EFFECTS OF DIRECTED THINKING ABOUT ROLE MODELS ON ATTITUDES TOWARD MATH AND SCIENCE

by

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Submitted to the Graduate Faculty of the
College of Science and Engineering
Texas Christian University
in partial fulfillment of the requirements
for the degree of

Master of Science

May 2013

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Thesis approved:

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For The College of Science and Engineering

ACKNOWLEDGEMENTS

I would like to express my gratitude to my primary advisor, Dr. Charles Lord, for the extensive help he provided throughout all phases of my thesis. I would also like to thank Dr. Sarah E. Hill and Dr. Cathy Cox for serving on my committee and providing helpful comments and suggestions. Finally, I could not have completed my thesis without the help and advice of my lab mates, Sara Brady, Amanda Morin, Tong Lu, and Emily Smith

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Effects of Directed Thinking about Role Models on Attitudes Toward Math and Science

In recent years the United States economy has been experiencing a downward trend, and unemployment rates have been on the rise. According to the United States Bureau of Labor Statistics (2011), unemployment rates have risen to 9.1 % over the past 4 years. Throughout President Barrack Obama's 2012 presidential campaign and reelection, the President emphasized math and science education as one of the keys to economic recovery. He noted that many U.S. business leaders have complained that a shortage of workers with strong math and science skills has forced them to look abroad, and in response the President has heavily pushed for increased funding for math and science education (Hefling, 2012). This move makes sense in that occupational opportunities in Science, Technology, Engineering, and Mathematics (STEM) have increased as much as three times compared to jobs in non-STEM fields over the past ten years, and are projected to grow by 17 % from 2008 to 2018 (U.S. Department of Commerce, 2011). In addition, the U.S. Department of Commerce reports that people in STEM occupations command top salaries, with college graduates in STEM fields earning 26 percent more than their non-STEM counterparts. With continued employment growth and top salaries, it seems that many students should be attracted to STEM fields in the current state of economic uncertainty, but this has not been the case.

The problem is that college students, especially women, are not pursuing STEM careers in anything close to sufficient numbers to meet the future demand. On the surface the number of people pursuing STEM degrees has increased in recent years, but this is more a reflection of increased numbers of people attending college in general. In reality, the proportion of STEM degrees awarded has actually decreased in several areas (National Science Foundation, 2010). According to a report released by the Organisation for Economic Cooperation and Development (2009), the United States ranks 27th of 29 developed countries for the total number of STEM degrees awarded. In addition, the lack of diversity in STEM fields is also disconcerting. While women make up nearly half of the labor force, they hold less than 25 % of STEM jobs (U.S. Department of Commerce, 2011). Of the women that do decide to major in STEM fields, they are less likely than their male counterpart to pursue a STEM occupation, and instead more often go into education or healthcare (U.S. Department of Commerce, 2011). This discrepancy has led to national concern over how to get students, especially women, to have more positive attitudes and interest in pursuing careers in STEM fields. The U.S. Department of Commerce (2011) reports that STEM workers play a key role in the sustained growth and stability of the US economy, and are a critical component to helping the U.S. win the future. The present studies examine possible strategies to increase both men and women students' interest to enroll in STEM courses and pursue STEM careers. Specifically, the central hypothesis is that students who are directed to think about successful same-sex role models will have increased behavioral intentions to enroll in STEM courses and pursue STEM careers.

Role Models and Stereotype Threat

One reason women may be deterred from mathematics, and STEM fields in general, is because they routinely encounter negative stereotypes about their math ability (Quinn & Spencer, 2001). Women are less confident about math, take fewer mathematics courses, and have more negative attitudes toward math (Hyde, Fennema, Ryan, Frost, & Hopp, 1990). Female undergraduates, even those who are pursuing math-related majors, generally possess a stereotypical association of math with men and also show a stronger negative association with the domain of math compared with their male peers (Nosek, Banaji, & Greenwald, 2002). In addition, factors such as fewer role models, preparational disadvantages, and societal views that subjects like mathematics are unfeminine may make it difficult for women to identify with mathematics (Steele, 1997). If a woman overcomes such obstacles and becomes identified with mathematics, she may then face stereotype threat. Steele and Aronson (1995) define stereotype threat as the immediate situational threat that comes from the knowledge that there are negative stereotypes about one's group. When people experience stereotype threat, they fear being judged and treated stereotypically, or that they might confirm the stereotype. In this context, stereotype threat for women can lead to decrements in math performance and disengagement from math (Steele & Aronson, 1995).

Previous studies have shown that women's math performance under stereotype threat can be improved by making successful role models more salient and accessible (McIntyre, Paulson, Taylor, Morin & Lord, 2011; Taylor, Lord, McIntyre & Paulson, 2011). In one study, women were placed under stereotype threat by being reminded of the stereotype that women do not perform as well as men in mathematics. Then, the women read about a successful female role model who was either deserving or undeserving of her success (McIntyre et al.). The women then took a difficult math test. Women who read about a successful woman role model who was deserving of her success were able to overcome the stereotype threat and performed just as well on the test as a no-threat control. In a related study, women who read a short biography of Hillary Clinton and thought she was a deserving role model were also able to overcome stereotype threat and scored as well on a math test as a no-threat control (Taylor et al.). The present research addresses effects of role models on interests and attitudes, not performance decrements, but stereotype threat studies that included role models might still be relevant.

Role Models, Interests, and Attitudes

In addition to improving women's math performance under stereotype threat, role models have also been shown to inspire and promote attitude change toward a variety of targets, although there is some disagreement as to the most effective type of role model. One problem is that exposure to role models can have different effects, sometimes imbuing individuals with inspiration and at other times leading individuals to feel demoralized because success seems out of reach. Previous research has exposed students to domain relevant role models chosen by the experimenter in order to induce feelings of inspiration and attitude change (Lockwood & Kunda, 1997; Marx, Stapel, & Muller, 2005). Lockwood and Kunda (1997), for example, found that accounting students were more inspired by accountant role models than teacher role models, whereas future teachers were more inspired by teacher role models than accountant role models. This is possibly because role models in the same profession are viewed as more similar and relevant to the individual.

What would be the most effective role model for convincing individuals to pursue STEM fields? One may initially think to use successful role models in STEM fields, since that seems most relevant to the goal at hand. One potential problem with this approach is that STEM role models may seem too dissimilar from the average person. Previous research, for example, has shown that STEM role models may be ineffective if they are stereotypical STEM individuals (i.e., nerdy, unkempt, enjoy science fiction), leading students to feel dissimilar from them and, as a result, underestimate their own likelihood of succeeding in STEM fields (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). In this instance, STEM-stereotypical role models who are supposed to inspire emulation may backfire and discourage those they were meant to benefit. Previously mentioned studies (McIntyre et al., 2011; Taylor et al., 2011) examining stereotype threat found that successful same-sex role models in domains unrelated to mathematics were effective at restoring women's math performance. These results suggest that the domain the role model excels in is perhaps not as important as other characteristics, such as role model similarity or deservingness. The problem is how does one choose a role model that the majority of students find deserving, similar, and inspirational, when students have such diverse beliefs and backgrounds? One answer might be found in research on directed thinking.

Directed Thinking and Role Models

It is possible that the most effective role models at inspiring students to have more positive attitudes toward STEM fields are not experimenter chosen role models. Previous research typically had students read about or interact with successful same-sex role models in STEM fields (e.g., Stout, Dasgupta, Hunsinger, & McManus, 2011; Lockwood & Kunda, 1997; Marx, Stapel, & Muller, 2005), which is only one type of persuasive communication. Specifically, this type of persuasive communication, one that provides new information or arguments, is a technique that McGuire and McGuire (1991) called "persuasion from without." To encourage students to pursue STEM careers, for example, one might provide students with statistics on employment opportunities and salary earnings in STEM fields. This type of persuasive strategy has been researched thoroughly and proven effective (Petty & Cacioppo, 1986), but it is not the only effective method of persuasive communication. McGuire and McGuire proposed that it may also be possible to change attitudes by directing people to think differently about what they already know, without providing any new information or arguments—a technique they called “persuasion from within” or directed thinking.

This technique is appealing because individuals generate their own ideas based on their unique mental representations and beliefs, as opposed to reading someone else’s arguments that may or may not be relevant. McGuire and McGuire (1991) claimed that the effectiveness of directed thinking strategies relies on making desirable information more salient or accessible. Previous research has shown that evaluative responses toward an attitude object can vary from one time to the next, depending on what subset of knowledge comes to mind (Lord & Lepper, 1999; Wilson & Hodges, 1992). The same student, for example, may activate thoughts about the health benefits of exercising on one occasion, and on another occasion associate exercise with decreased time to do homework, producing different responses toward exercising on each occasion. Most people have both negative and positive thoughts about any given attitude object, so the goal of directed thinking is to get desirable thoughts to come to mind more often when forming an evaluative response. In one example of directed thinking, McGuire and McGuire (1996) had students list either positive or negative self-characteristics, and then complete a standardized self-esteem measure. Students who were directed to list positive characteristics subsequently reported having higher self-esteem than students who were directed to list negative characteristics. McGuire and McGuire (1996) speculated this was because the directed thinking manipulation enhanced the salience of different types of information (positive or negative characteristics) at the time students completed the self-esteem measure, influencing students’ self-perceptions.

