Gender or Community: What Drives STEM Interest Among Middle School Students?

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Abstract

Much attention has been given to increasing women's and girls' interest and participation in STEM fields. One way of increasing STEM interest is to target STEM-gender stereotypes by presenting students with female stereotype-disconfirming exemplars. However, the exemplar approach has had mixed effectiveness in adolescent populations. The present study examined middle school students' interest in STEM fields and their communal goal interest. Participants were given different interventions that either presented a female exemplar of a scientist or leveraged communal goals. Results found no gender differences in STEM interest, but a correlation between communal goal endorsement and a belief that STEM careers are compatible with communal goals. The intervention that leveraged communal goals effectively increased STEM interest for some students, while the exemplar interventions were ineffective. These findings suggest that with regard to STEM interest in early adolescence, endorsement of communal goals may be a more influential factor than gender category membership.

Keywords: Science, Technology Engendering and Math, Gender, Communal Goals, Adolescents

Introduction

As the world becomes more reliant on technology, there is a growing interest in how to increase participation in science, technology, engineering and math (STEM) fields. Of particular concern is the underrepresentation of women in STEM fields. For example, in 2012, only 20% of bachelors' degrees in physics, engineering, and computer science were earned by women (National Science Foundation, 2015). The gender disparity is more pronounced at higher levels. For example, women earned 40% of bachelor's degrees in mathematics and statistics but only 20% of master's and doctoral degrees in these fields (NSF, 2015).

What explains the gender differences in levels of STEM interest and participation, and when do these differences emerge? An interesting part of the situation is the fact that there are no substantial gender differences in early mathematics and science ability (see Hill, Corbett, & St. Rose, 2010 for discussion), but there are differences in attitudes toward mathematics and science (e,g, Ganley & Lubienski, 2016; Hyde, Fennema, & Lamon, 1990). As early as elementary and middle school, girls tend to perceive themselves as less competent in mathematics than do boys (Ganley, & Lubienski, 2016; Herbert & Stiptik, 2005). In middle school and high school, boys are more likely to state that they are interested in math and science than girls (Cunningham, Mulvaney, & Sparks, 2015; Hill, Corbett, & St. Rose, 2010).

One factor that may contribute to students' attitudes toward mathematics and science is the pervasive stereotypes that scientists and mathematicians are men (Eccles, 1987; Fennema, 1985; Nosek, Banaji, & Greenwald, 2002). Young children in the United States tend to draw men when asked to depict a scientist or mathematician (Chambers, 1983; Steele, 2003). There is evidence that gender and the strength of gender identity are correlated with preference for mathematics, mathematics identity, and math-gender stereotypes (Nosek, Banaji, & Greenwald, 2002).

Because it is possible that gender-STEM stereotypes negatively impact women and girls participation in STEM, many interventions have been developed to break common stereotypic misconceptions by presenting stereotype-disconfirming exemplars to students. For example, reading about the successes of women in STEM and non-STEM fields has been shown to boost women's performance on math examinations (McIntyre, Paulson & Lord, 2003).

The proposed mechanism behind these exemplars is that encountering a particular stereotype-defying example will encourage participants to expand their notion of membership in the stereotyped category. In this instance, presenting examples of women who are successful in STEM fields would prompt a change in the perceived membership of the category of "scientist" or "mathematician". By extension, presenting a highly feminine exemplar as successful in a stereotypically male domain like STEM may be effective because it forces the perceiver to include all feminine characteristics in their category definition of who may be successful in STEM fields and discourages subtyping.

Although the power of stereotypes and representation biases cannot be denied, the stereotype explanation leaves questions about gender differences in STEM participation. Women and girls continue to select out of STEM fields, even as women continue to gain representation in other high achieving, stereotypically male disciplines like law and medicine (Snyder, Dillow, & Hoffman 2009; Wang, Eccles & Kenny, 2013). This suggests that other factors such as motivation and personality characteristics may be contributing to the gender disparity in STEM fields. In addition, there may be practical problems with designing STEM participation interventions based simply on expanding students' perception of STEM "membership" because these theories assume that students will see the exemplar as similar to themselves. How would characteristics such as race, socio-economic background, geographic region, and culture be appropriately included in exemplars to appeal to all students?

