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Article

The effects of social media on STEM identity in adolescent girls

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SUMMARY

Social media is widely used and easily accessible for adolescents, it has the potential to increase STEM (Science, Technology, Engineering, and Math) identity in girls. We aimed to investigate the effects of exposure to counter-stereotypical portrayals of women in STEM on social media on the STEM identity of adolescent girls. The study involved 20 high school girls, randomly divided into an experimental group and a control group. The participants completed pretest and posttest surveys to measure their STEM identity, including STEM interest and self-efficacy. The results did not support the hypothesis that exposure to counter-stereotypical portrayals of women in STEM on social media would increase STEM identity in adolescent girls. There was no statistically significant difference in STEM identity scores between the experimental and control groups. Similarly, there was no significant change in STEM interest or self-efficacy for both groups. Additional data analysis revealed that the participants who had aspirations for a career outside of STEM experienced a significantly higher increase in STEM identity than those who aspired to have a STEM career. The study concluded that social media alone may not be an effective tool to increase STEM identity in girls. It is worth exploring other, potentially more impactful solutions to bridge the gender gap in STEM. Social media can still be used as a complementary tool to support and encourage women in STEM, but it should not be relied upon solely to address the gender disparity in STEM fields.

INTRODUCTION

The presence of gender inequality has been well documented in the fields of science, technology, engineering, and math (STEM). According to the United States (US) Census Bureau, women are nearly half of the US workforce but represent only 27% of US STEM workers (1). This disparity is highly prominent in the engineering and physics fields, where only 25% and 33% of doctorates were awarded to women in 2020, respectively (2). This significant gender disproportion in the STEM workforce highlights the insufficient representation of women in STEM. From a young age, girls are exposed to gender inequality, and their representation in STEM continues to decrease as they go through higher education. According to Wells, the ratio of female to male students in 10th-grade academic science classes was 1:1; however, by the time the students graduated with PhDs, the ratio of females to males dropped to 1:4 (3).

One of the main causes of the gender gap in STEM is low STEM identity among young girls (4). STEM identity refers to an individual's ability to see themselves as a person who could be a legitimate participant in STEM (4). STEM identity can be broken down into two parts: interest in STEM and self-efficacy as it relates to STEM domains (4). When both of these factors occur positively in a person, they are likely to have a strong STEM identity (4). A positive STEM identity is important for reducing the gender gap in STEM because it increases the motivation for girls to pursue STEM careers (5). The development of STEM identity begins in childhood and continues throughout adolescence (6). There are numerous causes for the decreased STEM identity in girls. There is a widely held stereotype that men are better at math and science, while women are better at arts and humanities (7). These stereotypes decrease girls' STEM identities because those who think they do not fit the stereotype of a certain group may feel less like a member of that group (5). Studies have concluded that girls' STEM identities decrease as they are exposed to gender inequality and gender stereotypes (5). Another cause of decreased STEM identity among girls is a lack of female role models. Due to the low representation of women in the STEM field, there may not be many female STEM professionals that young women can look up to and ask for guidance. In fact, many women identified a lack of guidance and support as the reason why they left STEM (8). Role models can reduce the self-stereotyping of stigmatized groups, such as women in male-dominated STEM fields (9).

While numerous published studies have recognized decreased STEM identity as a causal factor of the gender gap in STEM, fewer have investigated possible solutions to increase STEM identity in girls (9). Some of the possible solutions explored include girls-only organizations, female mentors, and traditional media sources (3). Another possible solution is exposure to counter-stereotypical portrayals of women, which are defined as portrayals of individuals who engage in a role that is contrasting to gender stereotypes (e.g., a female in STEM) (10). Prior studies have analyzed the effects of counter-stereotypical portrayals of women in STEM in traditional media (television, magazines, videos) on girls (6,7), however, no studies have analyzed the effects of these portrayals on social media. Social media is used significantly more often than traditional media platforms, especially among adolescent girls. In fact, more than 80% of teens and young adults use social media daily (11). Although traditional media types have historically portrayed women stereotypically, there have been recent trends toward making increasingly counter-stereotypical content, especially on social media. For example, on Instagram, there has been a notable increase

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in STEM-related hashtag usage, such as #STEM (3.7 million posts) and #womeninSTEM (1 million) (12). Social media can be used to reduce stereotypes and assumptions of stigmatized and underrepresented groups through exposure to counter-stereotypical portrayals and role models (6).