While McGuire and McGuire (1996) showed that directed thinking can be used to alter students' momentary self-esteem, other researchers have used directed thinking to encourage self-beneficial behaviors. Most of these studies have directed students to generate either actions that lead to performing the target behavior, or positive consequences that would result from performing the target behavior (Ratcliff et al., 1999; Ten Eyck, Gresky, & Lord, 2008). Students who generated actions they could take to study more, for example, reported greater behavioral intentions to study more in the future compared to those that generated reasons they should study more. In another example, sedentary students who generated actions they could take to exercise more over a 9-week period reported increased exercised behavior and performed better on a fitness test at the end of 9 weeks compared to students who generated reasons to exercise more or a baseline group who did not engage in directed thinking (Ten Eyck et al., 2008).

It might not make sense for students to generate actions they could take to pursue STEM fields, but it is possible that directing students to generate their own role models would be an effective manipulation. Thinking about self-generated role models, as opposed to experimenter chosen role models, might have a greater likelihood of inducing inspiration in students because the role models are relevant to each individual. Hillary Clinton, for example, was an effective role model in restoring women's math performance under stereotype threat when students perceived her as deserving of her success, but did not work for students who perceived her as undeserving (Taylor et al., 2011). Again, this suggests that not everyone is inspired by the same successful superstars. It is possible that having students generate role models will make the role models more accessible and salient at the time they evaluate their attitudes toward STEM fields, potentially inspiring students to tackle something difficult they may not have attempted otherwise.

The overall research strategy in the present studies was to measure participants' interest in taking STEM courses and pursuing STEM careers, direct participants to think in depth about successful role models of the same sex, and re-measure participants' interest in taking STEM courses and pursuing STEM careers. It was hypothesized that the directed thinking manipulation would be effective through making participants' self-generated role models more accessible and salient, which would increase participants' interest and intentions to pursue a STEM career. This was accomplished in three ways. First, Experiment 1 tested whether generating same-sex role models might increase interest in math and science. Experiment 2 tested whether the number of role models students generated might influence these effects on interest in math and science. Lastly, Experiment 3 tested whether students who read about resilient role models who had overcome obstacles to succeed might increase interest in math and science.

Experiment 1

The purpose of Experiment 1 was to show that directed thinking about role models is effective at increasing interest in STEM fields. Although much of the previous research has focused specifically on women, there is no reason to believe that directed thinking about role models would not be effective for men. Women are underrepresented in STEM fields compared to men, but STEM fields are short on applicants regardless of gender, which is why we felt it was important to also include men in the study. Students were instructed to generate successful same-sex role models, and then reported their attitudes toward STEM fields. We chose same-sex role models because women in particular may benefit more from thinking about inspirational women when considering entering a male dominated field.

Method

Participants. Forty-two undergraduate students (33 women and 9 men) participated for course credit.[1]

Materials and procedure. The procedure had four main parts: Baseline intentions to take STEM courses and pursue STEM careers, generating role models or favorite foods, a filler activity, and post-manipulation measures.

Baseline measures. Participants' baseline measures were completed two days prior to the role model manipulation. The first part of the questionnaire asked for basic background information and courses that the participants had taken and planned on taking. In addition, participants rated their interest in pursuing a STEM career, as well as their interest in specific jobs within Science, Technology, Engineering, and Mathematics. All of these questions were on 11-point scales (*-5 = Not at all likely/interested; 5 = Extremely likely/interested*).

Individual differences. Several additional questionnaires were included because they might have moderated the predicted results. Participants completed the Interpersonal Dependency Inventory, which had three subscales that measured emotional reliance on other people, assertion of autonomy, and lack of social self-confidence (Hirschfeld et al., 1977). Students who were emotionally reliant on others, low in asserting autonomy, and low in self-confidence might be less likely to pursue STEM careers initially because they lack the confidence to take on such difficult coursework, but may feel especially inspired after

[1] No significant gender interactions emerged, possibly because there were too few male participants.

thinking about role models. Finally, students were asked how important it was for the student to be successful in the future, how important it was for them to support themselves financially and make a good salary, whether the student planned on working full-time after college, as well as the importance of getting married and having children. Women, for example, may vary in the emphasis they place on achieving financial independence compared to starting a family, which may in turn influence their perceptions of STEM careers. These questions ended the baseline attitude measure and Session 1 (Appendix A).

Role model manipulation. In the second session, two days later, participants were randomly assigned to either generate successful same-sex role models (*n* = 22) or their favorite foods (*n* = 20). Students in the role model condition were asked to list as many successful same-sex role models as they could think of, and explain why they thought each person was successful. Participants in the control condition listed as many of their favorite foods as they could think of, and explained why each food was appealing. All students engaged in similar thought processes, but we expected only directed thinking about successful same-sex role models to increase students' attitudes toward pursuing STEM classes and careers (Appendix B). Following the manipulation, students worked for 18 min on a filler task consisting of Sudoku puzzles. Eighteen minutes was chosen as the interval time because McGuire and McGuire (1996) found this to be the optimum amount of time for directed thinking manipulations to show an observable effect.

Post-manipulation measures. At the very end of the second session, students completed the post-manipulation measures. The post-manipulation measures were almost identical to the baseline measures, except the individual difference questions were omitted. In addition, some manipulation checks were added at the very end. Students were asked to report how easy it was to generate role models (or their favorite foods) on a 7-point scale (*1 = not at all easy; 7 = extremely easy*), to describe the purpose of the study, and to report any comments or concerns they had.

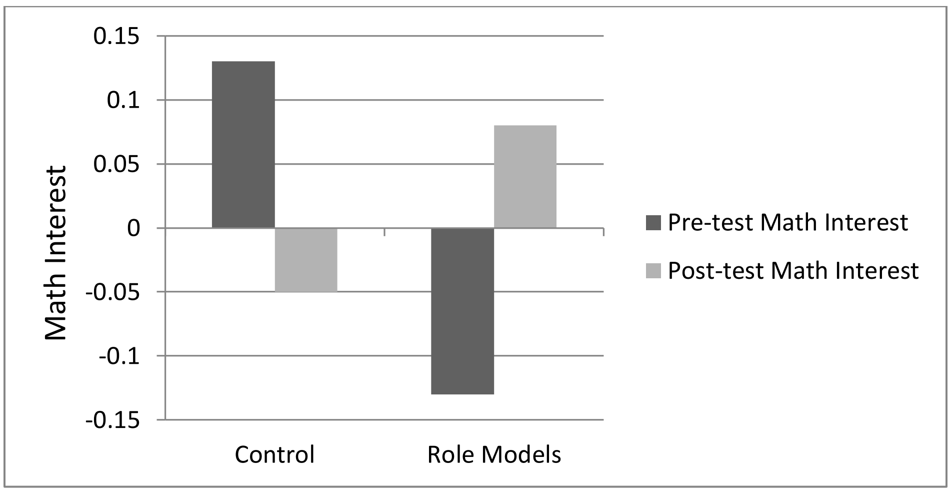
Results and Discussion

Interest in Math and Science. For the purpose of the analyses, we focused specifically on interest and intentions to take math and science courses and pursue careers in these domains. A factor analysis using varimax rotation was performed on nine questions assessing attitudes toward math and science, and there were two clear sets of factor loadings. One factor consisted of four questions assessing attitudes toward math (*interest in math, likelihood of taking unrequired math courses, number of additional math courses one plans on taking, likelihood of pursuing a math career*, $\alpha = .75$) and the other factor consisted of five questions assessing attitudes toward science (*interest in biology/chemistry, likelihood to take unrequired science classes, number of additional science classes one plans on taking, likelihood of pursuing STEM career, likelihood of pursuing a science career*, $\alpha = .84$)(see Appendix C for factor loadings). Because some of the questions were open-ended while others were scaled, each variable was standardized. The resulting *z* scores were averaged to form two "math" and "science" dependent variables. Experiments 2 and 3 used the same method for obtaining the dependent measures as in Experiment 1. The same two sets of factor loadings were present in each study.

Mathematics Interest. A one-way between-subjects analysis of variance (ANOVA) was conducted to see if generating role models (vs. generating favorite foods) made participants' attitudes toward mathematics more positive. Because participants answered the same questions pre- and post-manipulation, we calculated difference scores for the composite math interest variable to assess attitude change. Generating role models had a significant effect on students' attitudes toward mathematics, $F(1, 40) = 9.37$, $p = .004$, $\eta_p^2 = .19$. Specifically, participants who generated role models had a positive increase in their attitudes toward mathematics after the manipulation ($M_{Change} = .21$, $SD = .45$) compared to students who generated their favorite foods ($M_{Change} = -.19$, $SD = .39$) (See Figure 1).

Figure 1

Self-reported math interest for students who generated role models or who generated their favorite foods (control)



Note: Math interest is a standardized factor composed of four items

Analyses were also conducted on the individual difference variables described in the Method Section (see Table 1). Regression analyses were conducted examining the main effect of each individual difference measure on attitude change scores toward math, as well as the interaction between condition (role model vs. no role model) and the individual difference measure predicting attitude change scores toward math. No significant main effects or interactions emerged.