Indeed, despite their success with adult women, exemplars often generate mixed effects, especially among adolescents. Exposure to highly feminine exemplars actually weakens future goals to take optional math and science among adolescent girls who are disidentified with STEM fields and decreases adolescent girl's sense of efficacy and short-term expectations of success in math and science (Betz & Sekaquaptewa, 2012). This evidence suggests that using highly feminine exemplars to influence the future career plans of adolescent girls does not target the cleanest and most effective mechanism of STEM interest and identification.

These counterintuitive effects may stem from the complicated relationship adolescent girls have with gender stereotypes. During adolescence, especially early adolescence, girls' self-perceived math ability begins to decline relative to boys' (Wigfeild, Eccles, Mac Iver, Reuman & Midgely, 1991). In light of this intricate relationship between budding identity development and harsh cultural stereotypes, it is not surprising that interventions designed to leverage mechanisms tied to gender stereotypes yield adverse or mixed results.

Considering the baggage accompanying gender-STEM stereotypes during adolescence, it is important to explore other theories and mechanisms that could shed light on this phenomenon. One such theory is the goal congruity perspective. The goal congruity perspective posits that women highly value communal goals like intimacy, working together and helping others. This valuation is at odds with stereotypes about STEM fields portraying careers involving those fields as individualistic and isolating. In fact, compared to other high achieving careers, STEM careers are perceived as actually hindering the path to attain goals like helping others (Diekman, Brown, Johnson & Clark, 2010). These stereotypes work to portray STEM careers as incompatible with communal goals, leading to disinterest in pursuing math and science domains for those individuals that value communal goals. Thus, the mechanism behind the goal congruity perspective attempts to increase the degree to which goal affordance beliefs, or beliefs about what actions or pursuits will best facilitate the attainment of specific goals, align STEM careers with communal goals. In this way it might be possible to increase positivity toward STEM careers among individuals who value communal goals (Diekman, Clark, Johnston, Brown & Steinberg, 2011).

Indeed, this idea maps well on to the difference in female representation within STEM fields. According to 2013 census data, women make up 61% of social scientists, a field that has high communal goals stereotypicallity compared to only 27% and 13% of computer workers and engineers respectively, fields with low communal goal steryotypicallity (Landivar, 2013).

The current study

This study seeks to examine STEM interest in an adolescent population and to test several interventions designed to increase STEM interest. Specifically, we will consider the role of gender and communal goal endorsement. The use of exemplars, along with manipulations of female stereotypicality has yielded mixed results in this population, while the communal goal approach remains untested. It is predicted that adolescents will endorse communal goals and that the intervention targeting communal goals will yield the greatest increase in STEM interest, in particular a future desire to purse science and math, compared to exemplar focused interventions.

Method

Participants

Ninety-four seventh grade students (41 male, 53 female) at middle school in the Midwestern United States were recruited for this study. The majority (93%) of the sample self identified as White. Parental consent as well as participant consent was obtained.

Materials

The experiment included three phases: (1) measure of communal goal interest and pretest of STEM interests (2) an intervention designed to increase STEM interests and (3) posttest of STEM interest. Participants were randomly assigned to one of three conditions (feminine exemplar, neutral exemplar, or communal goals) that varied the intervention.

Interventions. Participants were exposed to either a stereotypically feminine exemplar (feminine condition), a female but stereotypically neutral exemplar (neutral condition), or a group exemplar designed to speak to communal goals (communal condition). The intervention text appears in Appendix A exactly as it was presented to participants. All exemplars were identical except for the necessary manipulations.

The material presented to participants consisted of a short paragraph written form the perspective of the exemplar detailing their hobbies and what they enjoy about their job. A picture followed this short paragraph. In the communal condition the picture included an ethnically diverse group of men and women, and in the feminine and neutral conditions the picture included an ethnically ambiguous woman.

Exemplars were portrayed as a "profile of a scientist" (feminine and neutral conditions) or the "profile of a team of scientists" (communal condition). This profile was sourced from a website that aims to connect students to female mentors working in STEM fields and can be found in full in Appendix A.

The manipulations of feminine stereotypicality (feminine and neutral conditions) were taken from Clark, Fuesting, & Diekman, 2016. This manipulation consisted of hobbies that were independently rated as highly feminine (knitting, watching romantic comedies and yoga) or neutral on feminine stereotypicality (running, watching nature documentaries and photography). The hobbies for the communal condition were simply "working and spending time together."

