are math test score, and academic science self-perception (science identity, science self-efficacy, and science beliefs). The math test scores were measured using items from the math section of the Graduate Record Exam (GRE) developed by the Educational Testing Service. The GRE is a standardized test that is used to measure basic some abilities that related to graduate school performance such as verbal reasoning, problem-solving ability, critical thinking, and analytical writing skills (Educational Testing Service, 2015). Using questions that are derived from the GRE to measure academic performance is common in the stereotype threat and performance literature because the task needs to be challenging (e.g., GRE vs. SAT) in order to produce stereotype threat results (Rodriguez, 2014; Clark, Eno, & Guadagno, 2011; Steele & Aronson, 1995).

The math test scores were measured by six multiple-choice quantitative questions that derived from the Graduate Record Exam (GRE) (Kaplan, 2011). These six multiple-choice quantitative questions were used previously to measure academic performance and self-efficacy under stereotype threat (Holmes, 2017). Using the six GRE multiple-choice quantitative questions met the condition of high level of difficulty of the academic test under a threat experiment/condition, and also unable me to administer the test in the expected time to finish the whole survey. If the student answered a question wrong, it was coded as 0. If the student answered a question right, it was coded as 1. Possible scores ranged from a minimum score of 0 and a maximum score of 6. Average math scores were calculated for each study condition.

The academic STEM self-perception were determined based by a 33-item scale used by Cole (2012). Participants were asked to respond to each item indicating their level of agreement with the statement on a 7-point scale where 1 = *totally Disagree* and 7 = *totally Agree*. Scores above the midpoint indicate positive agreement with science self-perception. Six of the items have been reverse-scored (see Appendix D). These items are number 6, 23, 25, 30, 31, and 32. The overall results for academic science self-perception were from the three subscale (science identity, science self-efficacy, and science beliefs).

The *science identity* subscale reflects the idea that the student feel herself a "science type person," and being in science practises is a part of her identity. The 11-item subscale includes statements such as "*I think of myself as a science person", "Science has an important impact on my life."*

The *science self-efficacy* subscale reflects the idea that the student beliefs that she able to learn science content and beliefs in her ability to achieve successfully her academic goals in her science major despite the level of the difficulty. The 10-item subscale includes statements such as "*when I try really hard, I am able to learn even the most difficult science content", "If I try hard enough, I can obtain the academic goals I desire in science."* One of the items was reverse worded and coded; "*I could never be a successful scientist"*.

The *science belief* subscale reflects the idea that of student's feelings and beliefs about studying and practising in science, who can do it, and its applications in in the life. The 12-item subscale includes statements such as "*There are many good careers that use science", "Science is fun."* Five of the items was reverse worded and coded, such as "*Science is boring."*

Data Analysis

First, data were prepared for analysis by testing each case for any acquiescence bias or extreme responding where participant has completed all the survey items with the same response (Peer & Gamliel, 2011). Two responses biases were discovered in the data, and they have been removed. Frequency tables and descriptive statistics were used to summarize the study variables. Table 1 summarized the categorical study variables. The total sample size of the study was 634. Table 1 summarized the categorical study variables. All participants were females. About half of the participants (320 students) were in single-gender classroom (50.5%), and there were 314 female (49.5%) in the mixed gender classrooms. Students who received the negative stereotype about women's ability in science were 322 (50.8%), while there were 312 students (49.2%) who received the positive statements about women's ability in science (Table 1).

Table 1

Classroom Type and Stereotypes about Women in Science

		N (%)
Gender	Female	634 (100.0)
Classroom type	Single-gender	320 (50.5)
	Mixed-gender	314 (49.5)
Stereotype about women in science	Negative	322 (50.8)
	Positive	312 (49.2)

The Cronbach's alpha measure was used to determine the internal reliability of the completed surveys. The results of Cronbach's alpha analysis for scale = 0.89. The mean for each individual in each group was determined for all items on each of the surveys. Also, the score on the math test was determined for each individual in each group. Average means on the math test then were determined for each group. Because larger sample size can make p-value smaller, it is maybe helpful to determine the minimum number of subjects that are enough to be included to find the effects in the experiment. Therefore, sample the size has been determined using G*Power, a software that helps in determining appropriate sample size (Aguirre-Urreta & Rönkkö, 2015). Thus, I used G*Power version 3.1.9.4 to run the power analyses, with power (1 - β) set at 0.80. The results of the power analysis referred to 126 participants. Testing of hypotheses was performed by using ANOVA, and the .05 level was used for statistical analysis.

Results

Hypothesis 1A predicted that there would be a main effect of the types of stereotype about women's science ability (stereotype threat vs. positive stereotype) on math scores. I predicted that participants will have the highest math scores after reading a positive statement on women's academic science ability, and lowest scores after reading a negative statement on women's academic science ability. I ran analysis of variances (ANOVA). The results indicated that the main effect of receiving different types of stereotype was statistically significant $F(1, 632) = 1455.47$, $p < .001$, $\eta_p^2 = .698$. Regardless of classroom type, the mean math test score for women exposed to a negative stereotype regarding women's academic science ability was statistically significantly lower ($M = 1.11$, $SE = .44$) than women exposed to a positive stereotype regarding women's academic science ability ($M = 3.52$, $SE = .45$). Thus, I concluded that the effect of stereotype on math scores were different based on the type of stereotype about women's science ability (stereotype threat vs. positive stereotype). Therefore, there was support for Hypothesis 1A.

In Hypothesis 1B, I predicted there would be a main effect of types of stereotype about women's science ability on academic self-perception. I predicted that women will have the highest level of academic self-perceptions (science identity, science self-efficacy, beliefs about science, and the overall of academic self-perceptions) after reading a positive statement on women's academic science ability and the lowest level of academic self-perceptions after reading a negative statement on women's academic science ability.

I ran analysis of variances (ANOVA). In term of science identity as the first subscale dependent variable, the results indicated that the main effect of stereotype was statistically significant $F(1, 632) = 269.30$, $p < .001$, $\eta_p^2 = .299$. Regardless of gender classroom type, the mean score of science identity for women exposed to a negative stereotype regarding women's academic science ability was statistically significantly lower (*M* = 5.09, *SE* = .22) than for women exposed to positive statements regarding women's academic science ability (*M* = 5.60, *SE* = .22). Thus, I concluded that the level of science identity was affected by the type of stereotype women's academic science ability (stereotype threat vs. positive stereotype). Therefore, there was support for Hypothesis 1B in term of science identity.

Regarding to science self-efficacy as the second dependent variable, the results indicated that the main effect of stereotype on self-efficacy was statistically significant $F(1, 632) = 2263.61$, $p < .001$, $\eta_p^2 = .782$. Regardless of gender classroom type, the mean score of self-efficacy for women exposed to the negative stereotype regarding women's academic science ability was statistically significantly lower (*M* = 3.76, *SE* = .28) than for women who read a positive article regarding women's academic science ability (*M* = 5.69, *SE* = . 29). Therefore, the result supported that the level of science self-efficacy for women's college students in STEM was affected based on the type of stereotype women's academic science ability (stereotype threat vs. positive stereotype). Thus, there was support for Hypothesis 1B in term of science identity.

In term of beliefs about science as the third subscale dependent variable, the results indicated that the main effect of stereotype was statistically significant $F(1, 632) = 400.38$, $p < .001$, $\eta_p^2 = .389$. As a function of the types of women's science stereotypes (stereotype threat vs. positive stereotype), and regardless of gender classroom type, the mean score of beliefs about science for women who read an article with a negative stereotype regarding women's academic science ability was statistically significantly lower (*M* = 5.27, *SE* = .18) than women who read a positive article regarding women's academic science ability (*M* = 5.79, *SE* = .18).

For the overall science self-perceptions as the dependent variable that includes the three subscales (science identity, science self-efficacy, and beliefs about science), the results indicated that the main effect of stereotype was statistically significant $F(1, 632) = 1849.03$, $p < .001$, $\eta_p^2 = .750$. As a function of the types of women's science stereotypes, and regardless of classroom type, the mean score of the academic self-perception for women exposed to a negative stereotype regarding women's academic science ability was statistically significantly lower ($M = 4.75$, $SE = .15$) than women who read a positive article regarding women's academic science ability ($M = 5.69$, $SE = .15$). Therefore, Hypothesis 1B was supported.

