The Representation of Professional Females in Math and Science Textbooks used in Public School Education Curriculums.

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A Master's Thesis submitted to the Department of Psychology in partial fulfillment of specialist degree requirements for the School Psychology Program at the State University of New York at Plattsburgh

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At the 2011 National Science Foundation Policy Meeting, Michelle Obama said, "If we're going to out-innovate and out-educate the rest of the world, we've got to open doors for everyone. We need all hands on deck, and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering, and math" (Remarks by first lady, 2011). Equal opportunity for women to an education is a fairly recent phenomenon. In recent decades, the gender gap for women in education and employment opportunities has narrowed dramatically. In 1972, Title IX of the Higher Education Act was passed, which prohibited gender discrimination by federally funded institutions, which allowed women full participation in all aspects of education (Aliprandini & Wagner, 2015). Overall, women now outnumber men among college graduates, but women only represent 25 percent of graduates from math-heavy fields (Ceci, Ginther, Kahn, & Williams, 2015).

We live in a world dominated by fields of technology, yet there is not an equal representation of professional women in these major fields. Women are making strides in education and careers, yet they are still underrepresented in the field which dominates much of our daily lives. There has been no employment growth for females in STEM jobs since 2000 (Huhman, 2012). The U.S Department of Commerce reported that even though women fill close to half of the jobs in the U.S economy, they hold less than 25 percent of STEM jobs. Furthermore, in 2009 only 14 percent of engineers were female. Also, women are pursuing fewer STEM degrees than their male counterparts; 2.5 million women received STEM degrees, whereas 6.7 million men received degrees in the STEM fields. Alarmingly, when women do receive degrees in the STEM field, they are still less likely than men to use these degrees to pursue STEM careers. (Beede, Julian, Langdon, McKittrick, Khan & Doms, 2011)

So, if there are equal education opportunities and women are attending college at higher rates than men, then why does this discrepancy in the STEM field still exist? Recent research looks at many possible factors contributing to the continuing discrepancy of women and men in the STEM fields, including: a lack of female role models, gender stereotypes, women's perception of their perceived abilities, and other socialization factors which discourage women from pursuing education and careers in these fields (Ceci et al, 2015; Beede et al, 2015).

Currently, one of the biggest areas of study concerning the underrepresentation of women in the STEM fields is gender stereotypes, which are still embedded in our culture. Gendered stereotypes and media representations act as a barrier to inclusion for women in the STEM fields; these stereotypical beliefs can deter women from seeking majors and careers in science, technology, engineering, and math. Societal messages and images promoting the idea that women lack mathematical ability, such as the idea that math is not for girls or exposure to only male mathematicians, is also likely to be contributing to these strong stereotypes (Ceci et al, 2015; Mercier, Barron, & O'Connor, 2006; Beede et al, 2015; Gunderson, Ramirez, Levine, and Beilock, 2011)

Children's math attitudes are formed as a result of their environment, especially from interactions with their parents and teachers. Parents' and teachers' gender-related math attitudes, including their stereotypes and anxieties, can play a critical role in girls' development of math attitudes and interests. Broad situational cues can also communicate gender-relevant math attitudes to girls, which combined with a poor performance in math could confirm that the stereotypes are indeed true for oneself or the group (Gunderson et al., 2011). However, there is no longer a gap between boys and girls on math achievement tests, indicating that ability is not the issue. Negative math attitudes can still prevent children from performing at their best and can deter girls from pursuing math-related courses and career paths (Gunderson et al., 2011; Ceci et al, 2015).

Mercier, Barron, and O'Connor (2006) investigated sixth and eighth grade students' perception of knowledgeable computer users and found clear evidence that a cultural stereotype of a computer user still exists. The first part of their study found that the majority of the students' perception of a knowledgeable computer user was someone who is male, indicating that there is still a cultural stereotype. However, in the second part of their study, even though the cultural stereotype was evident, males and females were found to be equally as likely to perceive themselves as computer type people.

