

#WomenInSTEM: exploring self-presentation of identity on Instagram

Jocelyn Steinke, Amanda Coletti and Christine Gilbert

Abstract

Despite prior research on portrayals of women in STEM in traditional media, fewer studies have considered portrayals on social media. This content analysis of Instagram posts ($N = 300$) examined how individuals using the hashtag #WomenInSTEM presented their gender identity, STEM identity, and other social identities through digital self-portraits, selfies, and associated text. Results showed that those associating with this hashtag community primarily presented: 1) counter-gender-stereotyped portrayals, but occasionally reflected gender stereotypes in subtle ways; 2) STEM identity portrayals, mostly focused on self-recognition; and 3) self-promotional and lifestyle portrayals. Findings advance understanding of identity presentation and negotiation for individuals associating with the hashtag #WomenInSTEM through portrayals presented on Instagram. Implications for the use of social media to promote equity in STEM through outreach programs that feature women STEM role models are discussed.

Keywords

Representations of science and technology; Science and media; Women in science

DOI

<https://doi.org/10.22323/2.23010203>

Submitted: 20th December 2022

Accepted: 10th December 2023

Published: 28th February 2024

What if in the midst of pictures of latte art (#coffee — 60,101,499 posts), too-cool-for-school street style bloggers (#streetstyle — 22,467,290 posts) and perfectly posed selfies (#selfie — 285,503,611 posts) there were some really cool science (#science — 4,064,469) posts that made even just one girl stop and wonder a little bit longer. Girls need to see that science is cool and exciting and that scientists are girls just [like] them.

And that is why I post pictures of the above. I am not immune to the pull of a delicious cup of latte-art or a good selfie just because I am a scientist. In order to promote science, we need to destroy barriers and make science and those who do the science relatable. We need to encourage girls to be excited about the potential science holds and we cannot let girls be deterred because there is no one for them to aspire to become.
Sasha Weiditch, Soapbox Science [Weiditch, 2017]

Social media has great potential to connect a vast audience of girls and young women with inspiring role models of women in STEM (science, technology, engineering, and math). While women's representation in STEM fields has improved in recent years, women comprise only 35 percent of the STEM workforce and are still underrepresented in computer science, engineering, physics, and mathematics [NCSES, 2023]. Examining images of women in STEM on social media is important because prior research focused on traditional media has found that media images influence girls' perceptions of STEM professionals [Miller, Nolla, Eagly & Uttal, 2018], internalization of gender-stereotyped views that promote STEM careers as more appropriate for men [Cheryan & Markus, 2020; Prieto-Rodriguez et al., 2022], identification with STEM professionals [Steinke, Applegate, Penny & Merlino, 2022; Steinke et al., 2007], and STEM identity, which has indirect effects on STEM career interest [Chen, Hardjo, Sonnert, Hui & Sadler, 2023]. Thus, social media may be important for providing adolescent girls with access to more inclusive images of STEM professionals as well as strategies for identifying with STEM and overcoming challenges related to gender bias they may experience in STEM settings. Further, these images may be especially important for adolescent girls from racial and ethnic groups that historically have been underserved and have experienced discrimination, microaggressions, and a lack of support in STEM that can lead to exclusion, isolation, and feelings of not belonging in STEM [Carlone & Johnson, 2007; Johnson, 2011a; Wilkins-Yel, Hyman & Zounlome, 2019].

Women in STEM who participate in public communication on social media have the potential to serve as vicarious role models when direct contact with real-life women STEM professionals is lacking [Fujioka, 1999; Steinke, 2017]. Prior research has identified both real-life and media role models as effective for increasing girls' and young women's interest and participation in STEM, and particularly for STEM fields where women are most underrepresented [Barakat, 2022; Farland-Smith, 2012; Merritt et al., 2021; Todd & Zvoch, 2019]. Research has also stressed the importance of interaction with women role models from culturally diverse backgrounds [Prieto-Rodriguez et al., 2022]. Social media portrayals of women in STEM, in particular, may be highly salient role models because of adolescent girls' widespread attraction to and use of social media [Anderson & Jiang, 2018; Vogels, Gelles-Watnick & Massarat, 2022]. Despite an increased focus on research in this area [Huber & Baena, 2023; Jarreau et al., 2019; Phillips et al., 2022; Wells, 2023], relatively little is known about portrayals of women in STEM on social media. In particular, many questions remain about *how* individuals who identify as women in STEM address gender-STEM stereotypes as they negotiate their gender and STEM identities through their self-presentation on Instagram.