Table 1

Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitude change toward math

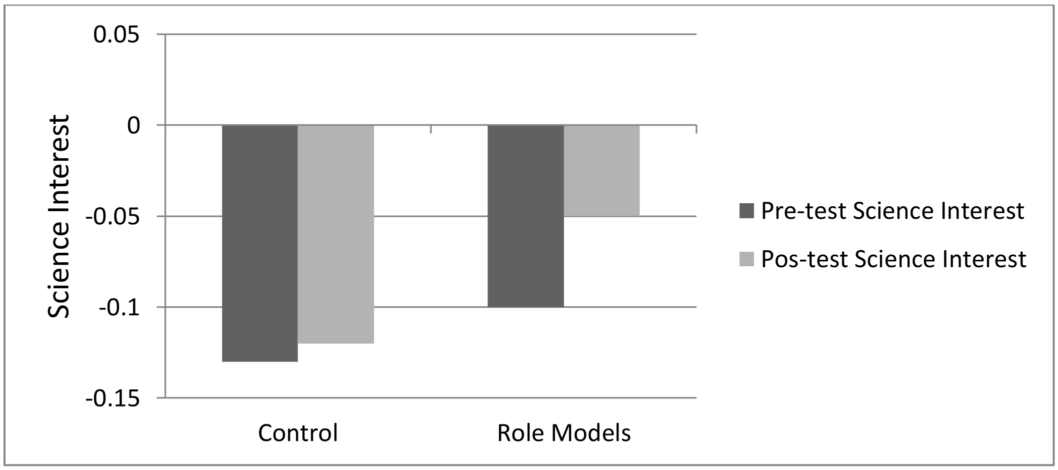
	Main Effect		*Interaction*	
	t	*p*	*t*	*p*
Individual Difference Measure				
Emotional reliance subscale	1.61	0.12	*1.78*	*0.08*
Lack of confidence subscale	0.27	0.79	0.47	0.64
Assertion of autonomy subscale	-0.57	0.57	1.03	0.31
"How important to you is it to be successful?"	1.24	0.22	-0.38	0.71
"How important to you is being able to support yourself financially?"	0.41	0.69	0.34	0.74
"How important to you is having a career where you make a good salary?"	0.21	0.83	-0.72	0.48
"How important to you is having a career you enjoy?"	0.56	0.58	-0.11	0.91
"How likely is it that you will work full-time after graduation?"	*-1.95*	*0.06*	0.46	0.65
"How important is it that you will be married in the future?"	0.12	0.90	-0.19	0.85
"How important is it that you will have children in the future?"	-1.11	0.27	0.33	0.74

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

Science Interest. A one-way between subjects analysis of variance (ANOVA) was conducted to see if generating role models (vs. generating favorite foods) had an effect on students' attitudes toward science. Because participants answered the same questions pre and post-manipulation, we calculated difference scores for the composite science interest variable to assess attitude change. Generating role models did not have a significant effect on students' attitudes toward science, $F < 1$ (See Figure 2 for pre and posttest means).

Figure 2

Self-reported science interest for students who generated role models or who generated their favorite foods (control)



Note: Science interest is a standardized factor composed of five items

Regression analyses were conducted examining the main effect of each individual difference measure on attitude change scores toward science, as well as the interaction between condition (role model vs. no role model) and the individual difference measure in predicting attitude change scores toward science. No significant main effects or interactions emerged (See Table 2).

Role models generated. Students were directed to generate their own successful same-sex role models or their favorite foods. It was easier for students to generate their favorite foods ($M = 5.05$, $SD = 1.57$) than role models ($M = 4.05$, $SD = 1.59$). In addition, students listed more of their favorite foods ($M = 7.65$, $SD = 1.57$) than role models ($M = 5.27$, $SD = 1.88$) during the allotted time. Simple linear regressions were conducted to see if generation ease or number of role models listed predicted math or science attitudes, but no significant findings emerged, *p*s > .05.[2]

Table 2

Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitude change toward science

	Main Effect		*Interaction*	
	t	*p*	*t*	*p*
Individual Difference Measure				
Emotional reliance subscale	-0.67	0.51	-0.18	0.86
Lack of confidence subscale	1.23	0.23	0.05	0.96
Assertion of autonomy subscale	-0.66	0.52	0.04	0.97
"How important to you is it to be successful?"	-0.04	0.97	0.39	0.70
"How important to you is being able to support yourself financially?"	-0.50	0.62	-0.05	0.96
"How important to you is having a career where you make a good salary?"	-0.53	0.60	0.86	0.40
"How important to you is having a career you enjoy?"	-0.04	0.97	-1.16	0.26
"How likely is it that you will work full-time after graduation?"	0.70	0.49	0.26	0.80
"How important is it that you will be married in the future?"	-1.46	0.15	0.64	0.52
"How important is it that you will have children in the future?"	0.95	0.35	0.06	0.95

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

[2]Regression analyses were also conducted looking at the interaction between condition (favorite foods vs. role models) and ease of generation for math and science attitudes. No significant interactions emerged, *p* > .05. A second set of regression analyses examined the interaction between condition and number of directed thinking items listed. No significant effects emerged, *p* > .05. Ease of generation was further explored in Experiment 2.

Another potential factor that may have influenced the results was the type of role models students listed. It was possible that certain types of role models were more effective at inspiring students than others, so we examined the most popular role models that students generated. Students overwhelmingly listed family and friends as their successful same-sex role models (See Table 3), which was different from previous studies where the most popular role models listed by students were famous individuals (Taylor et al., 2011). It is possible that famous role models may be more inspirational because these individuals typically have more achievements than a family member or best friend.[3]

Summary of Experiment 1. Experiment 1 provided some preliminary evidence that directed thinking about role models can make attitudes toward pursuing mathematics more positive, although there were some issues that needed to be addressed. First, it is unclear why the manipulation worked for mathematics and not science. It may be possible that students perceived the usefulness and practicality of taking extra mathematics courses, but they avoid mathematics because of the perceived difficulty of the material. In comparison, science classes may be perceived as less versatile and necessary. In order for role models to have a positive effect on science attitudes, individuals may need to also have moderate interest in the field and perceive the field as being difficult.

In addition, while the role model manipulation produced significant changes in math interest, it would have been preferable if the control condition did not have a decrease

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[3]We divided the role models into three categories based on whether they were close to the student (e.g., parent or best friend), known to the student (e.g., teacher or pastor), or a famous individual (e.g., Hillary Clinton or Oprah), and counted how many role models fell into each category for each student. Each category was then divided by the student's total number of role models generated, so we had a percentage of famous, known, and close role models generated for each student. In order to see if type of role model had an effect, simple linear regressions were used with each percentage entered as a predictor of math and science attitudes. No significant effects emerged, ps > .05. The same analyses were conducted in Experiment 2 with no significant findings, ps > .05.

in attitudes, but one possible explanation may have been the length of the survey measure. Participants completed the same lengthy survey with the same questions two days apart, and it is possible participants felt unmotivated to answer these questions again. The results do provide some preliminary evidence that generating role models might be a useful tool to increase intentions to pursue mathematics related courses and careers.

Table 3

Summary of the most popular role models listed by students

Role Models Listed	**N**	%
Parent	19	16.52%
Friend	14	12.17%
Grandparent	11	9.57%
Political Figure	10	8.70%
Actress/Singer	8	6.96%
Oprah	7	6.09%
Sibling	7	6.09%
Activist or Humanitarian	7	6.09%
Teacher	6	5.22%
Sorority Leader	6	5.22%

Note: There were only 2 male students in the role model condition, so both men and women are included in the table. *N* represents the frequency the role model was listed, and *%* represents the percentage the role model comprised of in the total sample of role models.

Another unforeseen finding was that students overwhelmingly listed family and friends as their role models, which may have affected the results. It is possible that well-known role models may be better at inducing a state of inspiration, since they likely have a greater list of impressive achievements. Lastly, the number of role models that students generated may have influenced the results. Students were instructed to list as many role models as they could and explain why they thought each person was successful in 10 min. They actually listed anywhere from two to nine role models – a wide variance in following instructions. Both the directed thinking manipulation instructions and the number of role models students generate may need to be more carefully controlled in order to determine whether directed thinking about role models is effective for making attitudes more positive toward math and science.

Experiment 2

The goal of Experiment 2 was to build upon the findings of Experiment 1 through making changes to the directed thinking instructions. We thought one way to strengthen the effectiveness of the manipulation was to instruct students to generate *well known* role models, perhaps leading them to generate individuals they found more inspirational than friends and family. In addition, Experiment 2 investigated the optimum number of role models that students should generate in order to make the manipulation most effective. In Experiment 1, students listed five to six role models on average. One may think that increasing the number of role models students generate would increase the benefits of the manipulation, but it is possible that after a point, increasing the number of role models may be a decrement to attitude change. Previous research, for example, has shown that ease of idea generation can influence subsequent judgments of self-assertiveness (Schwarz et al., 1991). For example, students who had to list six examples of themselves being assertive subsequently rated themselves as being more assertive than students who had the more difficult task of listing 12 examples of their assertiveness (Schwarz et al., 1991). In another study, people who found it easy to generate a few positive characteristics of BMW cars subsequently reported greater behavioral intentions to purchase a BMW car than did people who found it difficult to generate many positive characteristics (Wänke, Bohner & Jurkowitsch, 1997). A related study also showed that when students found it easy to come up with reasons to take public transportation they were more likely to report positive attitudes toward public transportation, compared to students who were induced to find idea generation difficult (Haddock, Rothman & Schwarz, 1996). Ease of idea generation is typically manipulated by having people generate few versus many ideas. It is plausible that, based on the previous research, directing students to generate a few role models might be more effective than directing students to generate many role models. Students who have to generate many successful same-sex role models may find the task difficult and conclude there are not many successful role models after all. Specifically, the prediction for Experiment 2 was that students who were directed to generate *six well known* role models (easy) would subsequently report more positive attitudes toward math and science than students who were directed to generate *12 well known* role models (difficult) or their favorite foods (control).