Cheryan, Plaut, Handron, and Hudson (2013) furthered this research by examining undergraduates' stereotypes of people in computer science. Similar to Mercier et al. (2006), these researchers found that cultural stereotypes of computer science majors still exist today. Cheryan et al. (2013) wanted to test whether changing these stereotypes using media would influence women's interest in computer science. In the second part of their study, they manipulated news articles and randomly assigned participants to one of two conditions: an article that claimed science majors no longer fit current stereotypes or an article claiming that science majors fit cultural stereotypes. After reading the article, the participants were then asked to summarize the main point of the article and questioned about their interest in computer science. The results showed that after reading the article claiming that computer science majors no longer fit the stereotypes, women reported that they considered majoring in computer science to a greater extent than when they read the article featuring stereotypical representations of science majors or read no article at all. These findings support the possibility of increasing women's interest in the STEM fields by countering stereotypical beliefs and representing the STEM fields as being more diverse by increasing the exposure of positive women role models in these fields.

Quimby and DeSantis (2006) explored the influence of self-efficacy and role models on women's career choices for each of Holland's RIASEC types; realistic, investigative, artistic, social, enterprising, conventional. The researchers measured undergraduate students' self-efficacy in the different types of careers, their role model influences in the different categories, and their overall occupational choices. Their findings are consistent with research suggesting a need for mentoring programs to increase female students' aspirations and confidence in nontraditional careers. The results also suggest that role models have a small but significant influence on career choice independent of self-efficacy. This highlights the importance of increasing exposure to positive female role models in professions to assist female students in making career choices in the STEM fields. This finding also demonstrates that career choices are impacted by role models regardless of one's self-esteem (Quimby & DeSantis, 2006)

Stereotype threat is the phenomenon that groups of people are affected by unconscious fears of confirming negative stereotypes concerning their performance in a particular area (Shapiro & Williams, 2012). In the context of women's performance in STEM subjects, stereotype threat can occur for a variety of reasons. Stereotype threat can lead to negative thinking, anxiety, and thought intrusion, which all negatively impact performance (Kiefer & Sekaquaptewa 2007; Bell, Spencer, Iserman, & Logel, 2003; Danaher & Crandall, 2008; Shapiro & Williams, 2011).

Kiefer and Sekaquaptewa (2007) examine the effects of implicit stereotypes on women's math performance. Implicit gender-math stereotypes are the unconscious associations of men with mathematics and the disassociation of women with mathematics. These implicit stereotypes are linked to less explicit math identification, poor attitudes towards mathematics, and lower reported performance on math-related achievement tests for women. Individuals' behaviors and perceptions can be affected by these stereotypes, even without their intention or awareness. Danaher and Crandall (2008) found that when female students were asked to report their gender before completing an AP calculus exam, their performance was reduced by 33% compared to female students asked to report their gender after taking the exam. Therefore, when gender was made relevant prior to the test, the females performed worse than when gender was not asked until after they completed the test.

More specifically, Kiefer and Sekaquaptewa (2007) found that implicit gender-math stereotyping moderated the effect of stereotype threat on women's performance on math tests. Participants were given a brief math test and were either told it was a diagnostic of math ability, (the threat condition), or a non-diagnostic test (reduced threat condition). The authors then measured implicit gender stereotypes through Implicit Association Tests, which assessed the participants' implicit gender-math stereotypes, gender identification, and math identification. Participants' explicit math-gender stereotyping beliefs were also assessed. Threat condition emerged as a marginally significant predictor of performance on the math tests. Women scored lower in the threat condition than in the reduced threat condition. Therefore, when women thought that the test was a direct diagnosis of their math ability, their performance was negatively affected. Implicit gender-math stereotyping moderated the effect of stereotype threat on women's math test in the reduced threat condition; women who showed implicit gender-math stereotype beliefs scored lower than women who did not. Interestingly, this finding suggests that women who possess strong gender stereotypes about math can activate these stereotypes even in "reduced-threat" conditions. Therefore, these stereotypic beliefs can play a role in women's performance in math, even when stereotype threat is not directly activated. This implies that interventions to improve women's math performance should work on reducing the associations of math being masculine and only for men.