Social media has become increasingly more crucial in science communication [Brossard & Scheufele, 2013] as STEM professionals have turned to social media for public outreach and public engagement [Keng & Cheng, 2023]. Additionally, women in STEM have often utilized social media to advocate for social change in STEM [Yammine, Liu, Jarreau & Coe, 2018]. In fact, social media has become an especially powerful tool for challenging traditional structures in STEM and promoting individuals who historically have been unseen and unheard in STEM contexts [Yammine et al., 2018]. This transformative power of social media is underscored by the popularity of campaigns such as #thisiswhatascientistlookslike [Wilkinson, 2012] and #womendoingscience [Phillips et al., 2022], which encourage

the use of social media to address traditional gender-STEM stereotypes that portray STEM as male gender-typed [Bond, 2016; Smyth & Nosek, 2015]. Indeed, in recent years, women in STEM have gained both visibility and voice on a wide array of social media platforms including Facebook, Twitter, Tumblr, YouTube, Instagram, TikTok, and LinkedIn [Calandrelli, 2022; GoldieBlox, 2022; Jarreau et al., 2019; Papadopoulos, 2018]. While there is a long history of research on portrayals of women in STEM in traditional media [Flicker, 2003; LaFollette, 1981; Long et al., 2010; Steinke, 2005; Steinke & Long, 1996; Steinke & Tavarez, 2018], research on portrayals of women in STEM on social media is a relatively new area of inquiry [Huber & Baena, 2023; Phillips et al., 2022; Steinke, n.d.; Wells, 2023].

Social media provides content creators with unique opportunities for self-expression and identity performance, giving them a great deal of control over the online identities they share and present to others [Barker & Rodriguez, 2019; Birnholtz & Macapagal, 2021; Butkowski, Dixon, Weeks & Smith, 2020; Van Ouytsel, Walrave, Ojeda, Del Rey & Ponnet, 2020]. Self-presentation has been defined, originally, in interpersonal contexts as both verbal and nonverbal messages used to depict the most credible image to others [Goffman, 1959] and defined more recently in social media contexts as self-disclosure [Smith & Sanderson, 2015]. Self-presentation is manifested on Instagram primarily through the creation, posting, and sharing of digital self-portraits and selfies that typically include an image of the subject as well as the subject's surrounding. In addition to a featured image of the subject, posts also may include an associated caption and/or text as well as metadata such as hashtags, tagging, and comments. It is important to examine posts by individuals who identify as women in STEM on Instagram because of the recent proliferation of these posts on social media [Wells, 2023].

Instagram is a highly visual platform whose affordances privilege visual content and encourage content creators to share personal details about their lives as a way to connect with followers through text, photo, video, voice notes, and polls [Meta, 2023]. Additionally, the platform vernacular [Gibbs, Meese, Arnold, Nansen & Carter, 2015] — the unique communication genre that develops from particular social media platform affordances as well as the mediated practices and communication habits of users [Gibbs et al., 2015; Keller, 2019] — shapes how both content creators communicate and platform audiences engage with social media [Waterloo, Baumgartner, Peter & Valkenburg, 2018]. For Instagram, for example, the platform vernacular is manifested through photo-sharing and hashtagging, which reflect the specific communicative practices, styles, and conventions of this platform [Burgess, 2006; Caliandro & Graham, 2020]. Prior research has found that Instagram posts present many images of individuals who identify as women in STEM; these images represent women from diverse backgrounds and identities (e.g. presenting gender, race and ethnicity, age, STEM field, geographical location) [Jarreau et al., 2019; Phillips et al., 2022; Winick Anthony, 2016; Yammine et al., 2018]. Examining portrayals associated with the #WomenInSTEM on Instagram is particularly crucial because adolescent girls and young women are frequent and impressionable users of the platform [Anderson & Jiang, 2018; Butkowski et al., 2020]. As of June 2022, 55.1% of women in the U.S. ages 13 years or older reported using Instagram [NapoleonCat, 2023], with 72% of adolescents reporting regular use [Anderson & Jiang, 2018]. Relatedly, research has also found that adolescent girls strategically choose social media platforms, carefully considering the benefits of a particular platform vernacular as well as issues like community, privacy, and