Following the intervention manipulation, participants were asked to complete a writing assignment. In this task, they first read a list of daily tasks the exemplar would perform. Then they were asked to write about what they think an average day would be like if they were a scientist doing a similar job (Appendix A). This writing exercise was timed; all participants were instructed to write for five minutes. The daily tasks were manipulated to reflect or not reflect communal goals similar to the manipulation in Clark, Fuesting, & Diekman, 2016. For the feminine and neutral conditions the daily tasks consisted mainly of solitary work and problem solving (ex: "Look up and read about past research to help you develop new experiments."). In the communal condition the daily tasks reflected working with others (ex: "Brainstorm with your fellow researchers about past research to help you develop new experiments.").

Communal Goals Scale. The nine-question communal goals scale (Clark, Fuesting, & Diekman, 2016) was used to assess communal goal identification. Participants were asked to rate the importance to them of nine goals, like helping others, intimacy, relationships with others and working with people, on a seven-point Likert scale.

Measures of STEM Interest. Three measures were used to assess STEM interest: a measure of future goals (Betz & Sekaquaptewa, 2012), a measure of STEM positivity and a measure of STEM goal attainment (Clark, Fuesting, & Diekman, 2016). The measure of future goals asked participants to rate their likelihood of taking science and math classes in high school and college on a seven point Likert scale. The measure of positivity asked participants to rate how positive they feel towards a STEM career and how much they would enjoy being successful in a STEM career on a seven point Likert scale. The STEM goal attainment measure contains two questions that ask participants to rate on a seven point Likert scale the extent to which a career in STEM fields would "fulfill goals like intimacy, working with people and helping people" and to what extent such a career would fulfill their own goals of intimacy, working with people and helping people.

Procedure

Students took part in this study as an extension of their daily math class. Participants were first administered consent forms. Participants then completed a pen and paper pre-test questionnaire consisting of the communal goals scale, the two question future goals scale, the two question STEM positivity scale, and the two question STEM goal attainment scale. Participants were also asked to list their top three favorite academic subjects.

Participants were then exposed to the exemplar intervention materials that aligned with their assigned condition (feminine, neutral or communal). Participants were then given a uniform amount of time (5 minutes) to complete the writing assignment corresponding to their condition: the feminine and neutral condition received the non-communal manipulation and the communal condition received the communal manipulation.

Following this writing assignment participants were administered a post-test consisting of the future goals scale, the STEM positivity scale and the goal attainment scale. Participants were then thanked and debriefed.

Results

Effects of gender and communal goal endorsement.

The communal goals scale, the future goals scale, the STEM positivity scale and the goal attainment scale were each assessed on a 1 (low) to 7 (high) likert scale. These four scales were averaged to yield mean scores for each participant on each measure. Eleven participants were removed from analysis. One participant was removed due to incomplete responses and ten were removed as outliers due to reporting a communal goals score or a measure of STEM interest score that was greater than 2.5 standard deviations from the mean of the entire sample.

Overall, participants reported high communal goals scores and pre-test STEM interest scores (Table 1). Eighty percent of participants reported an average communal goal score of 5 or above and only two participants reported an average communal goal score below 4. There were no gender differences on ratings of communal goals or measures of STEM interest, ANOVA with gender as a factor $F(1,80)$s < 1.52, ps > .22.

To consider whether participants' communal goal endorsement affected STEM interest, correlations between participants' communal goals ratings and their STEM interest scores were examined. Pearson correlation found that communal goals scores were positively correlated with STEM goal attainment scores $r(82) = .35$, $p < .01$. Communal goals scores were not correlated with future goals scores $r(82) = .18$, $p > .05$ or STEM positivity scores $r(82) = .10$, $p > .05$.

Table 1. Mean Ratings of Communal Goal Endorsement and STEM Interest Measures. Standard deviations are in parentheses.

	STEM Interest Measures			
	Communal Goal Endorsement	Future Goals	Positivity	Goal Attainment
Boys	5.67 (.73)	5.94(.86)	5.57(1.5)	5.77(.96)
Girls	5.86 (.68)	6.13(.88)	5.40(1.3)	5.80(.93)

Effectiveness of the Interventions.

Because communal goals scores were positively correlated with goal attainment scores, it is possible that the effects of the interventions may be different for participants with high and low communal goals scores. To consider the effect of communal goal endorsement, a median split was performed based on communal goal ratings, (median =5.78) which resulted in 46% of participants below the median and 54% or participants at or above the median.