Similarly, Bell et al. (2003) researched the effects of stereotype threat on women's performance on a shortened version of the Fundamental of Engineering Exam. The relevance of stereotype threat was manipulated to create three different conditions. The relevant stereotype condition presented the test as being able to discriminate between capable and incapable engineers, which represented the high stereotype threat condition for the women. The non-diagnostic condition presented the test as being unable to judge a persons' engineering competence, which represented reduced stereotype threat since it was not a judgment of their performance. Lastly, the gender fair condition presented the test as one in which no gender differences have been found, therefore greatly reducing stereotype threat for women. As the authors predicted, women's scores and performance was significantly lower than men when stereotype threat was high; women in the high stereotype condition also performed significantly worse than men and women in all of the other conditions. However, women performed equally as well as men in the non-diagnostics condition and the gender-fair instruction condition.

The results of Bell et al.'s (2003) study support the idea that stereotype threat undermines women's performance on engineering exams. It also suggests that stereotype threat may be a very important hindrance to women's success and persistence in the STEM fields. Additionally, Shapiro and Williams (2012) address other-as-source stereotype threat, which is based on how others might assess one's performance. This is the idea that a child is aware that their performance and actions are monitored by parents and teachers, who may endorse math-gender stereotypes. This form of stereotype threat can harm performance, confidence, self-efficacy, and interest in these subjects. Cheryan (2012) also highlights the importance of changing stereotypes to make careers in this field less masculine, in order to encourage more girls to pursue these careers. She found that exposure to role models who do not fit the stereotypes, whether they are male or female, can have a beneficial effect on women's interest and anticipated success in STEM field careers. Therefore, it is of utmost concern to ensure that children are exposed to role models that do not fit the stereotypical role.

All of these studies on stereotype threat and women's performance in the STEM field suggest that if educators can create environments in which stereotype threat is low then more women should succeed and persist. The current research suggests that creating warm environments in STEM programs may be an important way to reduce the underrepresentation of women in these fields. Also, increasing female role models in the STEM professions could create a positive environment in which girls feel that they can succeed, despite the possible stereotype threats they have encountered. Studies have shown that a lack of role models in nontraditional careers such as engineering and science has been identified as an additional barrier for women who would like to pursue these professions (Ceci et al, 2015; Quimby & DeSantis, 2006). In order to address the continued lack of female representation in the STEM field, students need to be adequately exposed to positive female role models in these professions at a young age. One of the teacher's primary resources to educate students is through textbooks, and it is highly probable that teachers would be more likely to present a science free of gender bias if textbooks themselves represented male and female role-models equally (Beede et al, 2011; Cheryan, 2012; Huhman, 2012).

The purpose of this research is to examine the representation of professional women role models in STEM field textbooks used in public school curriculums. Based on the above research, it is predicted that textbooks used in schools do not clearly reflect a positive role of women in higher education or STEM field professions. It is predicted that women will lack representation in these STEM textbooks; furthermore, when they are represented it will be in a secondary role vs. a primary role. For the purpose of this research, a primary role will be considered a professional position, such as scientists, doctors, professors, astronauts, etc. A secondary role is considered a student, assistant, or observer, etc. Unequal representation of women professionals in the STEM fields results in young girls not getting sufficient or accurate information about what women are capable of in these fields. Education and schools play a vital role in the socialization of children and there needs to be accountability in regards to the information provided to these children.

Methods

Measures

Textbooks will be collected from local schools in the northeastern New York State area. These textbooks will then be reviewed and the number of female and male images will be recorded. Also, it will be noted whether the male or female images are depicted in the form of a primary role (i.e. professor, doctor, astronaut), or a secondary role (i.e. observing, assistant, student). For the purpose of this research, images will be considered any pictures included within the textbook. Also, additional data will be collected for each book, including: the date of publication, publishing company/city, and the target grade for the book (see Appendix B). A comparison will be made across the years to evaluate whether representation of women has increased. Furthermore, an analysis will be done to determine whether female representation is equally as prevalent as the male representation in children's textbooks.