peer support when engaging with feminist politics online [Keller, 2019]. Subsequently, it is important to examine what self-portraits and selfies of individuals who use the #WomenInSTEM hashtag on Instagram reveal through self-presentation of their identities online because of their potential influence as role models.

Communication research on self-presentation on social media has been quite prolific for various identity groups, such as young women [Butkowski et al., 2020; Döring, Reif & Poeschl, 2016], young women from Egypt and Tunisia [Bardhan, 2022], athletes [Smith & Sanderson, 2015], young Muslims [Trysnes & Synnes, 2022]; however, there have been gaps in this research. First, most prior research has focused on women, in general [see, for example, Butkowski et al., 2020; Chang, Li, Loh & Chua, 2019; Döring et al., 2016], and fewer studies have focused specifically on professional women. Second, few studies have considered women's self-presentation of multiple identities [Phillips et al., 2022] and negotiation of conflicting identities. Thus, it is important to determine how members of the #WomenInSTEM hashtag community presented their identities on Instagram to raise awareness and challenge culturally supported gender-STEM stereotypes that continue to contribute to the underrepresentation of women in STEM and create persistent systematic inequities for women in STEM.

Literature review

Social identity theory

Social identity theory [Tajfel & Turner, 1979, 1986] is an especially useful framework for the present study because it highlights the *active negotiation* that occurs when individuals who associate with different social groups (i.e., woman and STEM person) integrate multiple identities into their overall self-identity. Through affiliations with *both* of these social groups, individuals who identify as women in STEM signify the importance and value of *both* groups for their self-identity. Social identity explains how identity development is driven by individuals' desire for connections with various social groups [Tajfel & Turner, 1979] and describes how individuals view themselves and others based on their perceptions of social groups [Tajfel & Turner, 1979]. According to social identity theory, individuals continuously strive to associate with ingroups that are positively perceived and that reinforce their self-esteem and simultaneously disassociate from outgroups that are negatively perceived because they are viewed as unsatisfactory, lower in status, or inferior [Tajfel & Turner, 1979]. Social identity theory highlights the dynamic, ongoing nature of identity development and recognizes how shifting perceptions of social groups (and priorities) influence individuals during the process of integrating multiple social identities into a desirable self-identity [Stets & Burke, 2000; Tajfel, 1981; Tajfel & Turner, 1979]. Thus, social identity theory is useful for exploring the integration of two distinct social identities: a gender identity (i.e., woman identity) and a professional identity (i.e., STEM person) for those who identify with both social groups.

Social identity theory also provides insights about why individuals present social group identities in certain ways on social media. Communicating identity or identity signaling has become widespread on social media and may reflect both individuals' actual selves as well as their idealized selves [Hollenbeck & Kaikati, 2012]. In the context of the present study, social identity theory advances

understanding of why self-presentation of two social group identities (i.e., woman identity and STEM identity) may be enacted on Instagram. Enduring, traditional cultural norms and assumptions have associated STEM professions with masculine attributes and as a male domain [Archer, 1985; Francis et al., 2017], conveying ingroup attributes and values that may discourage women from STEM careers. Indeed, prior research has found that these gendered cultural representations of STEM have caused identity conflict, also described as identity interference, for women in STEM [Settles, 2004]. Thus, drawing on social identity theory to better understand how and why certain social identities were self-presented by individuals who associated with the #WomenInSTEM on Instagram in light of pervasive gender-STEM stereotypes, the first overarching research question is proposed below.