Method

Participants. Eighty undergraduate students (59 women and 21 men) participated for course credit.[4]

Materials and procedure. The procedure was similar to Experiment 1 and had four main parts: Baseline intentions to take STEM courses and pursue STEM careers, generating role models or favorite foods, a filler activity, and post-manipulation measures.

Baseline measures. Participants' baseline measures were completed 2 days prior to the role model manipulation. The baseline measures were the same items used in

[4] No significant gender interactions emerged

Experiment 1 to assess interest in math and science. Participants also completed the same 10 individual difference measures as Experiment 1. This concluded the first session.

Role model manipulation. In the second session, 2 days later, students were randomly assigned to either generate six well known successful same-sex role models (*n* = 27), 12 well known successful same-sex role models (*n* = 27), or 12 of their favorite foods (*n* = 26). Students in the six role model condition also generated six of their favorite foods (always before they generated role models) so that everyone generated the same number of items and the tasks were comparable in length. For the role model task students explained why they thought each person was successful, whereas in the favorite foods task students explained why each food was appealing (Appendix D). All students engaged in similar thought processes, but generating six successful role models was expected to be most effective at increasing interest in math and science. Students were given 12 min to work on the task. Following the manipulation, students worked for 18 min on a filler task. Students were instructed to list things they associated with three foreign countries (Canada, France, & Mexico). A similar filler task was successfully used by McGuire and McGuire (1996), and we wanted to use something in Experiment 2 that was unrelated to mathematics (as opposed to Sudoku puzzles in Experiment 1).

Post-manipulation measure. At the end of the second session, students completed the post-manipulation measures. The post-manipulation measures were almost identical to the baseline measures, except the individual difference questions were omitted. In addition, some manipulation checks were added at the very end. Students were asked to report how hard it was to generate role models (or their favorite foods) on a 7-point scale (*1 = very easy;*

7 = very hard), to describe the purpose of the study, and to report any comments or concerns they had.

Results and Discussion

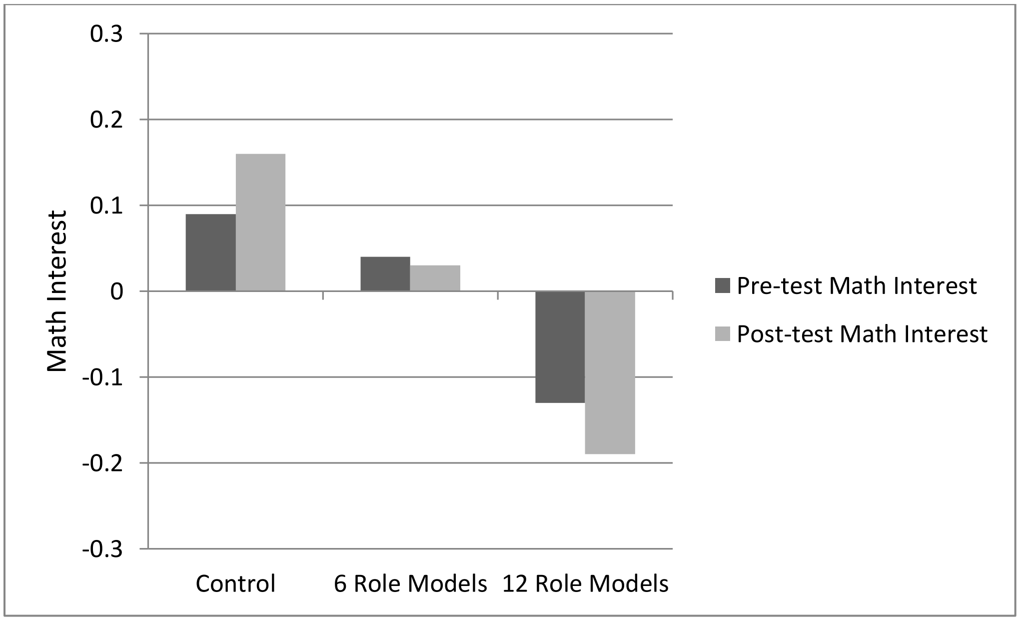
Manipulation checks. Students who were instructed to generate 12 role models listed 9.04 (*SD* = 2.98) role models on average, students who were instructed to list six role models listed 4.96 (*SD* = 1.81) role models on average, and students who were asked to list 12 of their favorite foods listed 11.65 (*SD* = 1.02) foods on average. As for the difficulty of the tasks, students who were told to generate 12 role models did not report the task as being more difficult (*M* = 4.89, *SD* = 1.48) compared to students who were told to generate six role models (*M* = 4.70, *SD* = 1.71), and the foods task was reported as being easier than both role models tasks (*M* = 3.50, *SD* = 1.70). In short, the 6 vs. 12 role model instructions did not create the intended differences in subjective ease.

Interest in Math and Science. For the purpose of the analyses, we focused specifically on interest and intentions to take math and science courses and pursue careers in these domains. As in Experiment 1, the same nine items were standardized and made into two composite measures representing attitudes toward math and science.

Mathematics Interest. A one-way between-subjects analysis of variance (ANOVA) was conducted to see if generating 6 role models, 12 role models, or one's favorite foods (control) had an effect on students' attitudes toward mathematics. Because participants answered the same questions pre and post-manipulation, we calculated difference scores for the composite math interest variable to assess attitude change. The manipulation did not have a significant effect on students' attitudes toward mathematics, $F(2, 77) = 1.15$, $p = .32$. There was little change in attitudes toward math across all three groups (See Figure 3).

Figure 3

Self-reported math interest for students who generated 6 role models, 12 role models, or who generated their favorite foods (control)



Note: Math interest is a standardized factor composed of four items

Although the role model manipulation failed to have an effect on attitudes toward math, we still examined the 10 individual difference measures that could have moderated the results. Again, these measures included three subscales from the Interpersonal Dependency Inventory (Hirschfeld et al., 1977) and several questions about the importance of job salary, career enjoyment, and starting a family. Regression analyses were conducted examining the main effect of each individual difference measure on attitude change scores toward math, as well as the interaction between condition and the individual difference measure predicting attitude change scores toward math. The control condition was always dummy coded as “0,” so the 6 role model and 12 role model conditions were individually compared to the control. Few significant findings emerged (See Table 4 for summary of results). There was a significant main effect for assertion of autonomy, such that students who reported being more autonomous had more positive attitude change toward mathematics, $t = 2.16$, $p = .03$. No other findings were significant.

Science Interest. Next, a one-way between subjects analysis of variance (ANOVA) was conducted to see if generating 6 role models, 12 role models, or one's favorite foods (control) had an effect on students' attitudes toward science. Because participants answered the same questions pre and post-manipulation, we calculated difference scores for the composite science interest variable to assess attitude change. The results indicate the manipulation did not have a significant effect on students' attitudes toward science, $F < 1$ (See Figure 4).

In order to test for possible moderators, the same regression analyses were performed as for the math dependent variable. A few significant findings emerged for the 10 individual difference measures tested predicting attitude change toward science (See Table 5). First, there was a main effect for emotional reliance, such that students who were higher in emotional reliance on others (i.e., needing a great deal of social support to succeed) had less positive attitude change toward science, $t = -1.98$, $p = .05$. In addition, there were two significant interactions, in which the control condition stood out. These interactions were not found for the math dependent measure, or at all in Experiment 1. It is possible that these interactions were significant simply because of chance and the number of analyses that were conducted. If consistent findings with the same individual difference measures were present in Experiment 3, further investigation would be warranted.

Table 4

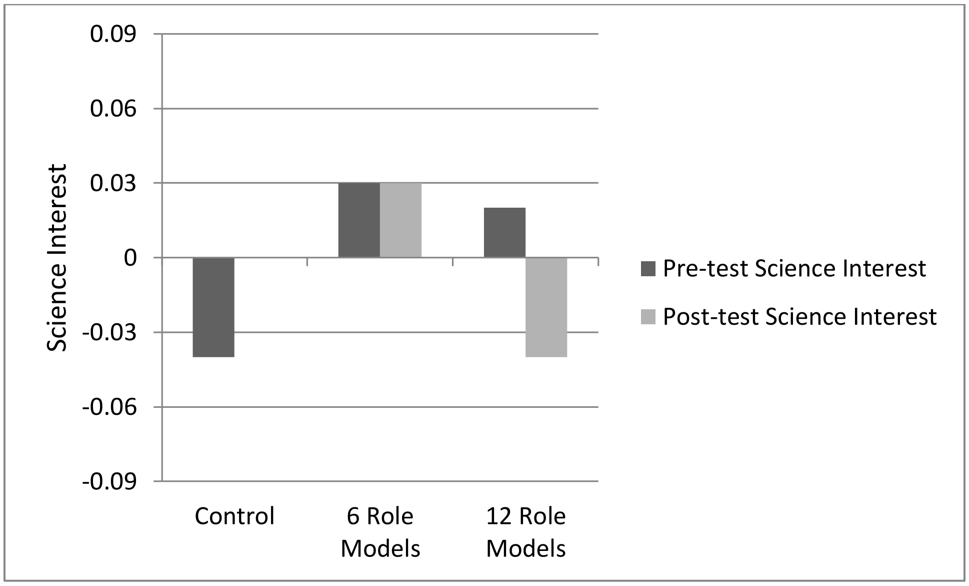
Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitude change toward math