Since social media is widely used and easily accessible for adolescents, it has the potential to increase STEM identity in girls in an efficient and relatively simple manner. Unlike traditional media sources, where information is created by media professionals, social media provides the opportunity for everyone to post and share their stories (13). This is important because in order for role models to be effective and inspire girls in STEM, young girls must perceive themselves as similar to the role model (10). Previous research on this topic has been limited to theoretical frameworks and conceptual predictions of how counter-stereotypical portrayals of women on social media can be used to influence STEM identity in girls (6,14). Therefore, the objective of this study was to see if such an influence was observed in real life by applying these solutions to a group of adolescent girls. We hypothesized that counter-stereotypical portrayals of women in social media will increase STEM identity in adolescent girls.

RESULTS

The purpose of this study was to analyze how exposure to counter-stereotypical portrayals of women in STEM on social media affected STEM identity in adolescent girls. To conduct this study, we gathered 20 female participants in grades 10-12 and used a pretest-posttest control group design to analyze differences in STEM identity before and after exposure to a social media intervention, which consisted of Instagram posts from the Women Doing Science Instagram page (15).

A total of 20 participants participated in the study, but 3 did not complete all of the steps and were excluded from the study. Thus, 17 responses were used for analysis (9 in the experimental group and 8 in the control group). All of the 17 participants identified as female and 1 was in 10th grade, 14 were in 11th grade, and 2 were in 12th grade.

We analyzed how STEM identity changed after exposure to the 'Women Doing Science' Instagram posts (**Table 1**).

Experimental		Control	
Participant Number	Score Difference	Participant Number	Score Difference
1	3	10	5
2	22	11	-4
3	11	12	5
4	1	13	2
5	7	14	-4
6	-1	15	2
7	3	16	4
8	2	17	9
9	3		
Mean	5.67	Mean	2.38
t-value	1.13		
p-value	0.28		

Table 1: Change in STEM identity score after the study period in experimental and control groups.

Experimental		Control	
Participant Number	Score Difference in STEM Interest	Participant Number	Score Difference in STEM Interest
1	2	10	1
2	10	11	0
3	6	12	4
4	1	13	2
5	3	14	-2
6	1	15	2
7	2	16	2
8	1	17	4
9	0		
Mean	2.89	Mean	1.63
t-value	0.97		
p-value	0.35		

Table 2: Change in STEM Interest score after the study period in experimental and control groups.

STEM identity was calculated by summing the scores of the STEM interest and self-efficacy in STEM scales. The mean difference in STEM identity scores before and after the 2-week period was 5.67 for the experimental group and 2.38 for the control group, which was not statistically significant ($p = 0.28$) (**Table 1**). Additionally, we analyzed the score difference after the social media intervention in each of the two components of STEM identity, STEM interest (**Table 2**) and self-efficacy in STEM (**Table 3**). The mean difference in STEM interest scores before and after the 2-week period was 2.89 for the experimental group and 1.63 for the control group, which also was not statistically significant ($p = 0.35$) (**Table 2**). The mean difference in self-efficacy in STEM scores before and after the 2-week period was 2.78 for the experimental group and 0.75 for the control group, which was not statistically significant ($p = 0.26$) (**Table 3**).

To further analyze the data, we looked at two additional

Experimental		Control	
Participant Number	Score Difference	Participant Number	Score Difference
1	1	10	4
2	12	11	-4
3	5	12	1
4	0	13	0
5	4	14	-2
6	-2	15	0
7	1	16	2
8	1	17	5
9	3		
Mean	2.78	Mean	0.75
t-value	1.16		
p-value	0.26		

Table 3: Change in self-efficacy in STEM score after the study period in experimental and control groups.