Hypothesis 2A predicted that there would be a main effect of gender classroom type (classes only for women vs. mixed gender classes) on math performance. I predicted that women in single-gender classrooms will have higher math scores than women in mixed-gender classrooms. To test this, I used the analysis of variances (ANOVA). The results indicated that the main effect of gender classroom's type was statistically significant $F(1, 632) = 21.68$, $p < .001$, $\eta_p^2 = .33$, but results indicated the opposite of what was predicted. Contrary to my prediction, the mean math test score for women in single-gender classrooms was statistically significantly lower ($M = 2.17$, $SE = .45$) than the scores of women in mixed-gender classrooms ($M = 2.47$, $SE = .45$). Therefore, the result supported that the level of math performance for women college students in STEM was affected by the type of gender classrooms (single-gender classroom vs. mixed-gender classrooms). However, for women in STEM, it is most likely that the environment of mixed gender classes has a positive impact on math performance more than the single classes that only have women. Thus, Hypothesis 2A was not supported in term of math performance based on gender classroom type.

Hypothesis 2B predicted there would be an effect of gender classroom type (classes only for women vs. mixed gender classes) on academic self-perception. I predicted that women in single-gender classrooms will have a higher level of academic self-perceptions (science identity, science self-efficacy, beliefs about science, and the overall of science self-perceptions) than women in mixed-gender classrooms.

ANOVAs were conducted to investigate the hypotheses. With regard to science identity, the results indicated that the main effect of gender classroom type was statistically significant $F(1, 632) = 6.49$, $p = .001$, $\eta_p^2 = .10$, but in the opposite direction. Contrary to my prediction, the mean score of science identity for women in single-gender classrooms was statistically significantly lower ($M = 5.31$, $SE = .22$) than women in mixed-gender classrooms ($M = 5.39$, $SE = .22$). Thus, I concluded the results referred that the level of science identity for women college students in STEM was different based on gender classroom type (classes only for women vs. mixed gender classes). However, the results were the opposite of what was predicted. The results suggested that mixed gender classes have positive impact on science identity for women students in STEM more than the single classes that only for women. Thus, the results did not support Hypothesis 2B for science identity.

Regarding science self-efficacy, the results indicated that the main effect of gender classroom type was statistically significant $F(1, 632) = 53.72$, $p < .001$, $\eta_p^2 = .79$, but in the opposite direction. The mean score of science self-efficacy for women in single-gender classrooms was statistically significantly lower ($M = 4.58$, $SE = .28$) than women in mixed-gender classrooms ($M = 4.88$, $SE = .29$). The results referred that the level of science self-efficacy for women college students in STEM was affected by the type of gender classroom type (classes only for women vs. mixed gender classes).

However, the results suggested that mixed gender classes have positively affected the science identity for women students in STEM more than the single classes that only for women. Thus, the results did not support Hypothesis 2B regarding science self-efficacy.

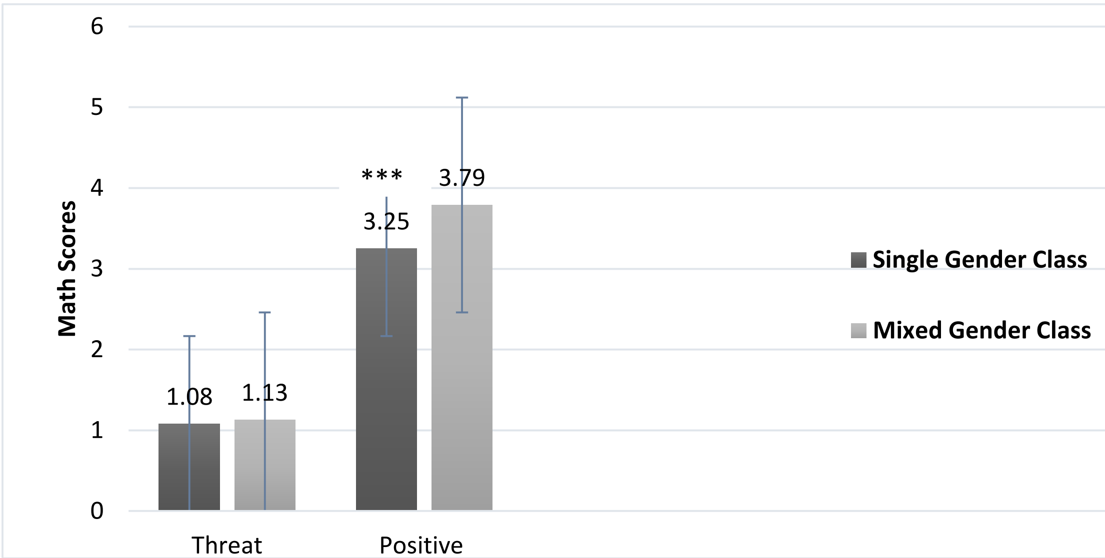
For the beliefs about science (the dependent variable) as the subscale of academic self-perceptions, the results indicated that the main effect of classroom type was not statistically significant $F(1, 632) = .002$, $p = .963$, $\eta_p^2 = .000$. The mean score of beliefs about science was not statistically significantly different between women in single-gender classrooms ($M = 5.53$, $SE = .018$) and women in mixed-gender classrooms ($M = 5.52$, $SE = 0.018$). However, all means were above the midpoint indicating strong positive beliefs about science. Thus, I concluded that women college students in STEM were highly similar in their beliefs about science in both gender classroom types (classes only for women and mixed gender classes). There was no support for the predication that women students in single-gender classrooms would have a higher level of academic self-perceptions (beliefs about science). Therefore, there was no partial support for hypothesis 2B regarding beliefs about science.

For the overall academic STEM self-perceptions, the results indicated that the main effect of the classroom type was statistically significant $F(1, 632) = 28.755$, $p < .001$, $\eta_p^2 = .044$, but once again in the opposite direction. The mean score of overall academic self-perception was statistically significantly lower for women in single-gender classrooms ($M = 5.16$, $SE = .015$) compared to women in mixed-gender classrooms ($M = 5.28$, $SE = .015$). The results referred that the levels of academic self-perception for women's college students in STEM were affected by the gender classroom type (classes only for women vs. mixed gender classes). The results suggested that studying science in mixed gender classes positively affected the academic STEM self-perceptions for women students in STEM more than women students in single classes that are only for women. Thus, the results did not support Hypothesis 2B on academic self-perceptions. However, all means for the three subscales and the mean of the overall academic self-perceptions were above the midpoint (four) indicating strong overall positive science perceptions among the women students.

In Hypothesis 3A, it was predicted that there would be an interaction between gender classroom type (single classes only for women vs. mixed gender classes) and the type of stereotype about women's academic science ability (stereotype threat vs. positive stereotype) on math performance as the dependent variable. I predicted that for women in single-gender classrooms, math scores would be highest for those who read the positive statement about women's ability in science, and lower for those who read the negative statement; however, for those in mixed-gender classes, the scores will be moderate for those who read the positive stereotype and lower for those who read the negative stereotype. The results of the tests of between-subjects effects for ANOVA indicated that the interaction effect between gender classroom type and type of stereotype was statistically significant, indicating the effect of the article (stereotype threat vs. positive stereotype) depended on the gender classroom type $F(1, 632) = 14.08$, $p < .001$, $\eta_p^2 = .022$. In Figure 3, the results showed that in stereotype threat experiment condition women scored equally low in the math test regardless the type of gender classrooms. They scored low when they were in single classes ($M = 1.08$, $SE = .063$), and the women in mixed gender classes also scored low ($M = 1.14$, $SE = .063$). However, the results Figure 3 showed that in the positive stereotype experiment condition, women who were in mixed-gender classrooms scored significantly higher in math test score ($M = 3.79$, $SE = .064$) compared to the women who in single-gender classrooms ($M = 3.25$, $SE = .063$).

Thus, there was partial support for Hypothesis 3A, the effects of article were moderated by classroom type, but in the opposite direction predicted.

