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Influence of Gender Stereotype Threats on Undergraduate Students' Achievement in Mathematics and Science

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Abstract
This paper sought to find out the influence of gender stereotype threats on undergraduate students' achievement in mathematics and science. The study adopted a quasi-experimental research design, specifically, a non-equivalent control group design. Two research questions and two null hypotheses guided the study. A sample of forty (40) undergraduate students in the department of science education, University of Nigeria, Nsukka was used for the study. The subjects were divided into two groups 1&2. Group 1 students were taught a mathematics and science course with gender stereotype threats while group 2 students were taught the same concept without gender stereotype threats. Data were collected using an instrument called Mathematics and Science Achievement Test (MSAT). The instrument was face validated by three experts in the department of science education, University of Nigeria, Nsukka. Content validity of the instrument was ensured through the use of test blue print. Mean and Standard deviation were used to answer the research questions while analysis of Covariance (ANCOVA) was used for testing the null hypotheses at 0.05 level of significance. The result revealed that significant difference occurred in the achievement of male and female students exposed to gender stereotype threats in favour of the males but there was no significant difference in the achievement of the students that were taught without gender stereotype threats. The implications of the findings were highlighted based on which it was recommended among others that, teachers should avoid gender stereotype threats during mathematics and science curriculum delivery.
Keywords: Gender, Stereotype, Threat, Mathematics and Science

1. Introduction

The technological advancement of any nation depends on the quality of science and mathematics education of her citizens. The issue of gender disparity in science and mathematics achievement has been investigated even at the tertiary level of education, and there is no consensus yet about which group is better. Mathematics is the abstract study of topics encompassing quantity, structure, space, change and other properties (Army and Denis, 2006). The knowledge of mathematics is important because it enables one to solve mathematically related problems in science subjects, such as physics, chemistry, biology and engineering. The term "science" includes engineering, chemistry, physics, biology, among others, or a composite of any or all areas of scientific knowledge. The achievement of undergraduate students in both mathematics and science has been the major concern of both parents and science educators. Many factors have been identified as determinants of students' achievement in mathematics and science. Such factors include: learners' non-challant attitude to school work and lack of understanding of the basic scientific principles (Jegede, 1986 & Ariyo, 2006); teachers qualification, school environment (Isiugo-Abanihe & Labo-Popoola, 2004); and gender stereotype threat (Steele, James, & Barnett, 2002). Among these factors, the current study focuses on the influence of gender stereotype threat on students' achievement in mathematics and science.

According to Amy & Denise (2006), the statement "girls just aren't good at mathematics and science" has been used to explain the gender gap in mathematics and science for decades. They observed that in elementary and middle schools, girls' and boys' scores are relatively equal on standardized tests. However, beginning in junior high school and continuing through adulthood, the gender gap widens between boys' and girls' scores. Nkechi (1996) found that women's potential in ancient technology were not well recognized and so with time, people began to see science, mathematics and technology as masculine, to the extent that the gap is noticed in male and female participation in modern technology that has science and mathematics as base. The National Center for Educational Statistics (NCES), (2003) reports that from 1990 to 2003, both girls and boys in the 4th and 8th grades had gain mean math scores, with boys outperforming girls in 4th grade by one to three points, and 8th grade boys scoring one to two points above their female classmates on the mathematics assessments (NCES, 2003). Kahle (1985) found that boys perform better than girls in science and mathematics while girls excel in languages and arts subjects. Similarly, the studies by Ezanya (2004), Lynch and Paterson (2002), and Ugwuanyi (2012) on the influence of gender on students' achievement in chemistry, science process skills and physics respectively showed that boys performed better than girls. The question remains apparent, if both genders have shown parallel increases in mathematics and science scores, why do boys still outperform girls in mathematical,

chemistry, science process skills and physics tests? Research on gender stereotype threat has offered insight into what causes this constant difference in scores.
Gender stereotype has to do with judging one of the sexes to be less intelligent or academically inferior in relation to the opposite sex. Stereotypes about an individual's gender, which can be shaped as either positive or negative, elicit a variety of emotions. Negative stereotypes often cause negative responses, which can manifest themselves in the stereotyped individual's reactions, performance on a task, motivation, and self-esteem. Research has shown that the threat of being evaluated, judged by, or treated in terms of a negative stereotype can cause individuals to perform worse in a domain in which negative stereotypes exist about a group of which they are a member.