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	In STEM EC	Not in STEM EC
Number of participants	5	4
Mean pretest STEM identity	67.2	60.8
Mean posttest STEM identity	72.8	66.5
Mean difference	5.6	5.7
t-value	-0.03	
p-value	0.98	

Table 4: Experimental group's change in STEM identity score based on participation in STEM extracurriculars (EC).

variables that may have affected the effectiveness of the social media intervention in the experimental group. First, we investigated the influence of participation in STEM extracurriculars (ECs) (**Table 4**). Participants who were in a STEM EC had a mean increase of 5.6 points in STEM identity, while participants who were not in a STEM EC had a mean increase of 5.7 points, which was not statistically significant ($p = 0.98$) (**Table 4**). We then analyzed the influence of career aspirations (**Table 5**). Participants who aspired to have a career in STEM had a mean increase of 2.0 points in STEM identity, while participants who aspired to have a career outside of STEM had a mean increase of 10.3 points, which was statistically significant ($p = 0.04$) (**Table 5**). Among the participants in the experimental group ($n = 9$), eight participants indicated that they would want to continue to follow 'Women Doing Science' Instagram page in the future, while one participant indicated that they would not want to.

DISCUSSION

This study was the first to analyze the effectiveness of exposure to counter-stereotypical portrayals of women in STEM in social media on adolescent girls' STEM identities. The results from this study did not support the hypothesis that exposure to counter-stereotypical portrayals of women in STEM on social media would increase the STEM identity of adolescent girls. While the social media intervention resulted in similar increases in both components of STEM identity (mean changes in STEM interest and self-efficacy in STEM, 2.89 and 2.78 respectively), these were not statistically significant. In this study, we were only analyzing factors like gender, participation in STEM ECs, and career orientation, but there are other aspects that can influence STEM identity such as race and socioeconomic status that our study does not touch on Overall, our data suggest that social media intervention used in this study was not an effective method to increase STEM identity among adolescent girls.

The findings of this study can be examined using previously described theoretical frameworks that explain factors that influence STEM identity formation such as the Possible Selves Theory (6). The Possible Selves Theory states that the extent to which an individual perceives themselves as similar to a media character affects the influence of exposure to counter-stereotypical women in STEM on girls' STEM identity (6). The images used in the social media intervention depicted middle-aged female STEM professionals, so age was a major difference between the media models and the participants. According to the Possible Selves Theory, this gap in age similarity might have reduced the influence of the social media intervention in this study.

	STEM career	Not a STEM career
Number of participants	5	4
Mean pretest STEM identity	70.6	56.5
Mean posttest STEM identity	72.6	66.8
Mean difference	2.0	10.3
t-value	-2.07	
p-value	0.04	

Table 5: Experimental group's change in STEM identity score based on career aspirations.

The results from this study also align with the current literature in the women in STEM community. This study's results corroborate with previous reports that studied the influence of televised counter-stereotypes on girls' perceptions of STEM, in which elementary school girls who viewed television clips with counter-stereotypical portrayals of women in STEM had no statistically significant increase in STEM interest or self-efficacy in STEM (16). This highlights the fact that both traditional media and social media have limited influence on the STEM identity of girls.

The results from this study were also analyzed based on additional data provided by the participants to highlight any factors that affected the influence of the social media intervention. The data from the experimental group's change in STEM identity based on EC participation indicated that there was not a significant difference ($p = 0.98$) between participants who were in a STEM EC and those who were not (**Table 4**). In contrast, girls in the experimental group who aspired to have a career outside of STEM had a significantly higher increase ($p = 0.04$) in STEM identity than those who aspired to have a career in STEM (**Table 5**). A possible explanation for this finding is the Ego Identity Formation Theory. The theory states that girls who are actively exploring a STEM identity are more likely to be influenced by counter-stereotypical portrayals of women in STEM than girls already committed to a STEM identity (14).