RQ1: What is the self-presentation of individuals who identified with the #WomenInSTEM on Instagram?

Negotiation of gender identity and STEM identity

Social identity is defined as “those aspects of an individual’s self-image that derive from the social categories to which he [/she/they] perceives himself [/herself/themself] as belonging” [Tajfel & Turner, 1979, p. 40]. Adopting a social identity “means being at one with a certain group, being like others in the group, and seeing things from the group’s perspective” [Stets & Burke, 2000, p. 226]. Individuals associate with multiple social groups at any given time [Jones & McEwen, 2000; Roccas & Brewer, 2002; Tajfel & Turner, 1979]. Identity compatibility describes the successful integration of associations forged among different social identities [Rosenthal, London, Levy & Lobel, 2011]. While identity incompatibility describes perceived interference among social identities in conflict [Settles, 2004], which emerge when there are differences in values, norms, and expectations. Identity integration and the “development of multiple aspects of identity” [Stewart, 2008, p. 184] may be particularly challenging when a group is hostile to one’s existing identities [Stewart, 2008]. This explains why many women in STEM face challenges in embracing and integrating two different — gender and STEM — social identities promoted as incompatible by dominant ingroup members in STEM [Schmader, 2023], often leading to perceptions of incompatibility by professional women in STEM [Settles, 2004].

Gender identity has been defined as the degree to which an individual perceives one’s self to be masculine or feminine, given societal definitions of gender [Perry & Pauletti, 2011; Vantieghem, Vermeersch & Van Houtte, 2014]. Expression of gender identity by individuals identifying as women on social media is often conveyed through Western feminine ideals related to attire, styling, posture, facial expressions, and gaze [Döring et al., 2016]. Expressions of gender identity by individuals identifying as women on social media have been found to reproduce “normative feminine cues” [Butkowski et al., 2020, p. 817] and gender stereotypes through stereotypical feminine gender displays in selfies [Butkowski et al., 2020; Döring et al., 2016]. Goffman’s [1979] approach for analyzing visual representations of feminine ideals identified five types of gender stereotypes in visual representations of women in print magazine advertisements (relative size of person, feminine touch, function ranking, ritualization of subordination, function

ranking or depiction in traditional roles or settings, withdrawing gaze). A sixth type of gender stereotype (body display) was later added to Goffman's framework [Kang, 1997].

Several studies have applied Goffman's [1979] framework to examine gender stereotyping in women's self-presentation on social media. For example, a study of 500 Instagram selfies found gender-stereotyped depictions of women exhibiting a feminine touch, imbalance, withdrawing gaze, and a loss of control [Döring et al., 2016]. Another study of 1,700 selfies posts by young women ages 18 to 30 in the U.S. found widespread use of visual feminine gender displays [Butkowski et al., 2020]. Specifically, the women in this sample often posted selfies that showed a loss of control (expressive emotions), body display (visibility of body parts) and canting (bending the head or body to indicate appeasement) [Butkowski et al., 2020]. Interestingly, the researchers described a normalization of gender display online and noted that through gender displays, women expressed gender stereotypes in more subtle and understated ways in selfies than typically evident in other media [Butkowski et al., 2020]. Prior research has considered how gender identity is expressed by women on social media, in general, but few studies have looked specifically at gender identity expression by those who identify as women in STEM on social media [Wells, 2023]. Thus, the next research question is posed below.

RQ1a: Do individuals who identified with the #WomenInSTEM use stereotypical gender displays and feminine ideals to represent their gender identity in Instagram posts?