Gender stereotype threat occurs when a negative stereotype about one's gender becomes self-relevant, typically as an interpretation for something one is doing, an experience one is having, or for the situation one is in, which has relevance to one's self definition (Steele, 1997). Stereotype threat sets up a mutually reinforcing system, the fear of confirming the stereotype leads to behavior that confirms it. Moreover, individuals do not have to believe the stereotype to be true for it to influence their behavior (Hyde & Kling, 2001). From the first seminal studies conducted on stereotype threat, researchers have suggested that stereotype activation plays a major role in the impact of stereotype threat on performance (Davies, Spencer, Quinn, & Gerhardstein, 2002; Steele & Aronson, 1995).

Stereotype activation in this context simply involves making one's membership in a group salient. For example, stereotype activation of gender stereotypes may be induced in a variety of ways, for instance by having individuals interact with a male mathematics or science professor (Bell, Spenser, Iserman, & Logel, 2003). Activating stereotypic beliefs related to stereotype threat may involve telling women that an assessment they are about to take, assesses mathematics or science ability. Given the widely held belief regarding women's underperformance compared to that of men in mathematics and science, simply mentioning that the task involves gender differences and that it involves these particular domains is enough to activate gender stereotypes and therefore induce stereotype threat. In Nigerian context, there is a notion that women's education ends in the kitchen and so their education should not be given adequate attention. Among those who venture into academics, the notion that science and mathematics are 'hard' and belong to the males, creates stereotype threat that can undermine achievement in the subjects. In a classroom environment where a teacher uses these notions against the female students during science or mathematics class, gender stereotype threat will definitely be induced in the female students.

Stereotype threat is known to negatively affect girls' performance. In one landmark study by Steven, Claude and Diane (1999), girls who were primed to feel inadequate did significantly worse than their male peers on a challenging mathematics test, whereas girls in the control group, who did not face a stereotype threat condition, scored similarly to the boys. Similar studies have also been conducted and similar results were obtained. These studies were mainly conducted using foreign students and to that effect, this study intends to use Nigerian undergraduate students to see how the findings compare with those of the foreign students, hence, the need for the study. The findings of this study will go a long way to helping in the attainment of the millennium development goal (MDG) number 3 on promoting gender equality and women empowerment.

The millennium development goals (MDGs) is a set of eight point agenda adopted by 149 World leaders on how to stem the problem of poverty and its attendant horrors in the Least Developed Countries (LDGs) of the world. The decisions to formulate a long term poverty reduction strategy was reached during the United Nations Millennium summit held in September 2000, in line with the International Development Targets (IDT's) which aims at improving economic well being, social and human development and ensuring environmental sustainability and regeneration. The outcome of the United Nations Millennium summit was a declaration committing all members states (including Nigeria) to strive and achieve eight Millennium Development Goals by 2015 and these include among others:
Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal basic education
Goal 3 Promote gender equality and empower women
Goal 4: Reduce child mortality
This study is addressing the millennium development goal 3 which addresses gender equality and women empowerment. It is expected that the outcome of this study will help reduce gender threats in the universities and

ensure adequate representation of women in the area of mathematics and science which are keys to technological advancement.

1.1 **Research Questions**

The following questions were posed to guide the study;

1. What are the mean achievement scores of students that were exposed to gender stereotype threats and those that were not exposed to them?
2. What are the mean achievement scores of male and female students who were exposed to gender stereotype threats and those not exposed to them?

1.1.1 **Hypotheses**

Two null hypotheses were formulated and tested at 5% probability level:

HO_1: There is no significant difference in the mean achievement scores of students that were exposed to gender stereotype threats and those that were not exposed to them.

HO_2: There is no significant difference in the mean achievement scores of male and female students exposed to gender stereotype threats and those that were not exposed to them.