	Main Effect		*Interaction (6 role models vs. control)*		*Interaction (12 role models vs. control)*	
	t	*p*	*t*	*p*	*t*	*p*
Individual Difference Measure						
Emotional reliance subscale	-0.99	0.33	0.40	0.69	-0.62	0.54
Lack of confidence subscale	0.16	0.87	0.59	0.56	-0.13	0.90
Assertion of autonomy subscale	2.16	0.03*	-1.39	0.17	-0.91	0.37
"How important to you is it to be successful?"	0.96	0.34	1.68	*0.10*	1.60	0.11
"How important to you is being able to support yourself financially?"	0.93	0.36	1.78	*0.08*	1.43	0.16
"How important to you is having a career where you make a good salary?"	0.17	0.87	1.47	0.15	-0.38	0.71
"How important to you is having a career you enjoy?"	-1.83	*0.07*	-0.65	0.52	0.60	0.55
"How likely is it that you will work full-time after graduation?"	0.36	0.72	0.08	0.99	-0.19	0.85
"How important is it that you will be married in the future?"	-1.29	0.20	1.25	0.22	-0.26	0.79
"How important is it that you will have children in the future?"	-0.82	0.42	-1.14	0.32	1.00	0.26

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

Figure 4

Self-reported science interest for students who generated 6 role models, 12 role models, or who generated their favorite foods (control)



Note: Science interest is a standardized factor composed of five items

Role models listed. Similar to Experiment 1, students were directed to generate their own successful same-sex role models. Some students were directed to generate six whereas other students were directed to generate 12 role models. Different from Experiment 1, students were specifically told to list *well known* role models in hopes of improving attitude change scores. We thought that famous role models might be more inspirational than family and friends, possibly because of the number and gravity of their achievements. In the current experiment, both men and women listed famous individuals more often compared to Experiment 1, but women still listed family and friends to a great degree (See Table 6). Despite the greater number of well-known role models listed by students, there was little to no attitude change in attitudes toward math and science. It is possible that the role models that are generated need to be domain specific to math and science, or perhaps it is important that the role models have overcome obstacles in order to achieve their success to be truly inspirational (McIntyre, Paulson & Lord, 2003).

Table 5

Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitude change toward science

	Main Effect		*Interaction (6 role models vs. control)*		*Interaction (12 role models vs. control)*	
	t	*P*	*t*	*p*	*t*	*p*
Individual Difference Measure						
Emotional reliance subscale	-1.98	0.05*	1.33	0.19	1.13	0.26
Lack of confidence subscale	-0.02	0.99	1.52	0.13	2.98	0.004*
Assertion of autonomy subscale	0.94	0.35	0.44	0.67	0.88	0.38
"How important to you is it to be successful?"	-1.54	0.13	-0.19	0.85	0.57	0.57
"How important to you is being able to support yourself financially?"	0.26	0.79	-0.01	0.99	0.38	0.70
"How important to you is having a career where you make a good salary?"	-1.76	0.08	-0.25	0.81	-0.01	0.99
"How important to you is having a career you enjoy?"	-0.37	0.71	-0.01	0.99	-0.39	0.70
"How likely is it that you will work full-time after graduation?"	0.12	0.91	-1.98	0.05*	0.49	0.63
"How important is it that you will be married in the future?"	-0.61	0.54	0.64	0.52	0.57	0.57
"How important is it that you will have children in the future?"	0.12	0.91	-0.25	0.80	-0.70	0.48

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

Table 6

Summary of the most popular role models listed by men and women students

Role Models Listed by Women	*N*	*%*
Famous Actress or Musician	47	17.22%
Mother	32	11.72%
Friend	32	11.72%
Grandmother	18	6.59%
Oprah	18	6.59%
Sister	10	3.66%
Aunt	9	3.30%
Michelle Obama	6	2.20%
Hilary Clinton	6	2.20%
Mother Theresa	5	1.83%
Ellen Degeneres	5	1.83%
Condoleeza Rice	5	1.83%

Role Models Listed by Men	*N*	*%*
Famous Athlete	26	26.80%
Political Figure	13	13.40%
Father	8	8.25%
Actor/Musician	8	8.25%
Religious Figure	5	5.15%
Philosophers	5	5.15%
Grandfather	3	3.09%
Friend	3	3.09%
Martin Luther King Jr.	3	3.09%
Uncle	3	3.09%

Note: *N* represents the frequency the role model was listed, and % represents the percentage the role model comprised of in the total sample of role models.

Summary of Experiment 2. The results of Experiment 2 did not support the hypothesis, and few significant findings emerged. There was a trend where individuals who listed 12 role models did seem to have more negative attitude change than students who listed six role models, but neither differed from the control. One problem was that there was no difference between groups in how they perceived the difficulty of the role model generation task. Students who generated 12 role models should have thought the task was more difficult in order for the manipulation to work properly (Schwarz et al., 1991). This failure of the manipulation could possibly be attributed to the experimenters not choosing the correct number of role models for students to generate. Perhaps three vs. nine role models would have been more effective, but we chose six as the easy generation condition because that was the average number of role models students listed in Experiment 1. Another potential problem could have been that students did not generate the exact number of role models that they were instructed to generate. While the two groups were significantly different from one another, there was a lot of variability within groups that may have affected the outcome.

In addition to the ease of generation manipulation, we thought that instructing students to list well-known role models would improve the manipulation. The results for Experiment 2 did not support this prediction. It is possible that the instructions were still too vague, and we were not guiding students to generate appropriate role models that induce inspiration. It may be more important for the role models to have overcome obstacles and worked hard to achieve their success if they are to be inspirational to students. Some of the role models participants listed were talented individuals, but not necessarily resilient. It is also possible that students were not thinking in depth about people who they felt were successful *role models*, and instead just listed famous people they thought were talented.

Experiment 3

The first two experiments provided only minimal evidence that self-generated role models are effective at making attitudes toward math and science more positive. One potential problem with both studies was that students completed the same lengthy survey 2 days apart. It is possible that students felt unmotivated to answer the same survey 2 days later. In order to control for this possibility, Experiment 3 eliminated the pre-test measures and examined post-manipulation attitudes only. We also had intended self-generated role models to be more meaningful and inspirational to students, but it is likely that self-generated role models still need to embody a specific set of characteristics in order to inspire. Students may not be that discriminating in recognizing people who would make inspirational role models. It is likely that in order for a role model to inspire an individual to overcome insecurities and approach math and science classes, the role model needs to have some sort of intellect and overcome obstacles in order to reach worthy goals. Experiment 3 stepped back from the directed thinking approach, and instead focused on exposing students to role models who were resilient and achieved success through hard work and perseverance. Previous research has shown that women who were induced with stereotype threat and then read about four individual women who were resilient and achieved success in architecture, law, medicine, and invention subsequently performed significantly better on a math test compared to women who read about successful corporations (McIntyre et al., 2003). The present study expanded on the previous work by testing whether reading about fictional successful same-sex role models who were deserving of their success could increase students' attitudes toward pursuing math and science compared to students who just read about successful corporations.

Method

Participants. Ninety-seven undergraduate students (46 women and 51 men) participated for course credit.[5]

Materials and procedure. Experiment 3 was different from the previous two experiments in that no baseline measures were assessed. Students arrived for one experimental session that consisted of three main parts: individual difference measures, role model manipulation, and dependent measures.

Individual difference measures. Upon arriving to the experiment, students received an experimental packet and were told they would be participating in several small unrelated studies. As part of the cover story, students were told that because it was the end of the semester the current study had been designed to pre-test materials for future studies and give students an opportunity to receive last minute experimental credit. Students were asked to complete background information and the same set of individual difference measures that were used in the previous two studies. In addition, students were given the Modern Sexism Scale (Swim, Aikin, Hall, & Hunter, 1995) and the Bem Sex-Roles Inventory (Bem, 1974). Men and women who endorse more feminine gender roles may have less interest in math and science, or women who have high modern sexism scores may be more resistant to attitude change toward math and science.

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[5]No significant gender interactions emerged. Men had significantly more positive attitudes toward math in general. No gender differences emerged for science.

Role model manipulation. After completing the first set of surveys, students were told they were going to read and critique four articles supposedly drawn from *Entrepreneur* and *Who's Who*, that might be used in future studies. All students read four short excerpts that were comparable in length. Participants who were randomly assigned to the role model condition (n = 62) read about four successful same-sex role models who overcame obstacles in order to achieve success in their domains (i.e., a doctor, architect, lawyer, and entrepreneur). The articles were adapted from a previous study where they were successful in improving math performance in women under stereotype threat (McIntyre et al., 2003). One of the role models, for example, struggled with dyslexia, whereas another came from a low socioeconomic background and was raised by a single mother. Men and women in the role model condition read very similar stories, except the names were changed to match the participant's gender. After reading the story, students were asked how successful, similar, and likable the role model was on 0 (*not at all*) to 7 (*very much so*) scales. Students who were in the control condition (n = 35) read four excerpts about successful corporations that paralleled the role model excerpts (McIntyre et al.). Students read, for example, about a successful architecture firm instead of a successful architect (See Appendix D for example). The task took approximately 10 min. Following the manipulation, students worked for 18 min on a filler task. As in Experiment 2, students were instructed to list things they associated with three foreign countries (Canada, France, & Mexico).