A "science identity" or "STEM identity" is a representation of one's self as a scientist [Carlone & Johnson, 2007] or a STEM person [Herrera, Hurtado, Garcia & Gasiewski, 2012]. Theoretical conceptualizations have posited four interrelated dimensions of a science identity: competence, performance, recognition [Carlone & Johnson, 2007], and interest [Hazari, Sonnert, Sadler & Shanahan, 2010]. An extension of these conceptualizations integrates multiple social identities with a STEM identity and situates them in two social contexts (STEM contexts and non-STEM contexts) within the overarching societal context [Herrera et al., 2012]. This extension [Herrera et al., 2012] describes and underscores the interactions among compounded social identities and highlights the potential influence of media (i.e., non-STEM contexts) on STEM identity formation. Understanding STEM identity is important because it has been shown to be related to STEM interest, persistence in STEM fields, and choice of STEM careers [Aschbacher, Ing & Tsai, 2014; Brickhouse, Lowery & Schultz, 2000; Chen et al., 2023; Hazari et al., 2010; Tan, Calabrese Barton, Kang & O'Neill, 2013; Vincent-Ruz & Schunn, 2018].

Much extant research has been devoted to examining how to foster STEM identity as well as the many factors that contribute to its development [Aschbacher et al., 2014; Aschbacher, Li & Roth, 2010; Hazari et al., 2010; Trujillo & Tanner, 2014]. More recent research has begun to explore the impact that informal (non-school) STEM and at-home STEM experiences [Cian, Dou, Castro, Palma-D'souza & Martinez, 2022; Dabney, Chakraverty & Tai, 2013; Dou, Hazari, Dabney, Sonnert & Sadler, 2019] and media [Chen et al., 2023] have on STEM identity development. However, there is a dearth of research on the influence of both traditional and social media experiences on STEM identity development [see Steinke, 2017]. In

addition, social media may be a site where content creators who identify as women in STEM actively negotiate their gender identity and STEM identity when they perceive conflict [Settles, 2004] and tension [Garr-Schultz & Gardner, 2018] between two social identities that are linked to traditional gender-STEM stereotypes. In fact, recent research has emphasized that visual narratives crafted by women in STEM on social media can be powerful in challenging outdated, sexist assumptions and attitudes about women in STEM [Wells, 2023] as well as crucial for advocating for social change in STEM [Yammine et al., 2018]. Thus, the next research question reflects conceptual work on STEM identity as posed below.

RQ1b: How do individuals who identified with the #WomenInSTEM express STEM identity dimensions (competence, performance, recognition, interest) to represent their STEM identity in Instagram posts?

Traditional media portrayals of women in STEM

Historically, portrayals of women STEM professionals in traditional media have appeared less frequently than those of men, promoting a “cultural invisibility” [LaFollette, 2013, p. 186] of women in STEM. Underrepresentation of women in STEM has been found on children’s television programs [LaFollette, 1981; Smith, Choueiti, Prescott & Pieper, 2012], children’s educational science television programs, [Long, Boiarsky & Thayer, 2001; Steinke & Long, 1996], television programs watched by adolescents [Long et al., 2010], primetime television programs [Dudo et al., 2011; Gerbner, Gross, Morgan & Signorielli, 1981; McIntosh, 2014; Weitekamp, 2015], and STEM children’s television programs [Aladé, Lauricella, Kumar & Wartella, 2021]. Similarly, women STEM professionals have been underrepresented and portrayed in stereotypical ways in popular films [Flicker, 2003; Smith et al., 2012; Steinke, 2005; Steinke & Tavarez, 2018; Szwydny & Pribbernow, 2018].