Procedure

Textbooks were sampled from public schools within the northeastern New York Region. However, due to many schools switching to the common core modules, textbooks were also found online through public school websites. The textbooks collected ranged from grades 1-11. See Appendix A for a list of the textbook references. All of the textbooks were analyzed by the researcher using the recording system (see Appendix B) and then translated using the data form to analyze the findings (see Appendix C).

Results

Results indicate that the mean number of primary male images was 10.82 (S.D = 10.42, range 0-36). The mean number of primary female images was 5.28 (S.D = 5.28, range 0-21). The mean number of secondary male images was 8.70 (S.D=11.51, range 0-59). The mean number of secondary female images was 9.06 (S.D=11.57, range 0-49). Furthermore, the publication dates of the textbooks ranged from 1980-2012. See Table 1 for full descriptive statistics.

Table 1

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Primary Male Images	0	36	10.82	10.42
Primary Female Images	0	21	5.28	5.28
Secondary Male Images	0	59	8.70	11.51
Secondary Female Images	0	49	9.06	11.57
Year Published	1980	2012	2003.28	6.80

A paired sample T-Test was completed to determine if the male representation was statistically more significant than the female representation Results indicate that there is statistically significant more primary male representation than primary female representation in science and math textbooks used in school curriculums ($p < 0.05$). However, there is no significant difference among the number of secondary male and secondary female images ($p > 0.05$). See Table 2.

Table 2.

Paired Samples Test

	df	t	Sig. (2 tailed)
Pair 1 Primary Male- Primary Female	49	5.001	.000
Pair 2 Secondary Male-Secondary Female	49	-.570	.571

One way ANOVAs were used to determine if there were differences in the mean number of gendered images by publication date, grade level, and publishing city.

The mean differences between publication date and representation within textbooks was not significant. The analysis on mean differences between publication date and image representation was as follows: primary male ($F=1.634$, $p = .111$), primary female ($F=.903$, $p=.584$), secondary male ($F=.497$, $p=.943$), and secondary female ($F=.734$, $p=.943$). See Table 3.

The mean differences between grade levels and representation within textbooks was not significant. The analysis between target grade levels and image representation was as follows: primary male ($F=1.70$, $p=.12$), primary female ($F=.599$, $p=.805$), secondary male ($F=.933$, $p=.515$), and secondary female ($F=.792$, $p=.637$). See Table 4.

Table 3.

Mean Differences of Image Representation Based on Year Published

	df	F	P
Primary Male Images			
Between Groups	19	1.634	.111
Within Groups	30		
Total	49		
Primary Female Images			
Between Group	19	.903	.584
Within Group	30		
Total	49		
Secondary Male Images			.943
Between Group	19	.497	
Within Group	30		
Total	49		
Secondary Female Images			.757
Between Group	19	.734	
Within Group	30		
Total	49		

The mean differences between the textbook's publishing city and representation within textbooks were also found to be not significant. The analysis between publishing city and image representation was as follows: primary male (F=.336, p=.852), primary female (F=.542, p=.705), secondary male (F=.455, p=.768), and secondary female (F=.267, p=.898). See Table 5.

Overall, the results suggest that textbooks used in public school curriculums display more professional male roles (primary male) in the STEM field than professional female roles (primary female). There is no significant difference between male and female representation in secondary roles, such as observing or students. Furthermore, the publication year, grade level or what area the book was published in did not impact the findings.

Table 4.

Mean Differences of Image Representation Based on Target Grade Level

	df	F	P
Primary Male Images			
Between Groups	10	1.701	.115
Within Groups	39		
Total	49		
Primary Female Images			
Between Group	10	.599	.805
Within Group	39		
Total	49		
Secondary Male Images			
Between Group	10	.933	.515
Within Group	39		
Total	49		
Secondary Female Images			
Between Group	10	.792	.637
Within Group	39		
Total	49		

Table 5.