Assessing Math and Science Interest. Following the filler activity, students completed the dependent measures. These included the same nine items that were used in the first two experiments to assess attitudes toward math and science. As a reminder, these items asked about general interest in math and science, desire to take unrequired courses in these fields, and pursue math and science related careers. Students then were then probed for suspicion and asked to report and concerns they may have had, and were dismissed.

Results and Discussion

Manipulation checks. Students reported how successful, likeable, and similar they were to each of the four role models they read about on 8-point scales (*0 = not at all*; *7 = very much so)*. Ratings were collapsed to form average success, likeability, and similarity indices. In general, students rated the role models as being highly successful (M = 6.00, SD = .68), moderately likeable (M = 3.96, SD = 1.44), and relatively low in similarity to them (M = 2.88, SD = 1.26). Success, likeability, and similarity scores were also averaged for each of the four role models. The architect role model who overcame educational disabilities (M = 4.72, SD = 1.16) and the neurosurgeon who overcame gender discrimination (M = 4.69, SD = 1.23) had the highest overall ratings, followed by the attorney who battled self-doubts (M = 4.03, SD = 1.21) and the business owner who battled depression after the loss of his/her family (M = 3.69, SD = 1.29).[6]

Interest in Math and Science. As in the first two experiments, the dependent measures consisted of two standardized composite factors that represented attitudes toward math and science (see Experiment 1 for more detail).

Mathematics Interest. A one-way between-subjects analysis of variance (ANOVA) was conducted to see if reading about successful same-sex role models versus successful corporations (control) had an effect on students' attitudes toward mathematics. Reading

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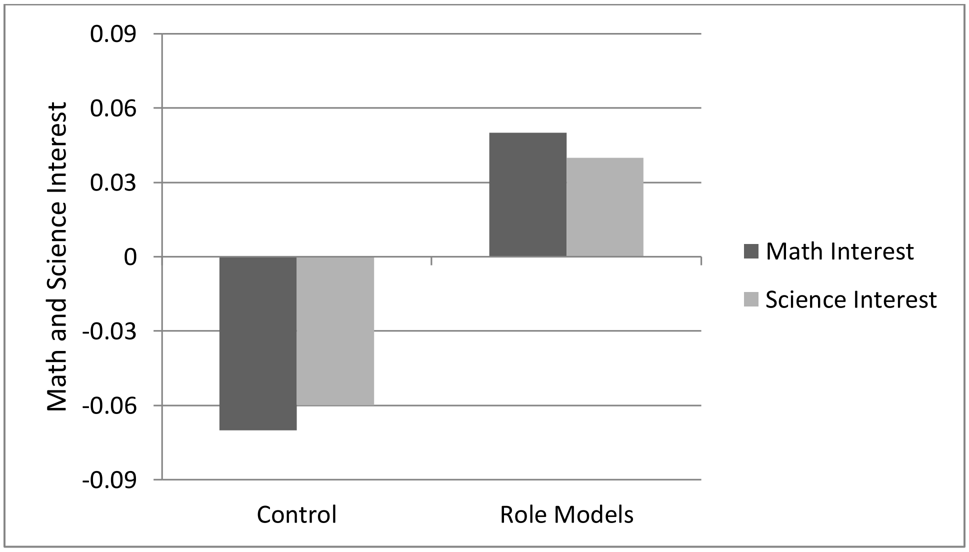
[6] Average role model success, likeability, and similarity did not predict math attitudes, nor did the composite scores for each role model, ps > .05. Two effects did emerge for science attitudes, such that increases in role model similarity (when controlling for likeability and success) predicted increases in science attitudes, t = 2.60, β = .43, p = .01, and increases in ratings of the neurosurgeon role model (while controlling for the other 3 role models) predicted increases in science attitudes, t = 2.73, β = .44, p < .01. No such effects were found for math attitudes.

about role models did not have a significant effect on students' attitudes toward mathematics, $F < 1$ (See Figure 5).

Figure 5

Self-reported math and science interest for students who read about four successful same-sex role models or four successful corporations (control)



Note: Math interest is a standardized factor composed of four items, and science interest is a standardized factor composed of five items.

Although the role model manipulation failed to have an effect on attitudes toward math, we still examined whether any of the individual difference measures moderated the results. In addition to the same 10 measures used in the first two experiments, the current experiment also had available the masculine and feminine gender role subscales from the Sex-Roles Inventory (Bem, 1974) and one score from the Modern Sexism Scale (Swim et al., 1995). Regression analyses were conducted examining the main effect of each individual difference measure on attitudes toward math, as well as the interaction between condition and each individual difference measure predicting attitudes toward math. The only significant findings that emerged were two main effects (See Table 7). Specifically, students who had high endorsement of feminine gender roles had more negative attitudes toward math, $t = -2.89$, $p = .005$, and students who scored higher on modern sexism also had more negative attitudes toward math, $t = -2.80$, $p = .006$. No other findings were significant.

Table 7

Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitudes toward math

	Main Effect		*Interaction*	
	t	*p*	*t*	*p*
Individual Difference Measure				
Emotional reliance subscale	-1.53	0.13	0.53	0.60
Lack of confidence subscale	-0.66	0.51	0.32	0.75
Assertion of autonomy subscale	0.30	0.77	-0.48	0.63
"How important to you is it to be successful?"	-1.04	0.30	-0.84	0.40
"How important to you is being able to support yourself financially?"	0.28	0.78	0.12	0.91
"How important to you is having a career where you make a good salary?"	1.45	0.15	-0.17	0.86
"How important to you is having a career you enjoy?"	0.26	0.80	0.17	0.87
"How likely is it that you will work full-time after graduation?"	1.03	0.30	-0.34	0.73
"How important is it that you will be married in the future?"	0.03	0.98	0.87	0.39
"How important is it that you will have children in the future?"	-0.26	0.80	0.70	0.48
Feminine Sex-Roles Composite	-2.89	0.005**	-0.76	0.44
Masculine Sex-Roles Composite	0.45	0.65	-0.24	0.81
Modern Sexism Composite	-2.80	0.006**	-0.49	0.21

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

Science Interest. Next, a one-way between-subjects analysis of variance (ANOVA) was conducted to see if reading about successful same-sex role models versus successful corporations had an effect on students' attitudes toward science. The manipulation did not have a significant effect on students' attitudes toward science, $F < 1$ (See Figure 5).

In order to test for possible moderators, the same regression analyses were performed for the math dependent variable. Of all the tests that were conducted, only one significant main effect emerged (See Table 8). Specifically, students who rated being able to support themselves financially as more important also had more positive attitudes toward science, $t = 2.49$, $p = .01$. No other significant findings emerged.

Summary of Experiment 3. The purpose of Experiment 3 was to test whether students who read about four successful same-sex role models who worked hard to achieve their success would be more likely to change their attitudes toward math and science than would students who read about successful corporations. We thought that reading about individuals who were resilient and worked hard to achieve their success might inspire students that they could also accomplish something difficult, like taking additional math and science courses that would benefit them in the future. The manipulation failed to inspire students to have more positive attitudes toward math or science. One reason may be that students did not perceive the role models as similar to themselves. The average reported similarity to the role models was low. This may be problematic, since previous research suggests that role model similarity is an important component to producing inspiration (Lockwood & Kunda, 1997).

The manipulation used in Experiment 3 was previously effective at alleviating mathematics stereotype threat in women (McIntyre et al., 2003), so we thought the manipulation could also be effective in inspiring students to pursue something difficult, like mathematics. This was not the case, perhaps because the role models were too dissimilar

Table 8

Summary of results for regression analyses examining the main effects and interactions of each individual difference measure predicting attitudes toward science

	Main Effect		*Interaction*	
	t	*p*	*t*	*p*
Individual Difference Measure				
Emotional reliance subscale	0.21	0.83	1.79	*0.08*
Lack of confidence subscale	0.92	0.36	1.25	0.22
Assertion of autonomy subscale	0.87	0.39	-0.53	0.60
"How important to you is it to be successful?"	1.41	0.16	-1.71	*0.09*
"How important to you is being able to support yourself financially?"	2.49	0.01**	0.76	0.45
"How important to you is having a career where you make a good salary?"	1.34	0.19	-0.82	0.42
"How important to you is having a career you enjoy?"	0.83	0.41	0.61	0.54
"How likely is it that you will work full-time after graduation?"	-0.94	0.35	1.95	*0.06*
"How important is it that you will be married in the future?"	0.53	0.60	0.81	0.42
"How important is it that you will have children in the future?"	0.98	0.33	0.90	0.37
Feminine Sex-Roles Composite	-0.32	0.75	0.47	0.64
Masculine Sex-Roles Composite	0.30	0.76	1.05	0.30
Modern Sexism Composite	-0.27	0.79	0.32	0.75

Note: Significant findings are noted with an asterisk. Marginally significant findings are italicized.

from students, they were not domain relevant, or their success seemed unattainable (Lockwood & Kunda, 1997). For women in particular, it is possible the role model manipulation was effective at dispelling negative stereotypes about women being bad at math but not at changing attitudes toward math. Forbes and Schmader (2010), for example, found that retraining negative stereotypes about women's math performance was effective at alleviating math performance decrements, whereas retraining attitudes toward math did not affect math performance. Reading about role models under stereotype threat likely helped dispel the negative stereotype and made women more confident in their mathematical ability (McIntyre, Paulson & Lord, 2003), but the current results suggest this did not have an effect on their interest in pursuing math or science careers.