When present in traditional media, women in STEM have often been depicted to reflect stereotyped cultural norms of femininity and have been mostly shown in traditional roles. For instance, gender-STEM stereotypes have been reinforced through portrayals of women in STEM that feature them in subordinate STEM professional roles [Steinke, 2005; Steinke & Long, 1996]; overemphasize their feminine qualities, physical attractiveness, or oversexualize them [Flicker, 2003; Steinke, 2005; Steinke & Tavarez, 2018]; focus on their romantic relationships [Steinke, 2005; Steinke & Tavarez, 2018]; downplay their intelligence and scientific careers [McIntosh, 2014]; present them as physically unattractive [Steinke, 2005] or nerdy — shown as “an awkward, outcast individual who paired intense intellectual interests with general social discomfort” [Weitekamp, 2015, p. 80] or appearing in “uncoordinated clothing, pocket protectors, lack of personal hygiene, too short (‘high-water’) pants, and glasses, especially with ad hoc repairs (i.e. held together with tape or glue)” [Kendall, 1999, p. 263]; and highlight motherhood and STEM careers as incompatible pursuits [Steinke, 2005]. Over time, counter-stereotypical portrayals of women STEM professionals, although less frequent, have appeared more regularly in popular media in children’s television programming [Aladé et al., 2021], television programs popular among adolescents [Long et al., 2010], and films [Carlson & Crowell, 2018; Long et al., 2010; Steinke & Tavarez, 2018]. These counter-stereotypes of women in STEM have begun the

important work of challenging long-held, cultural assumptions about gender and STEM. Research on counter-stereotyped portrayals of women in STEM in social media has emerged more recently [Huber & Baena, 2023; Jarreau et al., 2019; Phillips et al., 2022; Steinke, n.d.; Wells, 2023] as portrayals of women in STEM have become more pronounced on social media. Despite these advances in addressing and challenging gender-STEM stereotypes, it is important to consider whether social media show greater representation of women in STEM from an array of STEM fields because of their continued underrepresentation in engineering, physics, computer science and mathematics [NCSES, 2023]. The next research question is therefore presented below.

RQ1c: Do individuals who identified with the #WomenInSTEM self-present by STEM discipline in Instagram posts?

Social media portrayals of women in STEM

Studies have noted the underrepresentation of women STEM professionals across several social media platforms. For example, a study of “science stars” on *Twitter* found only four women out of 50 scientists listed among the top most followed scientists [You, 2014]. Another study of scientists appearing on *Twitter* also found fewer women scientists (38.6%) than men scientists (61.4%) [Ke, Ahn & Sugimoto, 2017]. A study focused on STEM *YouTube* hosts noted only 32 women were hosts of the 391 popular science, engineering, and mathematics-themed channels, and women hosts reported more negative, sexist, and appearance-focused comments [Amarasekara & Grant, 2019]. However, some studies have found more realistic as well as counter-stereotyped portrayals of women in STEM. For example, images associated with the #iLookLikeAnEngineer *Twitter* campaign found women were most often shown in regular clothing rather than uniforms [Wells, 2023]. In addition, women posting to this hashtag represented “the invisible faces of engineering: those who are female — Women of Color and white women — of varying age and attractiveness and presentation of femininity, doing the varied and diverse work of engineering” [Wells, 2023, p. 95]. A study that examined the influence of viewing images of scientists on social media associated with the #ScientistsWhoSelfie on *Instagram* found that woman scientists who appeared smiling in selfies were perceived to be warmer than women scientists who only posted images of objects in lab settings, suggesting that self-presentation in social media posts may be effective in challenging stereotypes about personality traits of scientists [Jarreau et al., 2019]. In addition, people viewing the selfies of women scientists were more likely to perceive science as less exclusively male [Jarreau et al., 2019]. Overall, however, research on portrayals of women in STEM on social media lags behind that for traditional media, thus, it is important to examine self-presentation in social media posts by individuals who identify as women in STEM.