2.0 Method

The study design is quasi experimental, specifically, a non-equivalent control group design. In this case two intact groups were used for the study. The study was conducted in University of Nigeria, Nsukka. The population of the study comprised of all the undergraduate students in the Department of Science Education that offer mathematics and science courses. The sample of the study was forty science and mathematics students, purposively sampled from the Department of Science Education. The instrument used for data collection was Mathematics and Science Achievement Test (MSAT) developed by the researchers. The experimental procedure involved grouping the forty (40) students into two treatment groups (Treatment group 1 and Treatment group 2). Students in treatment group 1 were exposed to gender stereotype threats in the course of teaching while those of treatment group 2 were not exposed to gender stereotype threats during teaching. Prior to the commencement of the experiment, a pretest was administered to the two groups to establish their relative standing on a basic mathematics and science course. After that, the two groups were treated (taught) separately by one teacher in order to control for teacher effect. After the treatment, the two groups were post tested using the MSAT. Each of the groups served as control to each other. Data collected were analyzed using mean and standard deviation, for the research questions and analysis of covariance (ANCOVA) for the null hypotheses.

3.0 Results

Research question one which sought information on the mean achievement scores of students exposed to gender stereotype threats and those not exposed to threats was answered using data in Table 1.

Table 1: **Mean and Standard deviation scores of students in MSAT**

Group	Pretest			Posttest			
	Number	Mean	SD	Number	Mean	SD	Mean Gain
Treatment group 1	20	7.65	2.62	20	13.15	3.43	5.50
Treatment group 2	20	7.60	2.39	20	17.60	2.83	10.00

Table 1 data show that the mean gain achievement score of students in group 1 (those exposed to gender stereotype threats) is 5.50 while that of the treatment group 2 (those not exposed to gender stereotype threats) is 10.00. This result implies that, there was a mean gain difference in the achievement of the two groups in favor of the treatment group 2.

Also, research question two, which sought information on the mean achievement scores of male and female students in groups 1 & 2, was answered using data in table 2.

Table 2: Mean and Standard deviation scores of Male and Female students in MSAT

Group	Gender	N	Mean	Std. Deviation
Treatment group 1	Male	10	13.20	2.740
	Female	10	10.40	4.175
Treatment group 2	Male	10	17.80	2.700
	Female	10	17.50	3.120

Table 2 data reveal that for the treatment group 1, the male students had mean achievement score of 13.20 with SD of 2.740 while the group 2 male students had mean achievement score of 17.80 with SD of 2.700. Also, the treatment group 1 female students had mean achievement score of 10.40 with SD of 4.175 while the group 2 female students had a mean achievement score of 17.50 with SD of 3.120. This shows that treatment group 2 male students achieved higher than the treatment group 1 male students. Similarly, treatment group 2 female students achieved higher than treatment group 1 female students. Thus both male and female students of group 2 outperformed their counterpart in group 1. This may probably be as a result of the exposition of treatment group 1 students to gender stereotype threats during lesson delivery.

Further testing of the hypothesis one using ANCOVA is shown in table 3.

Table 3: Analysis of covariance of influence of gender stereotype threats on Students' achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	229.117[a]	2	114.559	11.617	.000
Intercept	1109.992	1	1109.992	112.564	.000
Pretest	12.892	1	12.892	1.307	.260
Group	215.125	1	215.125	21.816	.000
Error	364.858	37	9.861		
Total	10173.000	40			
Corrected Total	593.975	39			

a. R Squared = .386 (Adjusted R Squared = .353)

The testing of hypothesis one which states that there is no significance difference in the mean achievement scores of students exposed to gender stereotype threats and those not exposed to them, revealed that the probability associated with the calculated value of F (21.816) is 0.000. Since this probability value is less than the 0.05 level of significance, the null hypothesis is not accepted. Hence, there is a significance difference in the mean achievement scores of students that were exposed to gender stereotype threats and those that were not exposed to them, in favour of treatment group 2.

In considering hypothesis two ($HO_2:$) of no significance difference in the mean achievement scores of male and female students exposed to gender stereotype threats and those not exposed to them, an ANCOVA was done in table 4.