Figure 3: Means of the interaction of math test score by classroom type and stereotype

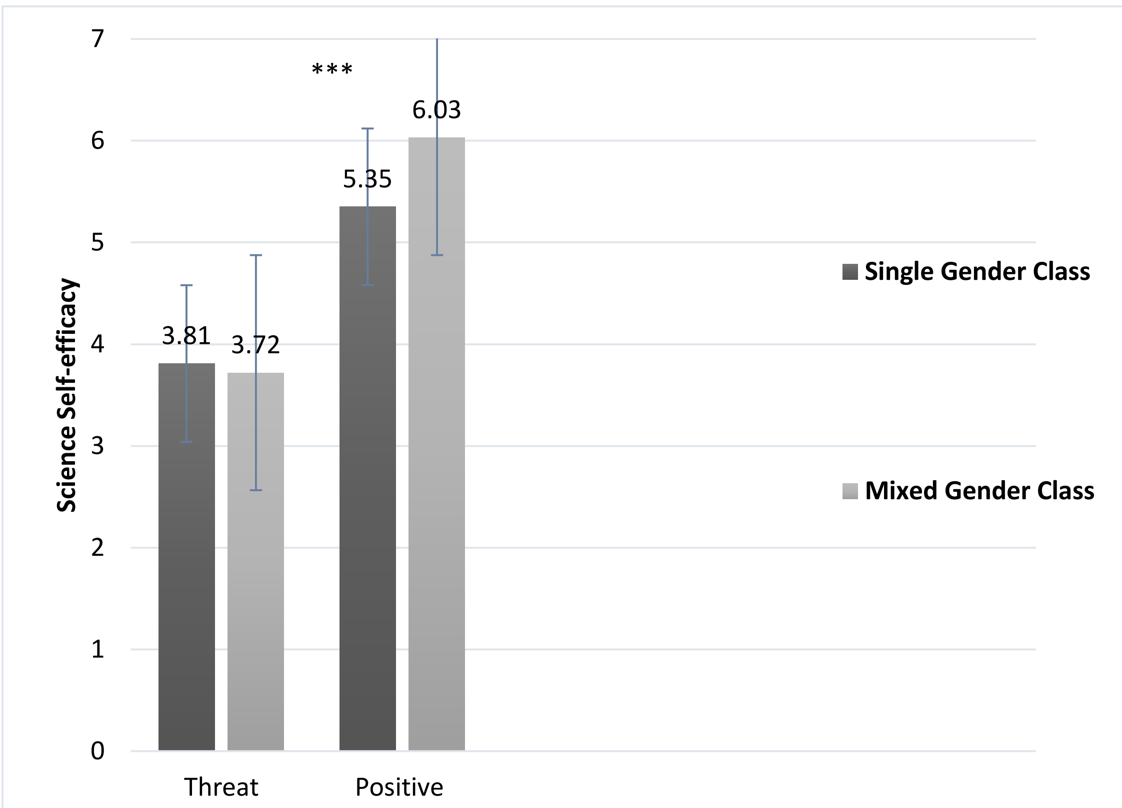


In Hypothesis 3B, it was predicted that there would be an interaction between gender classroom type (single classes only for women vs. mixed gender classes) and the type of stereotype about women's science ability (stereotype threat vs. positive stereotype) on academic self-perception. I predicted that for women in single-gender classrooms, level of academic self-perceptions (science identity, science self-efficacy, beliefs about science, and the overall of the academic self-perceptions) will be highest for women who read the positive statement about women's academic science ability and lower for women who read the negative statement. However, in mixed-gender classrooms, academic self-perceptions will be moderate for those who read the positive statement, and low for women who read the negative statement. To test that, I used the between-subjects effects ANOVA.

For science identity as a dependent variable, the results indicated that the interaction effect of gender classroom type and stereotype about women's academic science ability was not statistically significant, indicating the effect of stereotype's threat did not depend on the classroom type $F(1, 630) = 2.38$, $p = .123$, $\eta_p^2 = .004$. In other words, the mean difference in score of science identity between the two stereotype conditions was not statistically significantly different based on the classroom type. The results showed that for women in threat experiment conditions, women scored above the midpoint (four) in science identity in both types of gender classrooms (single vs. mixed). Students in single classes scored above the midpoint (four) ($M = 5.08$, $SE = .031$), and scored above the midpoint in mixed gender classes ($M = 5.11$, $SE = .031$). Nevertheless, there was not significant interaction effect of gender classroom type and stereotype about women's academic science ability, the results showed that women who exposed to positive stereotype experiment condition scored higher overall. Women who exposed to positive stereotype in mixed classrooms scored ($M = 5.66$, $SE = .031$) compared to the women who exposed to positive stereotype in single gender classrooms ($M = 5.54$, $SE = .031$).

Regarding science self-efficacy, the results indicated that the interaction effect of gender classroom type and stereotype about women's academic science ability was statistically significant, indicating the effect of stereotype threat depended on the classroom type $F(1, 630) = 89.68$, $p < .001$, $\eta_p^2 = .125$. In Figure 4, the results showed that for women in threat experiment conditions, they were statistically significantly lower in science self-efficacy regardless of the type of gender classrooms. They scored below the midpoint (four) in science self-efficacy when they were in single classes ($M = 3.81$, $SE = .040$), and scored low in mixed gender classes ($M = 3.72$, $SE = .040$). However, the results in Figure 4 showed that women who were exposed to the positive stereotype experiment condition scored highest overall. However, there was significant difference across the type of gender classrooms. Women exposed to positive stereotypes in mixed classrooms scored significantly higher in science self-efficacy (*M* = 6.03, *SE*= .040) compared to the women exposed to positive stereotype in single gender classrooms (*M* = 5.35, *SE*= .041).

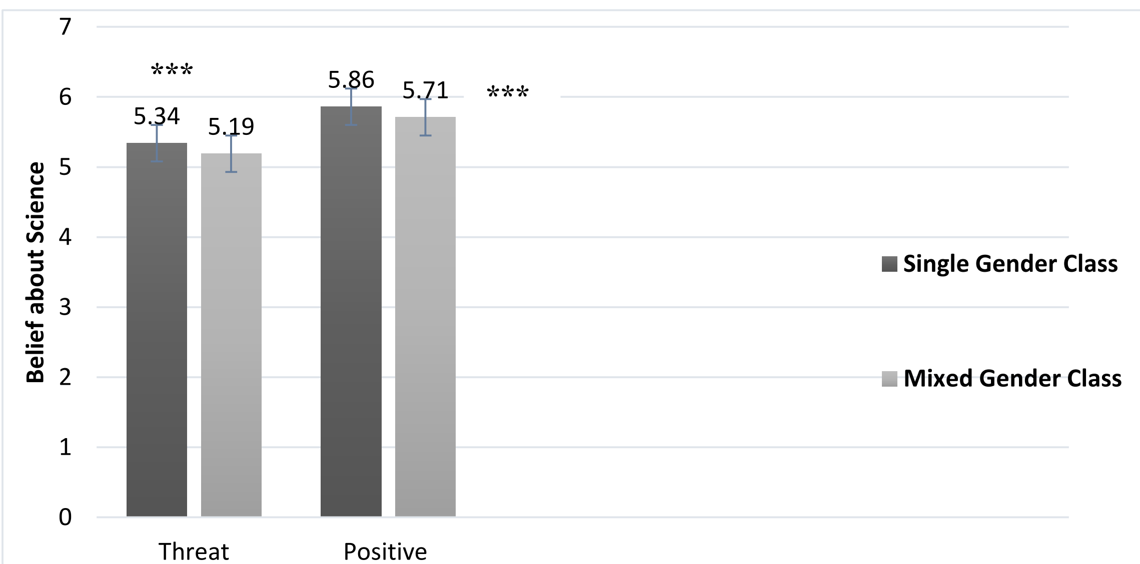
Figure 4: Estimated means of the interaction of science self-efficacy score by classroom type and stereotype.