General Discussion

While the future of our economy may be clouded with uncertainty, most can agree on the importance of recruiting more qualified applicants to pursue math and science careers in order to help sustain our economy. A report released in February 2012 by the President's Council of Advisers on Science and Technology found that the U.S. must increase the number of students receiving degrees in science, math, and related fields by 34% to keep up with the economic demand ("Obama Plans $1B Effort," 2012). The problem is that students, especially women, are not pursuing degrees in sufficient numbers to meet the future demand (National Science Foundation, 2010). The goal of the present set of experiments was to address this problem, and the central hypothesis was that directed thinking about role models would lead students to have more positive attitudes toward math and science.

We thought that directed thinking about role models would be an effective manipulation based on previous research showing that reading about successful role models can alleviate performance decrements in women who are under stereotype threat (McIntyre et al., 2003; McIntyre et al., 2011; Taylor et al., 2011), as well as research supporting that directed thinking was an effective tool for attitude change (e.g., McGuire & McGuire, 1996; Ten Eyck et al., 2008). Directed thinking involves asking people to think about what they already know instead of presenting them with new arguments (McGuire & Mcguire, 1996).

We thought that students who generated their own role models would make their role models more salient and accessible at the time they evaluated their attitudes toward math and science, giving them inspiration to approach fields that are often perceived as important but difficult to master. In addition, we thought that self-generated role models might be more similar and relatable to students than experimenter-provided role models, which has been shown to be important in past research on role models (Lockwood & Kunda, 1997). Three experiments were designed to examine the most effective role model manipulation for inspiring students to have more positive attitudes toward math and science.

The goal of Experiment 1 was to see whether directed thinking about role models could inspire students to have more positive attitudes and intentions to pursue math and science. Students reported their baseline attitudes toward math and science classes and careers, generated same-sex successful role models or their favorite foods (2 days later), and completed a post-attitude measure. Students who generated successful same-sex role models did report having more positive attitudes toward taking mathematics classes and pursuing a mathematics related career compared to students who generated their favorite foods. The same pattern was not present for attitudes toward science. Students may have viewed mathematics as more versatile and necessary than science, so their math attitudes may have been more susceptible to change. In addition, we also examined the types of role models that students generated. We noticed that students tended to list family and friends as their role models, when we intended them to generate well-known role models. We thought that well-known role models may have more accomplishments and as a result lead to greater inspiration than one's best friend. Experiment 1 provided some preliminary support that the role model manipulation may be effective for attitude change, at least for mathematics, although Experiment 2 sought to clarify the results further.

The goal of Experiment 2 was to find the optimum number of role models that students should generate for the manipulation to be most effective, in addition to explicitly telling students to generate successful well-known role models. Students reported their baseline attitudes toward math and science classes and careers, and 2 days later either generated six well-known same-sex successful role models, 12 well-known successful same-sex role models, or their favorite foods, and completed a post-attitude measure. We thought that students who generated six role models would have the most positive attitudes toward math and science. Previous research on idea generation suggested that coming up with a few ideas may lead people to believe the occurrence is more likely or true (e.g. Schwarz et al, 1991; Haddock et al., 1996). The results of Experiment 2 did not support our prediction, and none of the conditions significantly differed from one another for math or science attitudes. The first two experiments failed to provide substantial evidence that directed thinking about successful role models can change students' attitudes toward math and science. We thought that one possible reason was that students were generating role models who were talented, but not individuals who were resilient or what many would consider inspirational.

Instead of focusing on directed thinking, Experiment 3 tested whether students who read about successful same-sex role models who overcame obstacles would have more positive attitudes toward math and science compared to students who read about successful corporations. This was a posttest only design in hopes of making the material less repetitive for students. The materials were adapted from McIntyre et al. (2003), who showed that women who read about resilient role models were able to overcome math performance decrements while under stereotype threat. We thought the resilience component was perhaps missing from many of the self-generated role models in the first two experiments, and that role model resilience might be important to helping individuals feel like success was personally attainable if they worked hard. The results of Experiment 3 did not support this prediction. Reading about resilient successful role models did not produce more positive math and science attitudes for students.

Limitations and Future Directions

Although the results of the present experiments failed to provide consistent evidence that directed thinking about role models is effective at making attitudes toward math and science more positive, it still does not mean that this is not an important research question. There were several limitations in the current work that could be improved upon in future studies. One shortcoming in the current work is that we included participants with variable levels of math identity, when perhaps we should have been specifically targeting individuals who were moderately identified with mathematics. Previous research on stereotype threat suggests that women most susceptible to stereotype threat are the ones who are moderately to highly identified with mathematics, and such studies either control for math identity or specifically target women with a moderate to high math identity (Steele, 1997; Pronin, Steele & Ross, 2004). Students who are at the extremes of math identification are also likely to have extreme attitudes toward mathematics (Nosek et al., 2002) that would be more resistant to attitude change (e.g., Abelson, 1995; Bassili, 2008). It is possible that students with more moderate baseline attitudes toward math and science would have been the ones most susceptible to attitude change. In addition, we would have perhaps benefitted from including only freshman students in the experiments. Upperclassmen are more likely to have their minds made up about their future career, and less likely to change their career paths or take additional classes that are not required for graduation.

Another potential weakness with the current set of studies was the length of the dependent measure. Students were asked to complete the same lengthy survey 2 days apart (Experiment 1 & 2), and it is possible they lacked motivation to answer the same questions during Session 2. In addition, the self-report items may have not been the best way to accurately capture students' attitudes. Future studies may benefit from incorporating more behavioral measures. Forbes and Schmader (2010), for example, attempted to retrain math attitudes in students who were moderately identified with math using a personalized implicit association task. The manipulation produced no difference in self-reported math attitudes, but students did spend longer than control participants working on math problems following the manipulation (Forbes & Schmader). Perhaps measures that measure math motivation and are more behavioral in nature can be incorporated into future studies. Future studies, for example, could examine how long students persist at mathematics related tasks or games, such as solving a Rubik's Cube, or perhaps record students' enrollment in mathematics and science courses the following semester.

In addition to weaknesses with the dependent measure, there were also limitations to the directed thinking task. The role models most often listed in Experiment 1 were friends and family. This was different from previous studies examining role models and stereotype threat, where the most popular role models listed by students were famous individuals (Taylor et al., 2011). We thought that well-known individuals may have a greater list of accomplishments and produce a greater degree of inspiration (Lockwood & Kunda, 1997), so we changed the instructions in Experiment 2 so that students specifically generated well-known role models. A potentially better solution would have been to have some students generate well-known role models, and other students generate family and friends they admire. We had not considered that perhaps close attachment figures, such as one's parents or friends, may be an effective type of role model for producing attitude change. Parents serve as both a physical and emotional *safe haven* for their growing children (Bowlby, 1982), and individuals rely on attachment figures when faced with threat and external stressors (see, e.g., Mikulincer & Shaver, 2003, for a review). In one example, activating thoughts of one's parent following a mortality salience prime reduced death-thought accessibility and increased feelings of self-worth in students (Cox et al., 2008). In another example, students who wrote about a positive experience with their mothers experienced reduced distress following the recall of an upsetting memory (Selcuk, Zayas, Gunaydin, Hazan, & Kross, 2012). Future studies should explore whether directed thinking about positive attachment figures, such as one's mother, is an effective manipulation for inspiring and imbuing students with the confidence to approach math and science domains.

The current work also controlled for several different individual differences that could have affected the results, but perhaps there were more important individual differences that were omitted. The United States and perhaps Western societies in general often view math ability as a talent, something that one is either born with or not (Williams & King, 1980). If one believes mathematics is a skill that people are born with, and he or she does not think they possess that skill, then role models will probably be of little benefit. No matter how hard they try to succeed, they just are not a "math" person. In one example, Good, Rattan, and Dweck (2012) found women were more likely to persist in mathematics when their math environment promoted a malleable view (mathematical skill can be improved) compared to a fixed view (mathematical skill was a natural ability). Other studies have shown that African American students (and, to some degree, White students) who were encouraged to view intelligence as malleable (vs. fixed) reported greater enjoyment of the academic process, greater academic engagement, and obtained higher grade point averages than their counterparts in two control groups (Aronson, Fried, & Good, 2002). In another instance, students who endorsed malleable views of general academic ability had more positive self-evaluations, as opposed to being demoralized, after reading about an outstanding student in their field of study (Lockwood & Kunda, 1997). Perhaps directed thinking about role models is an effective tool for making math attitudes more positive, but only for students who believe that mathematics is a malleable skill that can be improved upon. Future studies should examine this individual difference further.