Data in table 4 revealed that the calculated value of F (19.310) has a probability value of 0.001 for the influence of gender on the treatment group meaning that there is a significant difference in the mean achievement scores of male and female students who were exposed to gender stereotype threats, in favour of the male students. But for the students who were not exposed to it, the calculated value of F (0.020) has a probability value of 0.888 meaning that there is no significant difference in the mean achievement scores of male and female who were not exposed to gender stereotype threats. This within group analysis indicates that when gender stereotype threats are removed during curriculum delivery, both the male and female students performed equally well in MSAT but when it is included, the males performed better than the females.

Table 4: Analysis of Covariance of Influence of Gender Stereotype threats on students' achievement in MSAT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26.856[a]	2	13.428	1.155	.339
Intercept	332.903	1	332.903	28.627	.000
Pretest	26.806	1	26.806	2.305	.147
Treatment group 1	15.235	1	15.235	19.310	.001
Treatment group 2	.179	1	.179	.020	.888
Total	3683.000	20			
Corrected Total	224.550	19			

a. R Squared = .120 (Adjusted R Squared = .016)

4.0 Summary of Findings

The following were obtained from the analysis of data;

1. There was a mean gain difference in the achievement scores of students of the two groups in favor of the treatment group 2.
2. Male and female students in treatment group 2 achieved higher than their counterparts in treatment group 1.
3. There is a significant difference in the mean achievement scores of students exposed to gender stereotype threats and those not exposed to them, in favour of treatment group 2.
4. There is a significant difference in the mean achievement scores of male and female students exposed to gender stereotype threats in favour of the male students but there is no significant difference in the mean achievement scores of male and female students who were not exposed to gender stereotype threats.

5.0 Discussion of the Findings

This experiment tested whether the pattern observed in the literature—that women underperform in mathematics and sciences when exposed to gender stereotype threats. It was observed that the statement holds true with the highly selected participants used in this research. A clear observation of the means of the two groups in tables 1 and 2 shows that this pattern did emerge. An ANCOVA analysis of Tables 3 and 4 revealed a significant main effect for the two groups F (21.816, p0.000), and a main effect for gender in group 2, F (19.310, p0.001), but no significant main effect for gender of group 1, F (.020, p.888). This finding is in agreement with that of Steven, Claude and Diane (1999), who found that female undergraduates who were exposed to gender stereotype threat underperformed in mathematics and science but performed equally like the male counterparts in the absence of gender stereotype threat. Also Gupta & Bhawe, (2007) found that Stereotype threats not only create performance decrements but ultimately may also impact major life decisions (e.g. choice of profession/career) and prevent individuals from reaching their full potential within a threatened domain. This actually was observed in this study because at the pretest stage, there was no much achievement gap in the two groups but the introduction of gender stereotype threats deterred the achievement of group 2 students. Perhaps, the underachievement of female students must have accounted for that. Furthermore, the females in group 1 did almost like their male counterparts in the posttest unlike the females in group 2 who underperformed in the post MSAT. This buttressed the negative influence of gender stereotype threats on the achievement of the female students.

6.0 Implications of the Findings

The findings of the study show that females underachieved in mathematics and science when students were exposed to gender stereotype threats and achieved higher without exposure to them during teaching. This has implication for teacher training in Colleges of Education and Universities. When the trainees are trained in the absence of gender stereotype threats, it is likely the females would achieve higher. They would also teach in the same way they were taught after graduation, in the secondary schools. This implies that more females will likely graduate in mathematics and science-related courses and will be able to contribute effectively to the science and technological development programmes of the nation. Also, if gender stereotypy threats are excluded while teaching in the secondary schools, more female students will opt for science and technology–based courses in the

universities. This invariably will close the gender gap already existing in mathematics and science courses offered in the universities; promote gender equality and women empowerment, thus leading to the achievement of the millennium Development Goal 3.

7.0 Recommendations

Based on the above implications, the following recommendations are proffered:

1) Teacher educators at all Universities and Colleges of Education should avoid gender stereotype threats while delivering their mathematics and science lessons.
2) Male and female students should be given equal opportunities to participate in science and mathematics, without any gender bias.
3) The government should encourage more females to participate in science and mathematics programmes, through sponsorship or providing financial assistance to such programmes.

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