For the belief about science as the third dependent variable, the results indicated that the interaction effect of gender classroom and stereotype about women's academic science ability was statistically significant, indicating the effect of stereotypes about women's academic science ability depended on the classroom type $F(1, 630) = 33.98$, $p <$

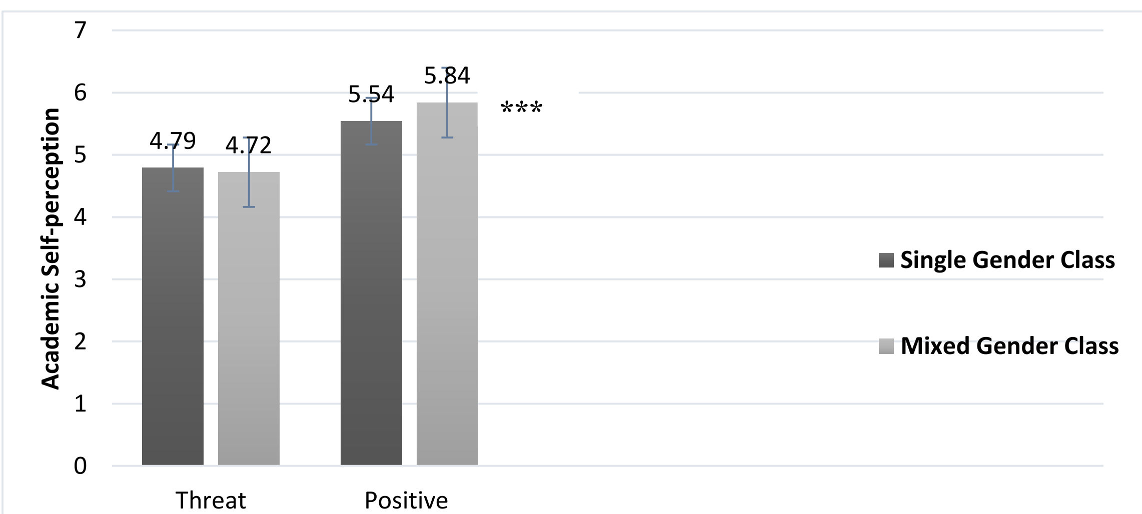
.001, η_p^2 = .051. In Figure 5, the results showed that in threat experiment condition, women were statistically significantly lower in belief about science even though they scored equally above the midpoint in both types of gender classrooms (single vs. mixed). Women scored above the midpoint (four) in belief about science when they were in single classes (*M* = 5.34, *SE*= .025), and scored above the midpoint in mixed gender classes (*M* = 5.19, *SE* = .026). However, the results in Figure 5 showed that women who exposed to positive stereotype experiment condition scored significantly higher overall. Nevertheless, there was significant difference across the type of gender classrooms. Women who exposed to positive stereotype in mixed classrooms scored significantly higher in belief about science (*M* = 5.86, *SE*= .026) cumbered to the women who exposed to positive stereotype in single gender classrooms (*M* = 5.71, *SE*= .026).

Figure 5: Estimated marginal means of the interaction of belief about science score by classroom type and stereotype.



For the overall academic self-perceptions dependent variable, the results indicated that the interaction effect of gender classroom type and stereotype about women's academic science ability was statistically significant, indicating the effect of stereotype depended on the classroom type $F(1, 630) = 75.226$, $p < .001$, $\eta_p^2 = .107$. In Figure 6, the results showed that in the threat experiment condition, women were statistically significantly overall lower in academic self-perceptions despite scoring equally above the midpoint in both types of gender classrooms (single vs. mixed). Women scored above the midpoint (four) in academic self-perceptions when they were in single classes ($M = 4.79$, $SE = .021$), also scored above the midpoint in mixed gender classes ($M = 4.72$, $SE = .021$). However, the results in Figure 6 showed that women exposed to the positive stereotype experiment condition scored significantly higher overall. Nevertheless, there were significant differences across the type of gender classrooms. Women who were exposed to positive stereotypes in mixed classrooms scored significantly higher in academic self-perceptions ($M = 5.84$, $SE = .022$) compared to women exposed to positive stereotypes in single gender classrooms ($M = 5.54$, $SE = .022$). In consistent with the results of all subscales academic self-perceptions, the patterns were found in the result of academic self-perceptions is a bit different from what I predicted.

Figure 6: Estimated means of the interaction of academic science self-perception score by classroom type and stereotype.



Discussion

The goal of this study was to investigate how exposure to a stereotype threat, compared to exposure to a positive statement about women's science ability (that women are just as skilled as men), influences academic performance (in terms of math test results) and self-perceptions in science (in terms of science identity, science self-efficacy, belief about science, and overall academic self-perception) for women STEM/medical students at university in Saudi Arabia. The women were exposed to either the stereotype threat or the positive statement about women's science ability before taking the math test and completing scales to measure science self-perception. In addition, it was investigated whether academic performance and academic self-perceptions would differ across types of gender classroom—single-gender compared to mixed-gender classrooms. There is a dearth of research regarding gender stereotypes in general within Saudi Arabia—despite having rigid gender roles—and consequently there is limited data available about the specific stereotypes of Saudi women in STEM.

I had three sets of hypotheses, with two hypotheses in each set. In the first set, I hypothesized that the participants will have the highest math scores (H1A) and highest science self-perception scores (H1B) after reading a positive statement about women's academic science ability and the lowest scores after reading a negative statement about women's academic science ability. The results of the study supported Hypothesis 1A, with the students exposed to a positive stereotype scoring higher on a math test than students exposed to a negative stereotype. This finding is consistent with previous findings in which members of a stereotyped group produced results poorer than they would if a stereotype threat was not present (Hively & El-Alayli, 2014; Kaye & Pennington, 2016; Rydell, Rydell, & Boucher, 2010). The results of the study are also consistent with research finding that providing a group with a positive message before the group engages in a cognitive test counters the negative effect of a stereotype threat (Ngoma, 2018; McGlone and Aronson, 2007; Wheeler & Petty, 2001).

There is evidence that the finding that exposure to stereotype threat led to reduced performance on a math test for Saudi university women who were, in comparison to those who were not, exposed to stereotype threat is linked to the common stereotype that females have less academic ability than males in STEM fields (Cadaret, Hartung, Subich, & Weigold, 2017; Kite et al., 2008). Some of these negative stereotypes are still present in the world academic scene, where women do not find educational and professional opportunities in science (UNESCO, 2017; Mertus & Flowers, 2017). From early in their childhood, girls often become aware of this widespread stereotype and become socialized to believe that they have less ability than boys in STEM subjects and that STEM fields are “masculine” rather than “feminine” subjects. (Nosek et al., 2009; Tiedemann, 2000; UNESCO, 2017). Based on their awareness of the stereotype that females are less able than males in math and other STEM fields, women who are exposed to a stereotype threat tend to produce poorer results than those who are not exposed to such a threat (Hively & El-Alayli, 2014; Kaye & Pennington, 2016).

Research suggests that the stereotype threat may act as a stressor that undermines a woman’s performance on a STEM-related task (London, Downey, Romero-Canyas, Rattan, & Tyson, 2012; Nguyen & Ryan, 2008). Furthermore, a stereotype threat may reduce an individual’s cognitive resources by increasing anxiety, negative thinking, and mind-wandering. The effort to suppress negative thoughts may also undermine cognitive performance (Pennington, Heim, Levy, & Larkin, 2016). Research also suggests that stereotype threat may undermine mathematics test results by reducing working memory resources that are important for problem solving math tests (Beilock, Rydell, & McConnell, 2007). The results of these previous studies suggest that in this study, stereotype threat may have reduced math test performance by increasing the women's stress, reducing their cognitive resources, or both.

In contrast, that the women who were exposed to a positive statement regarding women's abilities in STEM fields scored significantly higher on the math test than women who were exposed to stereotype threat may be due to the positive message weakening the applicability of the negative stereotype in the test-taking situation. Evidence for this includes a study in which researchers found that female students given a difficult mathematics test had improved grades when they were provided with a positive message that was designed to counter any negative stereotype about females' math ability (McGlone and Aronson, 2007). In addition, Wheeler and Petty (2001) have suggested that providing a counteracting message may weaken the applicability of a stereotype among individuals taking an academic test.