Although the overall study results did not support the hypothesis that social media portrayal of women in STEM would increase STEM identity, it can disprove the notion that adolescent girls are not affected at all by counter-stereotypical portrayals of women in STEM on social media. Certain participants did experience a large increase in STEM identity after viewing the 'Women Doing Science' Instagram posts. For example, Participant 2 experienced a 22-point increase in STEM identity and Participant 3 experienced a 11-point increase in STEM identity (scale range 21-84) (4) (**Table 1**). As previously mentioned, this might relate to the Possible Selves Theory because the participants who experienced a large increase in STEM identity might have had a higher sense of similarity to the women in the Instagram posts (14). In addition, most participants in the experimental group reported wanting to continue following the 'Women Doing Science' Instagram page even after the completion of the study period. This indicates that the participants felt some connection with the Instagram posts they interacted with and had a desire to continue interacting with the women in STEM content.

With the gender gap in STEM still strikingly relevant in today's society, it is important to find effective solutions to increase STEM identity in girls. The results from this study suggest that future research focuses on alternative

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interventions to social media. Although from an ideological point of view, showing positive portrayals of women in STEM on social media to adolescent girls would seem likely to increase their STEM identity, the results from this study point otherwise. This study's findings indicate that the easily accessible and time-efficient solution of social media is not ideal because it sacrifices the effectiveness of the solution and its impact on girls. Other potential interventions, such as girls-only organizations, have been shown to result in a significant increase in STEM identity in girls and should be focused on in the future as a solution (17). That is not to say that social media should be ignored completely; it is a great tool to use because of its easy availability and ability to reach millions of people. Counter-stereotypical portrayals on social media do have a slight positive impact on the STEM identity in girls, so they can be used as complementary tools to a more concrete and effective intervention.

There were multiple limitations in this study. The main limitation was the small sample size (17 participants). However, this study was the first to analyze the topic of inquiry, so it provides preliminary findings that can be expanded upon in future studies with larger sample sizes. Another limitation of this study is that many participants in this study reported having As and Bs as their current grades in math and science classes. People who have high grades in STEM classes tend to have stronger STEM identities (18). Having a majority of participants with high grades in STEM in both the experimental and control groups might introduce some bias in the data toward that specific population, which limits the generalizability of the findings. Another possible limitation of this study was that because iMessage group chats were used as the form of communication, participants had access to other participants' phone numbers and possibly could have discussed the study, influencing their responses to the survey forms. However, the participants were requested to only discuss the study directly with the researchers and were not allowed to post any information in the group chat.

Potential for future research includes conducting a qualitative analysis on the effects of counter-stereotypical portrayals of women in STEM on social media on adolescent girls. This study focused solely on numerical data to measure the change in STEM identity, which limits the understanding of how and why the social media intervention produced those changes. A qualitative analysis of this topic would be especially useful in gaining a more thorough explanation of why certain participants had a higher increase in STEM identity than others. Additionally, in this study, it was identified that differences in age between participants and media models might have reduced the influence of the social media intervention. Thus, future studies should focus on investigating the extent of similarities to social media role models on changes in STEM identity. Another route for future research is to investigate the effectiveness of exposure to counter-stereotypical portrayals of women in STEM at later stages in the STEM pipeline, such as when obtaining graduate degrees. This study included adolescent girls because adolescence is when most girls are first exposed to STEM in an academic setting, but it is possible that a social media intervention could be more effective in the later stages of the STEM pipeline when the gap in female representation widens.

The data from this study suggest that exposure to counter-stereotypical portrayals of women in STEM on social media was not associated with a significant increase in STEM identity in adolescent girls. The study findings also suggest that the attention on social media as a solution to reduce the gender gap in STEM should be refocused on other potentially more effective solutions that would have a more significant impact on the STEM identity of adolescent girls. Social media should be thought of as a complementary tool that can be used to support and encourage women in STEM without the assumption that it alone will close the gender gap in STEM.