Despite the dearth of research in this area, many individuals who identify as women in STEM on social media regularly share digital portraits and selfies on a variety of platforms [Jarreau et al., 2019]. Self-presentation on social media primarily occurs through creating, posting, and sharing digital self-portraits and selfies that typically include an image of the subject as well as the subject’s surrounding. In addition to a featured image, digital self-portraits and selfies also

may include an associated caption and/or text as well as metadata such as hashtags, tagging, and comments. Social media users' self-presentation on social media has been described as a form of *identity work*. "Identity work" [Howard, 2000; Rounds, 2006] is distinguished from identity as it is focused on the *active processing of identity construction, maintenance, and change* [Rounds, 2006]. Prior research defined identity work as the cognitive "processes through which we construct, maintain, and adapt our sense of personal identity, and persuade other people to believe in that identity" [Rounds, 2006, p. 133]. Thus, self-presentation reflects carefully considered, active, and intentional crafting of "the self as a social media object in a very particular way and with very particular claims to authentic identities and experiences" [Iqani & Schroeder, 2016, p. 410]. Research has connected selfies, social identity theory, and identity work: "Selfies can be forms of identity work in which the ingroup of the individual is either implicit or clearly enacted" [Barker & Rodriguez, 2019, p. 1144]. Relatedly, our next research question is:

RQ1d: Do individuals who identified with the #WomenInSTEM present other social identities in Instagram posts? If so, how do they present other social identities in Instagram posts?

Digital social media self-portraits and selfies may be important vehicles for the self-presentation of identity work of individuals who identify as women in STEM. Prior work has found that posts featuring women in STEM are often created by professionals and students (typically undergraduate and graduate students) as well as science communicators and informal STEM educators interested in cultivating girls' interest in STEM [Calandrelli, 2022; GoldieBlox, 2022; Sung, 2018; Weiditch, 2017]. One study provided an analysis of the language women used in 14,611 tweets posted on Twitter 2018 using hashtags associated with women in STEM (74% of tweets were associated with the #womenintech and #WomenInSTEM) [Alkhamash, 2019]. This study found that women in STEM used positive language to convey information about women STEM professionals [Alkhamash, 2019]. Most of the tweets were informational, focused on professional contests, networking opportunities, online campaigning, and support [Alkhamash, 2019]. In addition, women acknowledged — and discussed how to change — gender bias and gender stereotypes in STEM [Alkhamash, 2019]. This study noted the practice of retweeting and using hashtags gave women a voice that they used to promote their work and the work of other women in STEM on Instagram [Alkhamash, 2019].

Hashtag activism and #WomenInSTEM

Hashtags, originally created on Twitter to allow users to follow topics of interest, are now frequently used by social media content creators to signal important issues and events, showcase trending topics, and connect with a community of interest [Sharma & Bedi, 2018]. Hashtags have become an integral part of social media culture and "serve as anchors for online conversation" [Naraine, Pegoraro & Wear, 2021, p. 626]. Beyond promoting discussion among community members who share similar experiences, hashtags also have been used to raise awareness of feminist issues and lobby for social change. Hashtag activism, in fact, has sparked

several powerful feminist social movements, calling attention to the issues of sexual assault of women [i.e., #MeToo; Suk et al., 2021], street harassment of Black women [i.e., #YouOKSis; Johnson, 2019], intimate partner violence [i.e., #WhyIStayed; Cravens, Whiting & Amar, 2015], and exclusion of women in engineering [i.e., #ILookLikeAnEngineer; Wells, 2023]. Despite some prior research on hashtag activism by individuals who identify as women in STEM [Alkhamash, 2019; Wells, 2023], little is known about the topics discussed by those who identify with the #WomenInSTEM. Examining this is crucial for determining the specific issues considered important to women in STEM [Alkhamash, 2019] and highlighted as important for addressing systematic gender inequities in STEM that hinder women's full participation [Yammine et al., 2018], changing outdated public perceptions of gender and STEM [Wells, 2023], and identifying women STEM role models to inspire a new generation of girls and young women in STEM [Steinke, 2017; Steinke, Baumel & Turner, n.d.]. Thus, the final research question is posited below.

RQ2: What are the primary topics discussed in Instagram posts for those who identify with the #WomenInSTEM?

The present study examined portrayals of individuals who self-identified with the #WomenInSTEM on Instagram. The goal of this study was to investigate the self-presentation of gender identity, STEM identity, and other social identities as well as the topics discussed by those who identify with Instagram's #WomenInSTEM. The present study provided important baseline data about identity negotiation of social identities by these individuals, highlighting their responses to gendered stereotypes of women in STEM.