To examine the effectiveness of the three different interventions and possible interactions with communal goal endorsement, a 2(gender) X 2(communal goals: high, low) X 3(condition: feminine, neutral, communal) repeated measures ANOVA was conducted with pretest and posttest STEM interest (time) as the within repeated measures. There was a significant interaction of time and gender on future goals, $F(1,68) = 4.04$, $p < .05$, $\eta_p^2 =.06$. Overall, girls' post-intervention future goals scores decreased (M = 6.13, SD = .88 to M = 6.03, SD = .87) while boys' ratings increased (M = 5.93, SD = .86 to M = 6.19, SD = .71). A significant interaction between time and communal goals emerged for goal attainment, $F(1,68) = 9.05$, $p <. 01$, $\eta_p^2 = .11$. Goal attainment scores decreased (M = 5.96, SD = .86; M = 5.43, SD = 1.2) for participants with high communal goal ratings and increased for participants with low communal goal ratings (M=5.59, SD = .99; M = 6.00, SD = .91).

There were no significant interactions with time, condition, or gender on any of the measures of STEM interest $F(2,70)$s < 2.46, ps > .08. However, a significant interaction between time, condition and communal goals on future goals scores was observed $F(2,69) = 5.879$, $p < .01$, $\eta_p^2 = .14$. This result suggests that condition produced different changes to STEM interest ratings (in particular future goals) as a function of participants' communal goal score.

To explore the interaction between time, condition, and communal goals and further investigate the effectiveness of each intervention on future goals scores, separate ANOVAs were conducted on future goals with communal goals scores as a covariate on each intervention condition. The communal condition evidenced a significant interaction between time (pretest and posttest STEM interest) and communal goals $F(2,25) = 6.44$, $p < .01$, $\eta_p^2 = .46$. No significant effects of time, communal goals or interactions between time and communal goals were observed in the feminine or neutral conditions, $F(2,27)$s < 2.17, ps > .08. This suggests that only participants in the communal goal condition had significant changes in their STEM future goal ratings. In the communal condition, future goal scores for participants with low communal goal scores increased significantly by 15%, paired sample t-test $t(11) = 2.40$, $p < .05$. However, none of the changes in the other conditions were statistically different than 0, ts < = 1.74, ps > .11. Figure 1 presents the percent increase in future goals scores across the three conditions, split by high and low communal goals ratings.

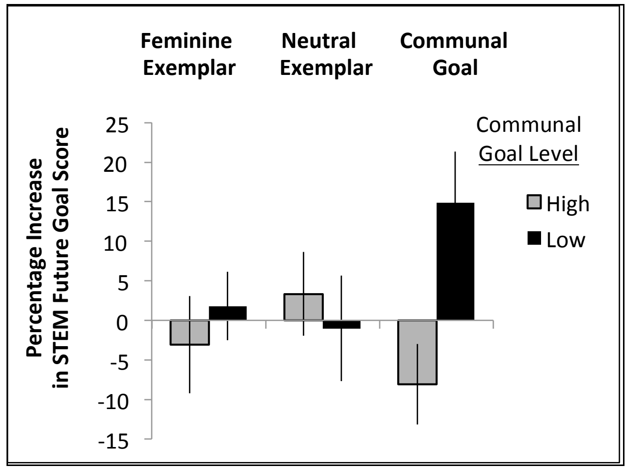

Figure 1: The percent increase in STEM Future Goal scores by experimental intervention condition and split into high and low communal goals groups. Error bars represent standard error of the mean.

Discussion

The goal of the present research was to examine adolescents' STEM interest and the relationships to gender as well as communal goal endorsement. Several interventions designed to increase STEM interest were tested. Previous research has suggested that girls are less interested in STEM fields than boys are, and that exposing students to examples of female scientists will increase STEM interest. However, we found no gender differences on any measure of STEM interest. Further, the interventions presenting a highly stereotypically feminine exemplar or a female but stereotypically neutral exemplar did not improve STEM interest among female or male participants.

While the interventions involving female exemplars did not increase STEM interest, the communal goals intervention did. This intervention was designed to increase recognition of the communal aspects of work in STEM fields. Participants with low communal goal scores who received this intervention increased their future goals scores, suggesting they were more likely to take optional science and math classes in high school and college. This increase in STEM interest was only observed in the low communal goals category possibly because participants in the high communal goals category reported future goals scores at ceiling on both the pre-test and post-test measures.

It was found that this sample of adolescents evidenced high average communal goal endorsement overall.