MATERIALS AND METHODS

Study Design:

The study design was a pretest-posttest with a randomized control-group (19). In this study design, participants were randomly assigned to two groups - an experimental group that was exposed to the study intervention and a control group. Both groups of participants were asked to complete a pretest. After the study intervention was administered, all of the participants were asked to complete a posttest. This type of design allowed us to determine whether any change takes place as the result of experimental intervention exposure and potentially eliminate confounding variables (19). Due to the separation of participants into experimental and control groups and the randomization of such groups, this study falls under a "true experimental design" (19).

Sampling:

The participants in this study were gathered using convenience sampling. A total of 20 high school girls from a single high school were gathered as participants. This number was chosen because 20 participants would be a large, yet attainable sample size that was sufficient for measuring the effects of media on adolescents (20). High school girls were the chosen demographic of participants because they are the target gender for the intervention and they fit into the category of adolescent girls.

Instrument Creation/Collection: The instruments used to gather data were surveys created using Google Forms (21). The first form used was an initial consent form, used to gather participants and confirm that they fit the necessary parameters. During data collection, there were a total of four forms utilized: a control pretest, an experimental pretest, a control posttest, and an experimental posttest. The pretests and posttests were split according to the group to make data analysis more efficient. All of the four forms were identical except for the experimental posttest form, which included a follow-up section that asked participants if they would continue following the Instagram page used in the study.

The survey used in this study was split into four sections. Section one asked for background information. Sections two and three measured STEM identity using Likert scale questions that measured its two components: STEM interest and self-efficacy in STEM. The two scales used were adapted from the scales used in Hughes and colleagues' study to measure STEM identity (4). Section two measured STEM interest using 11 four-point Likert scale style questions with 11 being the lowest score (indicating low STEM interest) and 44 being the highest (indicating high STEM interest). Section three measured participants' self-efficacy in STEM using 10 four-point Likert scale style questions with 10 being the lowest score and 40 being the highest. To calculate STEM identity,

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the STEM interest and self-efficacy in STEM scores were added together, with 21 being the lowest score and 84 being the highest (4). Section four asked for additional information, such as grades, career aspirations, and participation in STEM extracurriculars. All of the form responses were gathered in the researcher's personal, password-protected Google Drive and the responses were anonymous to maintain confidentiality.

Experimental Intervention:

The social media platform being used in this study was Instagram, a photo and video public social networking service that allows users to upload media (22). Instagram was chosen because of the high number of adolescents that use the app, with 73% of teens ages 15-17 stating that they use Instagram (23). The Instagram page used in this study for the intervention was 'Women Doing Science' (15). This page was chosen because a published content-analysis study about 'Women Doing Science' concluded that the page highlighted diverse and international female scientists (12). From the 'Women Doing Science' Instagram page, 14 Instagram posts were selected that included diverse female scientists from various STEM fields.

Study Procedure:

To gather participants, a flyer with a QR code to the consent form was displayed in teachers' rooms and at an all-girls club at a high school. Once all the participants were gathered (n = 20), they were randomly split into two groups with ten participants in each group using a random group generator found online (24). Two separate iMessage group chats were created for the two groups, one containing all the participants in the experimental group and one containing all the participants in the control group. All participants were asked to maintain anonymity in the group chats. The link to the pretest form was sent out in both group chats and participants had 48 hours to complete it. Over the next two-week period, a link to a social media post from the Instagram page 'Women Doing Science' was sent in the experimental group chat every morning (a total of 14 Instagram posts over 14 days). The participants had the rest of the day to view the post and read the caption associated with it. During this two week, the control group received nothing. After the two-week period, a link to the posttest was sent out in both group chats and participants had 48 hours to complete the posttest.

Data Analysis:

Google Sheets was used to collect and store the data from the surveys. The mean differences in pretest scores and posttest scores were analyzed using a two-tailed Student t-test with an online t-test calculator (25). A p-value of < 0.05 was considered as statistically significant.

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