Mean Differences of Image Representation Based on City Published

	df	F	P
Primary Male Images			
Between Groups	.336	.852	
Within Groups			
Total			
Primary Female Images			
Between Group	.542	.705	
Within Group			
Total			
Secondary Male Images			
Between Group	.455	.768	
Within Group			
Total			
Secondary Female Images			
Between Group	.267	.898	
Within Group			
Total			

Discussion

The purpose of this study was to examine whether textbooks used within public school curriculums were gender neutral and equally represented male and female professionals. In the textbooks analyzed, the results indicate that the frequency of visual representations of men in primary professional positions outnumbers the frequency of visual representations of women in primary professional positions. This finding was not impacted by the textbooks publication date, city, or the grade level each book was designed for. This finding suggests that the representation of professional females in textbooks has not improved over the years and it occurs regardless of where and when the book was published. As the research shows, the lack of positive female role models is a contributing factor to the lack of women seeking careers with the STEM field. Quimby and DeSantis (2006) found that role models have a small but significant influence on career choice. The lack of role models in the science and technology field has been identified as an additional barrier for women who would like to pursue these professions. Therefore, it is important for young girls to see women practicing in the field to encourage them that they are capable of being women in the profession. The results suggest that textbook creators need to be more cognizant of how they represent women in their textbooks. They tended to lack women professionals, even though they adequately represented secondary roles in the field, for example girls completing experiments. However, some textbooks did have a balance between genders, but the majority did not. Future research may want to examine textbooks that do have a balance of gender and determine whether girls who use those books are more likely to go into the STEM field.

There were some limitations to the present study. Due to increasing technology and the movement of common core, many local schools have turned to workbooks and online sources instead of textbooks. Furthermore, the only textbooks that were analyzed were textbooks that the researcher had access to. To address this weakness, future studies should try to sample a wider variety of textbooks to make the results more generalizable, including computer science textbooks. Also, future studies may want to record what specific professions are portrayed to examine which specific professions lack female representation. Future research could also look at what supplemental notes and information teachers are providing to their students to see if these additional notes include professional women in the field. Additionally, a future analysis could look at the gender and geographical location of the authors, rather than the publication city to see if there is any impact on the results. To counter the bias of textbooks, teachers need to be aware of the statistics. Knowing this information could help them to supplement lessons with highlights of important women in the STEM fields.

With the lack of women pursuing careers in these growingly important fields, any study that shines light on the reasons a discrepancy still exists can be helpful. Knowing this information allows us to take steps in expanding young girl's aspirations in any field and encouraging them to strive for the best. Regardless of why the discrepancy between women in the STEM field exists, women need to be exposed to positive role models in this growing field. They need to see that their dreams are possible and that math is not just for men. This can start with increasing the exposure of professional women in the textbooks that teachers base their lessons from.

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Appendix A: Textbook References

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Appendix B

Book Title: ______________________ Author: _________________________

Year Published: ____________________ City Published: ____________________

Subject: _________________________ Grade: ______

School: __________________________ M or F (Teacher)

	Male Representation	Female Representation
Primary Person (ex: doctor, professor, astronaut, etc)		
Secondary Person (ex: observing, student, assistant)		
TOTAL IMAGES:		

Appendix C
Data Translation

1: SUBJECT:

Math = 1
Science = 2

2: YEAR PUBLISHED:
Actual year in numerical form (ex. 2008=2008)

3: GRADE LEVEL:
Actual grade level in numerical form (ex. 8^{th} grade textbook = 8)

4: CITY PUBLISHED:
Northeast region = 1
Southeast region = 2
Midwest region = 3
West region = 4
Canada = 5

5: GENDER OF TEACHER USING TEXTBOOK:
Male = 1
Female = 2
Online Textbook = 3

6: # of PRIMARY MALE IMAGES:
Actual number of images (10 primary male images = 10)

7: # of SECONDARY MALE IMAGES:
Actual number of images (5 secondary male images = 5)

8: # of PRIMARY FEMALE IMAGES:
Actual number of images (10 primary female images = 10)

9: # of PRIMARY MALE IMAGES:
Actual number of images (5 secondary female images = 5)