The results of this study also supported Hypothesis 1B. Women who were exposed to the stereotype threat scored significantly lower on measures of science identity, science self-efficacy, beliefs about science, and overall science self-perceptions than women who were first provided a positive statement. This result is consistent with the findings of prior research suggesting that being exposed to stereotype threat may negatively affect women's academic self-perception (Deemer et al., 2014; Kray & Shirako, 2012).

The effect of stereotype threat on women's academic self-perception in STEM fields may be partly due to their previously internalizing the stereotype that females are deficient in ability in STEM areas compared to males (Bonnot & Croizet, 2007; Dresel et al., 2007; Eccles, 1994). The assessments of parents, teachers, and other people of females' ability in STEM domains may affect girls' self-perception about their abilities in those domains (Dresel, Schober, & Ziegler, 2007; Tiedemann, 2000; Viljaranta, Lazarides, Aunola, Räikkönen, & Nurmi, 2014). A study investigating gender bias toward women found that among 334 high school, undergraduate, and graduate women, the most likely to report gender bias were those who were in fields that required intensive mathematics and those who reported gender bias had a reduced self-concept regarding STEM subjects (Robnett, 2016). Communicating stereotypical ideas of females' capabilities in STEM fields may reduce girls' self-efficacy in those fields early in their education (Dresel et al., 2007; Tiedemann, 2000; Viljaranta et al., 2014). Internalization of the negative stereotype about the ability of females in STEM fields may be especially likely among women who strongly self-categorize themselves and develop a strong social identity as a woman (Turner & Reynolds, 2012). This evidence suggests that the internalization of the negative stereotype affects women's academic self-perception and makes them more susceptible to a stereotype threat, which may have been a factor helping to explain the results in this study.

The finding that women who were read the positive statement had a higher academic self-perception scores than those who were exposed to stereotype threat may be partly because the positive statement countered the negative stereotype about women's abilities in STEM subjects. Prior research has found that women's academic resilience, which is one aspect of academic self-perception, increases in STEM fields when they are led to believe that their intellectual abilities are not set by negative stereotypes (Dweck, 2006; Good, Rattan, & Dweck, 2012; Yeager & Dweck, 2012). The positive statement that was provided in the study may have helped counteract the STEM-related negative stereotype by leading them to believe that their STEM abilities were not limited by that stereotype. In this way, the positive statement that was read to some of the women may have given them a “stereotype boost” by providing a positive stereotype to counteract the negative stereotype (Shih, Pittinsky, & Ho, 2012). These results of the study support the importance of directing positive depictions of women’s abilities in STEM fields to female students.

In my second set of hypotheses, I predicted that women in single-gender classrooms will have higher math scores (H2A) and show stronger academic self-perceptions (H2B) than women in mixed-gender classrooms. The results for these hypotheses showed that there was a significant difference in math scores and academic self-perceptions depending on the nature of the classroom, but the difference was in the opposite direction from what I hypothesized. Women in the mixed-gender classroom scored higher on the math test and on the academic self-perception measures than women in the single-gender classroom.

There are several possible factors that influenced these results. In regard to academic self-perception, the women in the mixed-gender class may have partly based their self-evaluation on an external comparison of their achievements with the achievements of the males in their class (Ertl, Luttenberger, & Paechter, 2017). Evidence suggests that young women have as much actual ability as young men in science and mathematics (Wang, et al., 2015), and if the women in mixed-gender classroom discover that their achievements are equal to or greater than the men’s, then this may help the women develop a stronger academic self-perception in STEM subjects than the women in the single-gender classrooms.

In addition, the situation of Saudi women sitting next to men in the classroom is relatively recent. For that reason, Saudi women may differ from Western women in their psychological and social reactions to mixed-gender classrooms. The new generation of Saudi women may consider it a challenge to compete with men for work in places that were previously occupied only by men such as oil companies, aircraft management, genetic engineering, and chemistry. These women may be very competitive when they are in mixed classes with men and perform the same tasks.

Interestingly, despite the stereotype threat, academic self-perception was higher than the midpoint in terms of science identity and belief about science regardless of the type of classroom. Results indicate that the female students in science majors have overall high positive scientific concepts and strong beliefs about the study of science. This increase from the midpoint in both types of classrooms (women only and mixed) was also noticeable in the other dimensions forming academic self-perceptions. These results may be due to the fact that developing an academic self-identity is a cumulative process based on years of experience, and thus not easy to change. The women in this study were STEM majors, and enrollment in science majors is based on a prior perception of skills and abilities and on a number of attitudes towards knowledge fields and associated occupational opportunities. Thus, enrollment in a STEM major may be a protective factor for women who are exposed to a stereotype threat. In the last ten years some progress in improving women’s educational prospects has occurred and maybe inspired and encouraged new generation of Saudi women to explore and prove their identity and ability in STEM fields which were limited for men. For instance, in order to address the gender gaps between subjects at the tertiary level of education, Saudi Arabia established its first women-only university, known as Princess Noura bint Abdul Rahman

University. The big step toward the change of the education purpose for women in Saudi was founded in 2009 by establishing the first mixed gender university in Saudi society called King Abdullah University of Science and Technology (KAUST). A feature of the university is the inclusion of colleges specializing in science and technology, which may encourage women to participate in larger numbers in STEM-related fields. Another needed change has been increased levels of investment in the education sector, which has benefited the education of Saudi women. Specifically, the Saudi government has invested more than triple of what it had invested in the year 2000 towards education, constituting the highest increase in allocated funds since 2007 (Qureshi, 2014). Between the years 2010 and 2012 alone, the amount invested in education had already exceeded 100 billion dollars (Qureshi, 2014). These increases have led to the construction of new schools, colleges, research facilities and training of educators, including at least 160 colleges constructed exclusively for women (Qureshi, 2014).

In my third set of hypotheses, I predicted that there will be an interaction between gender classroom type and type of stereotype on women's math scores (H3A) and their academic self-perception (H3B). In particular, I predicted that for women in single-gender classrooms, math scores would be highest for those who exposed to the positive statement about women's ability in science, and lower for those who exposed to the negative statement; however, for those in mixed-gender classes, I predicted the scores will be moderate for those who read the positive stereotype and lower for those who read the negative Stereotype. Hypothesis H3A was partly supported, as results showed that type of classroom made no difference on math scores for women exposed to stereotype threat. However, for women exposed to a positive statement, there was a significant difference between single-gender and mixed-gender classrooms, but in the opposite direction from what was predicted. Women in mixed-gender classroom who were exposed to the positive statement scored significantly higher on the math test than women in the single-gender classroom. These results suggest that the stereotype threat had similar effects on women in both types of classroom, whereas the positive statement had a stronger effect on women in the mixed-gender classroom.

There were mixed results for Hypothesis H3B. Academic self-perception of the women was measured by four constructs: science identity, science self-efficacy, belief about science, and overall academic self-perception. For science identity, there was no interaction between type of classroom and type of stereotype presented to the students. For science self-efficacy, belief about science, and overall academic self-perception there were significant interactions, but in the opposite direction than predicted, with women exposed to the positive statement in the mixed classroom having higher science self-efficacy, belief about science, and overall academic self-perception than those in the single-gender classroom.

Summarizing the results for Hypothesis 3B, first, for all four components of academic self-perception, results for the stereotype threat condition were not statistically different for the two kinds of classroom. Second, for three of the components of academic self- perception, results for the positive statement condition were significantly higher for women in the mixed-gender classroom. These results suggest that classroom type was more important for women exposed to the positive statement than for those exposed to the stereotype threat. Women in mixed gender classrooms may have more experience comparing themselves to men and knowing that they can perform as well so might have believed the positive stereotypes more. This may suggests that Saudi women students want to hear the positive messages that they are similar to men or not lees competent, as they have been seen in the society (Omair, 2017). Therefore, it is possible that Saudi women need the positive image to confirm and approve their science abilities when they are in mix class with men. This need became necessary to the new generation because the Saudi government is trying to change some traditions in term of women's work and education. For example, more recently, Saudi government enabled Saudi girls to enroll in foreign scholarship programs to study outside Saudi Arabia in North America, Europe, and East Asia, along with Saudi men (Omair, 2017). Perhaps this educational and social movement for women by the government had a positive impact among the young women in forming a positive image of the efficiency and capabilities of the Saudi women in science major. In addition, the advent of globalized markets has led to loosening of policies regarding women workers, particularly in the private sector. This has been necessary in order to diversify an economy overly reliant on oil revenue. For example, the Saudi government has made it mandatory that all organizations within its borders hire a pre-specified number of Saudi employees, of which a given percentage has to be women. Such provisions have led to an increase in the presence of women employees within the Saudi workforce and will contribute to reduced gender disparities in STEM market (Almunajjed, 2010).