Concluding Remarks

Although the results of the present study were not as predicted, the current work addressed an important problem and raised new research questions that can be addressed in the future. In the words of President Barrack Obama "The belief that we belong on the cutting edge of innovation, that's an idea as old as America itself. We're a nation of thinkers, dreamers, believers in a better tomorrow" (Hefling, 2012). In order for America to remain a country that is innovative and competitive with the rest of the world, it is essential we are able to convince young Americans that pursuing STEM fields is worthwhile and attainable.

Appendix A

Baseline/Post-manipulation Measures (used in all three experiments)

How many Math courses have you taken?________________________________

How many more Math courses do you plan on taking?______________________

How many Science courses have you taken?______________________________

How many more Science courses do you plan on taking?____________________

How likely is it that you will take additional Psychology courses that are not required of you?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How likely is it that you will take additional Math courses that are not required of you?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How likely is it that you will take additional Science courses that are not required of you?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

On a scale of -5 to +5, please mark your interest in the following fields (-5= not at all interested, +5 = extremely interested). Please mark a score for EACH category.

________Engineering	________Business	________Physics
________Education	________Psychology	________Political Science
________Nursing	_______Biology/Chemistry	________Kinesiology
________Liberal Arts	________Mathematics	________Accounting
________Computer Science	________Communications	________Social Work

How likely is it that you will pursue a career in a STEM (sciences, technology, engineering, mathematics)

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

Specifically, how likely is it that you will pursue a career related to the sciences?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Clinical Laboratory Scientist?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Lab Technologist?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Medical Assistant?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Clinical Research Coordinator?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

Specifically, how likely is it that you will pursue a career related to technology?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Web Developer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Software Test Engineer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Software Developer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Programmer Analyst?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

Specifically, how likely is it that you will pursue a career related to engineering?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Product Design Engineer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Mechanical Engineer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as an Energy Engineer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as an Automotive Engineer?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

Specifically, how likely is it that you will pursue a career related to mathematics?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Statistical Consultant?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Research Analyst?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as an Environmental Mathematician?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

How interested are you in pursuing a career as a Mathematics Educator?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Not at all Likely					Not Sure					Extremely Likely

Appendix B

Instructions students read for role model manipulation in Experiment 1

Control Condition

Please take the next few minutes to think about some of your favorite foods. Think about why you like each food in particular. On the lines provided below, please list as many of your favorite foods as possible. In addition, please explain why you find each food appealing.

Role Model Condition

Please take the next few minutes to think about what kinds of qualities a successful role model has, and people who you may consider to be a successful role model. On the lines provided below, please list as many **role models as possible that you consider successful and are the SAME GENDER as yourself.** After listing each role model, please explain why you think each person you listed is a successful role model.

Changes Made to the Role Model Instructions for Experiment 2

Please take the next few minutes to think about what kinds of qualities a successful role model has, and well-known people of your own sex that you consider as successful role models. On the lines provided below, please list six role models (**or twelve)** that you consider successful and are the SAME GENDER as yourself. After listing each role model, please explain why you think each person you listed is a successful role model. Please do your best to come up with six role models.

Appendix C

Factor loadings for each of the three experiments

Questions	Experiment 1		Experiment 2		Experiment 3	
	Science Factor	**Math Factor**	**Science Factor**	**Math Factor**	**Science Factor**	**Math Factor**
How many more math courses do you plan on taking?	0.04	**0.74**	-0.03	**0.77**	-0.12	**0.55**
How many more science courses do you plan on taking?	**0.71**	0.15	**0.55**	0.19	**0.66**	-0.13
How likely is it that you will take additional Math courses that are not required of you?	0.09	**0.81**	0.28	**0.73**	0.20	**0.85**
How likely is it that you will take additional Science courses that are not required of you?	**0.70**	0.11	**0.63**	0.31	**0.78**	0.16
What is your interest in biology/chemistry?	**0.87**	0.02	**0.80**	0.16	**0.81**	0.07
What is your interest in math?	0.32	**0.72**	0.34	**0.66**	0.20	**0.83**
How likely is it that you will pursue a career in a STEM (sciences, technology, engineering, mathematics) related field?	**0.74**	0.37	**0.80**	0.29	**0.85**	0.28
Specifically, how likely is it that you will pursue a career related to the sciences?	**0.83**	0.14	**0.88**	0.01	**0.90**	0.11
Specifically, how likely is it that you will pursue a career related to mathematics?	0.18	**0.83**	0.26	**0.77**	0.18	**0.83**

Appendix D

Examples of the passages students read in Experiment 3

Role Model Passage #1 (Women)

Sarah Haley is a highly successful architect who lives and works in London, England. Although Sarah struggled with dyslexia since her childhood, she didn't let her disability dictate her success. Born in Houston, Texas, she received an undergraduate degree in art history from the University of Houston and a Master's degree in architecture from the Minnesota School of Design. She was the only woman among nine males in her entering class at MSD and feels that she "had to prove myself" to the faculty, most of whom were male. In her graduate courses in architecture, however, Sarah was more frequently the top student in her class. On graduating with her master's degree, she worked briefly for the well-known Houghton and associates architectural firm, which has its corporate headquarters in New York City and London, England. Although the firm made Sarah responsible for designing a few small structures in the west counties of England, she began to notice that the most prestigious contracts were invariable awarded to her male counterparts in the "old boy network."

Taking a chance, Sarah resigned from the firm to start her own architectural consulting business. For the first two years, she was unable to secure a contract. Almost out of money, she briefly considered quitting and retraining for a new career. In 1996, however, the Tate Museum asked Sarah Haley to design their modern sculpture facility in Bradford-on-Avon, which recently opened to enormous critical acclaim. Since the opening of that art facility, Sarah has been showered with offers, many of them from clients who used to take all their business to Houghton. According to a recent review in the London Times, "Sarah Haley's architectural designs constitute a significant creative step forward from the old-school Houghton approach, which is so mired in past ideas that it has lost its utility and appeal."

Role Model Passage #1 (Men)

Jonathan Haley is a highly successful architect who lives and works in London, England. Although Jonathan struggled with dyslexia since his childhood, he didn't let his disability dictate his success. Born in Houston, Texas, he received an undergraduate degree in art history from the University of Houston and a Master's degree in architecture from the Minnesota School of Design. He did not have as much experience as the nine other students in his entering class at MSD because he had to work odd jobs to pay his way through college, and he feels that he "had to prove myself" to the faculty. In his graduate courses in architecture, however, Jonathan was more frequently the top student in his class. On graduating with his master's degree, he worked briefly for the well-known Houghton and associates architectural firm, which has its corporate headquarters in New York City and London, England. Although the firm made Jonathan responsible for designing a few small structures in the west counties of England, he began to notice that the most prestigious contracts were invariable awarded to his colleagues who had more connections and came from wealthier backgrounds.

Taking a chance, Jonathan resigned from the firm to start his own architectural consulting business. For the first two years, he was unable to secure a contract. Almost out of money, he briefly considered quitting and retraining for a new career. In 1996, however, the Tate Museum asked Jonathan Haley to design their modern sculpture facility in Bradford-on-Avon, which recently opened to enormous critical acclaim. Since the opening of that art facility, Jonathan has been showered with offers, many of them from clients who used to take all their business to Houghton. According to a recent review in the London Times, "Jonathan Haley's architectural designs constitute a significant creative step forward from the old-school Houghton approach, which is so mired in past ideas that it has lost its utility and appeal.

Successful Corporation Passage #1 (control)

ART-itectural Associates is a highly successful architectural firm based in London, England. In fact the success of the firm is so great that high pressures have been placed upon other firms to live up to the philosophy of "quality before everything else" that ART-itectural has. ART-itectural only hires people who are the best at what they do, and approach their designs and endeavors with the attitude that "Quality is Pride-and Pride is Everything". This attitude is sought after because it is the same attitude that ART-itectural had when the firm was first established. In fact, the founder of ART-itectural was originally employed by the renowned Houghton and associates architectural firm, which has its corporate headquarters in New York City and London, England. Although the Houghton made the ART-itectural's founder responsible for designing the newest structures in England, their attitude for quality was second to making money which was a disappointment.

Taking a chance, ART-itectural Associates-architectural consulting business was formed. For the first two years, ART-itectural Associates was unable to secure a contract. Almost out of money, in 1996, however, the Tate Museum asked ART-itectural to design their modern sculpture facility in Bradford-on-Avon, which recently opened to enormous critical acclaim. Since the opening of that art facility, the firm has been showered with offers, many of them from clients who used to take all their business to Houghton. According to a recent review in the London Times, "ART-itectural designs constitute a significant creative step forward from the old-school Houghton approach, which is so mired in past ideas that it has lost its utility and appeal."

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ABSTRACT

EFFECTS OF DIRECTED THINKING ABOUT ROLE MODELS ON ATTITUDES TOWARD MATH AND SCIENCE

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The current experiments examined whether directed thinking about role models could increase students' attitudes toward pursuing math and science. Directed thinking involves persuasive strategies where individuals generate their own ideas or arguments (McGuire & McGuire, 1991). We predicted that directed thinking about role models would make role models more salient to students at the time they evaluated their attitudes toward math and science, leading to more positive attitudes (Study 1). In addition, we thought generating a few role models (as opposed to many) would be most effective (Study 2). In Study 1, some evidence supported the manipulation was effective for math attitudes, but no support was found in Study 2. We thought that students' self-generated role models may not have possessed resilience, possibly an important quality for inspiration, so we tried having students read about resilient role models (Study 3). The results of Study 3 did not support this prediction.