Approximately 80% of participants averaged a score at or above 5 on a seven-point scale. Communal goal endorsement was also positively correlated with goal attainment scores, or the belief that a career in STEM fields would fulfill both communal goals in general, and specifically the participants' communal goals.

These findings lend support to the goal congruity hypothesis of STEM interest. A simple, 10-minute intervention emphasizing the role of communal goals in STEM fields was able to significantly and positively affect one measure of STEM related future goals of students who did not score at ceiling on the communal goals scale. In comparison, more traditional interventions centered on exemplars and the emphasis of femininity produced no significant change in any measure of STEM interest.

Of course this is not to say that the power and influence of gender stereotypes should be discounted, certainly they do play a role in the decision to pursue a STEM career (McIntyre, Paulson & Lord, 2003; Nosek, Banaji, & Greenwald, 2002). However, our data suggests that during early adolescence valuing communal goals, like working with and helping others, may possibly be a more influential factor than gender category membership on STEM interest. Simply attributing STEM interest to the influence of gender stereotyping may be somewhat of an oversimplification. Thus, our data suggests that emphasizing communal goals in this population may be a more effective and practical way to increase STEM interest than more traditional interventions that emphasize stereotype-disconfirming exemplars and femininity.

There are limitations to this study. The sample was taken from one school district and was not racially diverse. In addition, our participants appeared to have high communal goal desires causing possible ceiling effects, which might have obscured other findings. Future studies should explore this finding with a larger, more diverse sample and a modified communal goals scale to attempt to combat ceiling effects.

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Appendix A: Stimuli

Feminine and Neutral Conditions.

Profile of a Scientist:
Name: Lisa Johnson
Biography:

Lisa is an electrical engineer. She enjoys yoga, watching romantic comedies and knitting (In Neutral Condition: running, watching nature documentaries and photography)

Lisa Says:

I am Electrical Engineer at the NASA Glenn Research Center. I work on Power System Development for future NASA missions. Specifically, I support the development of a power processing unit for high power, high voltage electric propulsion applications and the development of a flywheel energy storage system.

Flywheel energy storage, or storing energy mechanically in a rotating wheel, offers an alternative to traditional chemical energy storage systems, such as batteries, for future missions.

Every day I work to solve problems and learn new things. I figure out how to implement new technologies all the time and I go home everyday knowing that I made a difference!

<u>Writing Activity:</u>

Listed below are some typical daily tasks that a scientist like Lisa would perform. Imagine you are also a scientist doing work in an environment similar to Lisa's. What do you think your average day would be like? Please write a few sentences describing what you think it would be like if you worked as a scientist like Lisa.

<u>Daily Tasks of a Scientist:</u>

- Check a database for updates on ongoing experiments.
- Look up and read about past research to help you develop new experiments.
- Watch videos of other scientists presenting their recent findings
- Update a lab notebook with information about the progress and status of your experiments
- Work out data analysis problems by yourself
- Make a PowerPoint presentation of your recent experimental results to email to a supervisor

Communal Condition.

Profile of a team of Scientists:
Name: NASA Power Team
Biography:

The NASA Power Team is made up of six electrical engineers. They enjoy working and spending time together

The Power Team Says:

We are a team of six Electrical Engineers at the NASA Glenn Research Center. We work closely together on Power System Development for future NASA missions. Specifically, we support the development of a power processing unit for high power, high voltage electric propulsion applications and the development of a flywheel energy storage system.

Flywheel energy storage, or storing energy mechanically in a rotating wheel, offers an alternative to traditional chemical energy storage systems, such as batteries, for future missions. This technology also has the potential to help people here on Earth in many ways.

Every day we work together to solve problems and learn new things. Together, we figure out how to implement new technologies all the time. Each of us goes home everyday knowing we made a difference!

<u>Writing Activity:</u>

Listed below are some typical daily tasks that scientists like The NASA Power Team would perform. Imagine you are also a scientist doing work in an environment similar to the NASA Power Team. What do you think your average day would be like? Please write a few sentences describing what you think it would be like if you worked as a scientist like the NASA Power Team.

<u>Daily Tasks of a Scientist:</u>

- Talk with team members about updates on ongoing experiments.
- Brainstorm with your fellow researchers about past research to help you develop new experiments.
- Attend presentations from other scientists about their recent findings
- Update your team coordinator with information about the progress and status of your experiments
- Work out data analysis problems with your other members of your lab team.
- Present your recent experimental results to your supervisor with your team members.