Because mixed vs. single gender classrooms were not randomly assigned, it is important that some other variables may count as confounding variables that have possible effect on the dependent variables. For example, in the type of university that accepts both men and women to study in separate campuses, some classes have to be in mixed gender classrooms because of the type of major or courses. Also, some women were in the women-only university. However, there were students from campus and classrooms that are totally mixed-gender. These different types of universities with similar and different academic majors may reflect a major self-selection factor that was probably made based on a number of factors. For example, it is possible that women who enroll in totally mixed-gender campus and classrooms have more academic resilience, higher self-efficacy, and feel more comfortable and confident in STEM which is why they felt they were able to compete in mixed classrooms. This may increase the likelihood of high scores in math and STEM self-perception for women in mixed classes in both conditions (reading the negative vs. the positive stereotype).

The results of this study impact our understanding of stereotype threat by suggesting that both threats and positive messaging are powerful forces not only in the West, but in Saudi Arabia. The results also improve our understanding of gender dynamics in Saudi Arabia. In particular, the results suggest that while single-gender classrooms may protect girls and women in the West from the negative effects of gender stereotypes, they may not be protective in other cultures. It is possible that because women who self-select into science majors in mixed gender classrooms are more receptive to positive messages about their ability in science and need these messages to increase the feeling of science self-identity, and science self-efficacy. Even the differences between students who received the positive stereotype in mixed and single classrooms were significant; however, both groups were above the midpoint in term of STEM self-perception. In contrast, receiving a strong negative manipulation about women's ability in science has impacted self-efficacy for students in both groups (single and mixed gender classrooms). Some finding suggested that STEM self-efficacy might predicts academic performance beyond one's ability (Rittmayer, 2008). This maybe indicated that students who received a confirmation about their academic self-efficacy are motivated to succeed in their academic tasks. This also maybe explain why receiving negative messages about academic self-efficacy has strong effects on math performance among students in single and mixed gender classrooms compared to students who received strong positive manipulation about women's ability in science and did better on the math test.

It is possible that competitiveness with men and sense of challenge is a key to understanding the effectiveness of Saudi women in science classrooms. Women in mixed gender classes might feel more competitive when performing with men. Women who believe "I/we can do it" might be more likely to engage this competitiveness with men to show their same capabilities in STEM as men. Being in mixed gender classrooms itself became a motivation to feel positively about the academic self for Saudi women because the positive message from the government was to reduces the gap between men and women in favor to women to get more rights. However, students who are in single-gender classrooms may feel still isolated and less capable. Maybe mixing with men becomes more acceptable for some women in order to get jobs and positions that were limited to men; however, feelings of isolation combined with comparing negatively with men's opportunities may decrease the academic self-esteem, and increase the feeling that they are still behind in the society. Saudi female students in STEM fields may have a strong desire for self-assertion after the great opportunities that the Saudi government has recently provided to women in various fields, especially in education. This desire may be further stimulated by the situation of being in a classroom along with men.

Overall, the most potentially important findings of this study were the effects of stereotype threat compared to the effects of positive messages about women's STEM abilities. These results suggest that negative gender stereotypes about women in STEM fields persist in the Kingdom of Saudi Arabia. Negative in-group stereotypes work as a threat that may affect self-perceptions and performance in school (Casad et al., 2016). Therefore, researchers and experts in education suggest and recommend that schools should aim and contribute to gender-balanced science and technology fields. This goal can be achieved (for example) by encouraging students from both genders and providing them with a positive view of gender in STEM (Wang, & Degol, 2017). In the changing Saudi society, where efforts are being made to provide women greater freedom than in the past, it is important that women are encouraged to pursue any course of studies they wish to pursue, including in STEM fields. It is also important that the government, educators, and society do their best to dismantle negative stereotypes about women if they want these reforms to be successful.

Limitations and Future Directions

There were several limitations in the study. One of these was that female students were not from different regions in Saudi Arabia. The responses of students in other Saudi universities may be different than those in this study. I recommend that future studies investigate the effects of stereotype threat and positive stereotype statements on Saudi female students in different region's universities.

Another limitation of the study was that it was not possible to determine whether the differences in the math test that were found between students who were exposed to a stereotype threat and the students exposed to the positive statement were due mainly to the threat statement, the positive statement, or both. There are two ways a future study might deal with this limitation. One way to help understand which of the statements (stereotype threat or positive) had the most effect on the women's math test scores would be to also give the math test to female STEM students who are not given any statement, negative or positive, before taking the test. Then, the results for groups of students who are exposed to the two different statements could be compared to results for women exposed to no statement to help determine which kind of statement had the most effect.

Another way to better understand the effects of the two kinds of statements on women's math scores is to also have male students take the math test. That way, the women's scores on the test for the negative and positive statements can be compared to the men's average scores to better understand the cognitive effects of each kind of statement. It is recommended that this method be used in a future study.

A third limitation of the study is that it provided only statistical correlations between independent and dependent variables. Causation cannot be assumed in studies that are only correlational in nature. Therefore, even though the study found that women who were exposed to the positive statement had higher test scores and academic self-perception (the dependent variables) than women exposed to a stereotype threat, we cannot conclude that the difference in the dependent variables was caused by the difference in the independent variable. In the future, a more controlled experiment could provide information about whether the type of statement women are exposed to causes differences in the dependent variables.

Challenges and Suggestions for Stereotype Threat Research

Many research have examined stereotype threat effects among females students in different cultural contexts, and the results were somewhat mixed (for a review see Flore & Wicherts, 2015). Therefore, stereotype threat research is not without controversy in Western cultures. In contrast, other findings (for a review see Spencer et al., 2016) have shown that stereotype threat can harm the academic and math performance of students who exposed to negative stereotype about the academic ability of the groups they are belong. However, more recently, the results of several research in Western cultures show that stereotype threat effects are unreliable. For example, a study by Flore and colleagues (Flore, Mulder, & Wicherts, 2019) found that there is no effect of stereotype threat on math performance among a sample of high school girl students in the Netherlands. Despite the results being limited to the studied population (i.e. Dutch high school students, age 13–14) and the studied mathematics task, it is possible to conclude that the new generations of girls in Europe do not face a real challenge of discrimination and negative stereotypes in education. The political and social reforms that have taken place in Europe and arguably the U.S. for many decades led to a greater equality between men and women, which in turn is reflected in education and employment. Although there are still barriers against women in education and workplace settings (e.g., reflected in the #MeToo movement), there are stronger cultural messages that girls can be just as accomplished as boys. This message of gender equality has likely made it easier for women and girls to internalize positive beliefs about girls and to be more resistant to negative messaging. Therefore, Western women may have already received the message that women can succeed in any STEM field, and what a woman should do is just to follow her academic self-interests.

However, the case seems to be different in Saudi society. Political, economic, educational and social reforms towards reducing the gender gap in Saudi Arabia are still at an early stage. The most striking example of discrimination against women's rights is that Saudi women were not allowed to drive car until 2018. It can therefore be said that women in Saudi Arabia are still highly influenced by cultural messages that limit the identity and positive image of women as a group. Thus, any negative statements about the abilities of Saudi women, especially in traditionally male domains, will probably affect them more negatively than women in Western cultures. Saudi women face a challenge to prove their worth and efficacy because they have, for decades, suffered discrimination and negative profiling.

Another important issue is that much of stereotype threat research in the West uses very subtle manipulations of stereotype threat (just listing one's gender or race) rather than explicitly stating the stereotype (e.g., Steele & Aronson, 1995; Spencer, Steele, & Quinn, 1999). In the present research, I explicitly manipulated the perceived veracity of negative or positive beliefs about women in science by using a fake research article that cited evidence supporting either negative stereotypes (that women are not as good as men) or positive stereotypes (that women were just as good a men). By using a strong manipulation, it was more likely that Saudi women, who are being exposed to mixed messages about women in STEM, would be likely to believe the articles they read in this study. This could also explain why these results were stronger than previous stereotype threat results that used more subtle manipulations in cultural contexts that are more positive towards women.

Conclusion

Most studies on the gender stereotype that women are not as capable as men in STEM subjects have been done in Western countries. Very little such research has been done in Saudi Arabia, though women in the Kingdom have very rigid gender roles. This study helped bridge the gap in research by providing information about how stereotypes and stereotype threat are related to female university students who are in STEM fields in Saudi Arabia.

In the study, it was found that female Saudi STEM students who were exposed to stereotype threat had lower math test scores and lower academic self-perception than women exposed to a positive statement about their STEM abilities. These results are consistent with results from Western countries about the effects of stereotype threat and stereotype-countering messages given to women before a cognitive test. The results suggest that like women in Western countries, Saudi women are aware of and are affected by the stereotype that women have less ability in STEM, a stereotype that research suggests is false (Wang et al., 2015).

The study also found that women in mixed-gender classes had higher math test scores and academic self-perception than women in women-only classes. This finding suggests that the situation of women competing directly with men in a STEM class may provide added motivation and confidence to the women.

In addition, the study found that based on average scores on the positive end of the academic self-perception scale (i.e., score above the midpoint), Saudi women in STEM had fairly high levels of academic self-perception in science. At a time when Saudi women are gaining somewhat more freedom to learn and work in STEM areas, the study gives evidence that female Saudi students in STEM fields do not accept standard STEM-related gender stereotypes. They are not allowing those stereotypes to define their capabilities but are rather defining themselves as being very capable in STEM subjects.

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Appendix A:

Research Script

Hello, my name is Ali Omair. I am a graduate student at DePaul University in Chicago, IL USA. I am conducting a research study that is part of my graduate research.

To improve academic quality, we need to conduct research that discusses topics and issues in the learning environment, such as students' attitudes towards school and understanding the reasons for academic achievement. Therefore, I am conducting a research study because I am trying to learn more about what do college women and men in Saudi Arabia think about these topics. I believe that your voices and your opinions are very important.

I am asking you to be in the research because you are an adult over the age of 18. If you agree to be in this study, you will be asked to fill out a survey. The survey will include questions about your personal beliefs about science. We will also collect some personal information about you such as your age, gender, and parent's education. If there is a question you do not want to answer, you may skip it.

This study will take about 25-30 minutes of your time. Research data collected from you will be anonymous.

Your participation is voluntary, which means you can choose not to participate. There will be no negative consequences if you decide not to participate or change your mind later after you begin the study. You can withdraw your participation at any time prior to submitting your survey. If you change your mind later while answering the survey, you may simply stop doing the survey. Once you submit your responses, we will be unable to remove your data later from the study because all data is anonymous and we will not know which data belongs to you. Your decision whether or not to be in the research will not affect your grades at your school.

The first page of the survey packet is a sheet explaining this information. Please take a moment to read the information sheet carefully as I will ask you some questions afterwards to ensure that you understand the nature of this research.

Questions to ensure comprehension:

1) In your own words, summarize the nature and purpose of this research. (solicit answers).
   a) <u>If correct</u>: Would anyone like to add to this? Do people agree with this?
   b) <u>If incorrect</u>: Researcher will summarize the nature and purpose again and repeat step 1a.
2) How old do you have to be to participate in this survey? Are there any other restrictions?
   a) <u>If correct</u>: Would anyone like to add to this? Do people agree with this?
   b) <u>If incorrect</u>: Researcher will summarize the restrictions again and repeat step 2a.
3) Are you obligated to participate in this study? What if you do not want to participate?
   a) <u>If correct</u>: Would anyone like to add to this? Do people agree with this?
   b) <u>If incorrect</u>: Researcher will summarize the rights of participants again and repeat step 3a.
4) What should you do if you do not wish to answer a particular question?
   a) <u>If correct</u>: Would anyone like to add to this? Do people agree with this?
   b) <u>If incorrect</u>: Researcher will summarize their rights again and repeat step 4a.
5) Should you put your name or any other identifying information on the survey?

a) If correct: Would anyone like to add to this? Do people agree with this?
b) If incorrect: Researcher will explain the anonymous nature of the survey again and repeat step 5a.

If you still wish to participate in the survey, please tear off the information sheet and keep it for your records. It includes my contact information in case you have questions, concerns, or complaints about this study or you want to get additional information or provide input about this research.

APPENDIX B:

Information Sheet for Participation in the Stud

We are conducting a research study because we are trying to learn more about the impact of gender and cultural beliefs about gender on performance in STEM fields and self-perception among women and men in Saudi colleges. This research study is a student project that is being done as part of graduate research under the supervision of the faculty sponsor. We are asking you to be in the research because you are a young male or female adult over the age of 18 who is currently attending …university in Saudi Arabia. If you agree to be in this study, you will be asked to fill out a survey. The survey will include a brief math exam, questions about your personal feelings and beliefs about science majors and gender identity. We will also collect some personal information about you such as your age, gender, and parent's education. If there is a question you do not want to answer, you may skip it.

This study will take about 25-30 minutes of your time. Research data collected from you will be anonymous.

Your participation is voluntary, which means you can choose not to participate. There will be no negative consequences if you decide not to participate or change your mind later after you begin the study. You can withdraw your participation at any time prior to submitting your survey. If you change your mind later while answering the survey, you may simply stop completing the survey or not hand in the survey. Once you submit your responses, we will be unable to remove your data later from the study because all data is anonymous and we will not know which survey belongs to you. Your decision whether or not to be in the research will not affect your grades at your school.

The surveys will be collected at the end of class by a researcher who is not the course instructor. If you do not wish to participate, you are free to leave or you can turn in a blank survey if you wish to be perceived as having participated. You do not have to answer any questions that you feel uncomfortable answering and if you prefer not to answer a question, you can leave it blank. You will be asked to put the completed questionnaire in the envelope that is on the front table of the class after all participants have finished.

You must be age 18 or older to be in this study. This study is not approved for the enrollment of people under the age of 18.

Appendix C:

The Study Debriefing

Thank you for participating in the present study concerning gender STEM stereotypes of Saudi college students. The present study measures the impact of negative and positive STEM stereotypes on academic performance and academic self-concepts of Saudi college students. Each student was given a made-up summary of "research" that has been conducted regarding women in STEM fields. Half of you received a false summary that women are not good at STEM fields and the other half read a summary that woman are just as good as men in STEM fields. We did this to see if stress about confirming a negative stereotype (that women are bad at math and science) would negatively impact performance on the math test (called "stereotype threat"). We also wanted to see if receiving positive messages would reduce stress and improve performance. The actual research conducted in Western cultures has found that women perform just as well as men using standardized tests of mathematical ability; however, there is still a gender disparity in entering STEM fields. We hope this research will shed light on why women are not entering STEM fields.

Following the math test, we asked questions about science-identity, academic self-efficacy, attitude toward science, and gender identity. We are interested in whether or not stereotypes impact not only math performance but also self-perception and motivation in science. We hope that by studying this topic we will better understand how stereotype threat and positive stereotype statements are related to the academic self-perception and cognitive performance of STEM college students in Saudi Arabia. We see this issue as an important topic because the literature and previous studies referred to the relationship between gender stereotypes and perceiving self-worth in college and its impact on sex role expectations, and how it varies according to differences in community values and beliefs. However, most of these studies have been conducted in Western cultures, which necessitates the study of these relationships in other societies with different cultural backgrounds, especially those characterized by rigid sex roles, such as Saudi Arabia.

Although the existing research is valuable, there is no study which has been conducted in Saudi society to investigate the influence of gender STEM stereotypes on the academic self-perception and academic performance of Saudi individuals regarding sex roles, and they mostly study these issues in single gender school. In this research, we are examining these issues in both single-gender and mixed-gender schools.

This issue is especially important in light of rapid changes in technological culture, economic and cultural globalization, and the speed of communication and contacts between individuals in different cultures. The gender stereotypes within various societies is not a new idea, but is part of the cultural and social heritage that generations inherit through several time stages, even with successive civic and cultural changes. Thus, gender stereotypes become solid, stable, and resistant to change. We hope that this issue will shed light on possible barriers to success in STEM fields for women.

Again, we thank you for your participation in this study. Prior knowledge of questions asked during the study can invalidate the results, so we ask that you do not discuss this research with anyone who might participate in the study someday. We greatly appreciate your cooperation.

Appendix D:

The Full survey

To ensure that you understand the above research, please answer the following questions**:**

1. **The article refers to research regarding:**
   A. Academic technology.
   B. Women's education in poor societies.
   C. Academic ability of women in scientific fields.
   D. Differences between science and liberal arts.
   E. Women movement in Western culture.

2. **The results of some research that has been done outside Saudi society indicate that:**
   A. Both sexes face difficulties in scientific fields.
   B. Women excel in liberal majors.
   C. Female students are as good as male students in liberal majors.
   D. Men perceive scientific majors as more difficult than women.
   E. Women perceive scientific majors as more difficult than men.

3. **The results of some research that has been done in Saudi society indicate that:**
   A. Saudi women did not get enough opportunities to engage in science fields.
   B. Saudi women have lower academic success in the scientific fields and medical majors, and need extra training to develop their academic skills and abilities.
   C. Saudi female students are as competent as male students in math and medical majors.
   D. Both genders who study in scientific academic fields evaluate them as being not difficult
   E. Both genders believe that they face difficulties in scientific fields and medical majors.

STOP! Do not continue until instructed

Math Aptitude Test for College Students

You will have **10 minutes only to** complete this test. Do not begin until instructed.

1. **What is your sex?**

   A. Female

   B. Male

Math Performance Measure

- **Directions**: Please circle the letter to choose only one correct answer for each of the following questions: (**You have only 10 minutes** to answer these questions)

1. What is the average (arithmetic mean) of 2x + 3, 5x – 4, 6x – 6, and 3x – 1?

A. 2x + 4

B. 3x – 2

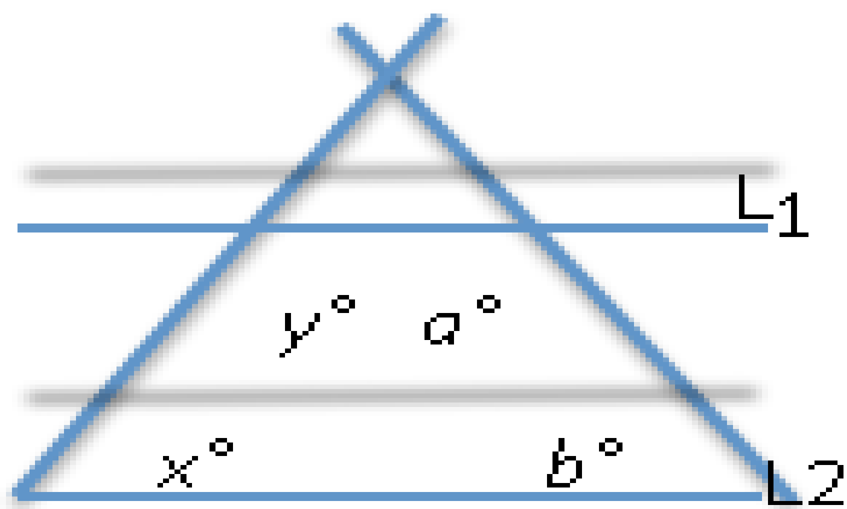
C. 3x + 2

D. 4x – 2

E. 4x + 2

2. Which of the following statements must be true about the figure shown below?

L1 is parallel to L2



A. $x = a$
B. $x = b$

C. $a = b$

D. $y = b$

E. $x + y = a + b$

3. Based on the diagram, please indicate the best answer about Quantity A and Quantity

Quantity A	Quantity B
$x + y$	180

A. Quantity A is greater.

B. Quantity B is greater.

C. The two quantities are equal.

D. The relationship cannot be determined from the information given.

4. Based on the given equations, choose the best answer that describes Quantity A and Quantity B.

$4x – 5y = 10$

$-3x + 6y = 22$

Quantity A	Quantity B
33	$x + y$

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

5. **Quantity A** **Quantity B**

(x – 1)2 (x – 1)3

A. Quantity A is greater.

B. Quantity B is greater.

C. The two quantities are equal.

D. The relationship cannot be determined form the information given.

6. **A 7 by 24 rectangle is inscribed in a circle. What is the circumference of the circle?**

A. 7π

B. 12.5π

C. 24π

D. 25π

E. 31

<u>At the end of 10 minutes, stop solving the math questions.</u>

Directions: Please use the numbers to indicate how much you agree or disagree with the statement. There are no “right” or “wrong” answers. Chose the answers that are true for you.

	1	2	3	4	5	6	7
	Totally disagree				Totally agree		
1. I think of myself as a “science person.”	1	2	3	4	5	6	7
2. My family thinks of me as a “science person.”	1	2	3	4	5	6	7
3. My friends think of me as a “science person.”	1	2	3	4	5	6	7
4. My teachers think of me as a “science person.”	1	2	3	4	5	6	7
5. Science has an important impact on my life	1	2	3	4	5	6	7
6. I could never be a successful scientist.	1	2	3	4	5	6	7
7. When it comes to scientific knowledge and understanding, I can compete at the highest levels.	1	2	3	4	5	6	7
8. I enjoy working on science projects.	1	2	3	4	5	6	7
9. Scientific topics interest me.	1	2	3	4	5	6	7
10. I am interested in pursuing a career in a scientific field.	1	2	3	4	5	6	7
11. I am interested in the way science can be used to solve problems.	1	2	3	4	5	6	7
12. I am interested in helping others using science.	1	2	3	4	5	6	7
13. I am convinced that I am able to successfully learn all relevant science content even if it is difficult.	1	2	3	4	5	6	7
14. I know that I can maintain a positive attitude toward my science courses even when tensions arise.	1	2	3	4	5	6	7
15. When I try really hard, I am able to learn even the most difficult science content.	1	2	3	4	5	6	7
16. I am convinced that, as time goes by, I will continue to become more and more capable of learning the content of my science courses.	1	2	3	4	5	6	7
17. I am confident in my ability to learn in my science classes, even if I am having a bad day.	1	2	3	4	5	6	7
18. If I try hard enough, I can obtain the academic goals I desire in science.	1	2	3	4	5	6	7
19. I am convinced that I can develop creative ways to cope with the stress that may occur while taking science courses	1	2	3	4	5	6	7
20. I know that I can stay motivated to participate in science courses.	1	2	3	4	5	6	7
21. I know that I can finish the assigned science projects and earn the grade I want, even when others think I can not.	1	2	3	4	5	6	7

	1	2	3	4	5	6	7
	Totally disagree				Totally agree		
22. Science is a great way to learn about the world and how it works	1	2	3	4	5	6	7
23. Science is for “nerds.”	1	2	3	4	5	6	7
24. You have to be smart to be good at science.	1	2	3	4	5	6	7
25. Science is boring.	1	2	3	4	5	6	7
26. Many good careers use science.	1	2	3	4	5	6	7
27. I am a very good science student.	1	2	3	4	5	6	7
28. Anyone can be good at science if they really tried.	1	2	3	4	5	6	7
29. Science is fun!	1	2	3	4	5	6	7
30. Science is mainly a “male” thing.	1	2	3	4	5	6	7
31. Being good at science is not very feminine.	1	2	3	4	5	6	7
32. In general, men are better at math and science than women.	1	2	3	4	5	6	7
33. Women are just as good at math and science as men.	1	2	3	4	5	6	7

Appendix E:

Inter-Item Correlation Matrix

	Science Identity sub11 items scale	Self efficacy sub10 items scale	Believe about science Sub12items	Science Self-perception (The overall scale)
Science Identity sub11 items scale	1.000	.614	.426	.775
Self efficacy sub10 items scale	.614	1.000	.575	.942
Believe about science Sub12items	.426	.575	1.000	.748
Science Self-perception (The overall scale)	.775	.942	.748	1.000