Methods

A quantitative content analysis [Krippendorff, 1980] was used to analyze 300 Instagram posts that used the hashtag #WomenInSTEM. A single Instagram post was the unit of analysis. A codebook was developed to guide an extensive analysis of 38 codes to assess portrayals of members associating with this hashtag community and to address the research questions (Supplementary material).

Sampling

A purposive sample of 300 Instagram posts that included the #WomenInSTEM were collected during a 14-day period between May 26, 2022 and June 8, 2022. The #WomenInSTEM was selected because prior research determined 74% of tweets were associated with the hashtags #WomenInSTEM and #womenintech [Alkhamash, 2019]. However, the #womenintech was not used to avoid oversampling from a specific STEM field. A final sample of 300 posts was determined to be appropriate for two primary reasons. First, prior research has suggested that a sample of 300 to 500 posts appropriate to effectively capture all codes for an identified time period and topic [Hoare, Garnett, Baur, Lister & Jebeile, 2022]. Second, given the lack of research on how women in STEM represent themselves on Instagram, providing a baseline for future work was prioritized over analyzing a larger sample that would have required additional resources.

The #WomenInSTEM hashtag was entered in the search function on Instagram to identify applicable posts. Prior research indicated that hashtags act as “markers of collective identity” [Konnolly, 2015, p. 11], thus searching by #WomenInSTEM provided a way to identify and screen Instagram posts of individuals who self-identified with this hashtag. Only “most recent” posts were considered rather than “top” posts in order to focus on women *in general* rather than top social media influencers and also because of a lack of transparency from Instagram about how top posts are selected. All 300 posts to the hashtag were collected over the 14-day sampling period. Two of the authors alternated sample collection every other day until all posts to the hashtag during the 14-day period were collected. Both images and videos were eligible; for videos, a still-shot was taken at 0:00 and the subsequent image coded. Posts were included only if the image or video still-shot in the post showed a real photo or video still-shot of a single individual. Group photos, cartoon images, drawings, or photos of only text were excluded. In addition, a post was excluded if it was a promotional post for other media (e.g., a podcast or interview), if the image or video still-shot was not of the owner of the Instagram account, or if the image or video still-shot was not related to STEM. The determination of whether a video still-shot was related or not to STEM was made by examining the still-shot for any signs or symbols of STEM, such as STEM content, visual cues, settings, language, demonstrations of STEM knowledge, STEM equipment, or STEM activity. If a post included multiple photos or videos, only the first image or video still-shot was included because it was considered to most likely be seen by Instagram users. Two of the authors met regularly during the sampling period to review identified posts to ensure applicability and remove duplicate posts.¹ In order to minimize the impact of the posts from any single day on the overall sample, the fewest number of posts collected for any one day (21) were included in the final sample from each of the 14 days. This resulted in a total of 294 posts. To identify the remaining six posts, a random number generator (random.org) was used to select from the additional 48 posts that had been collected during the sampling process.

Codebook development

A codebook was developed based on thorough review of prior research on 1) traditional media portrayals of women in STEM [Long et al., 2010; Steinke, 2005; Steinke & Tavarez, 2018], gender stereotypes of women, including women in STEM, in media [Döring et al., 2016; Goffman, 1979; Jarreau et al., 2019; Kang, 1997], gender stereotypes of women in selfies on Instagram [Butkowski et al., 2020], and conceptualizations of science/STEM identity [Carlone & Johnson, 2007; Hazari, Sadler & Sonnert, 2013; Herrera et al., 2012; Tran, Herrera & Gasiewski, 2011]; and 2) preliminary review of Instagram posts for #WomenInSTEM not included in the final sample. The codebook provided specific examples for each code (see Supplementary material). A description of each code can be found in Table 1. For each code, coders either coded for presence or absence or the specific category noted in the codebook.

¹All posts determined appropriate for inclusion were archived for analysis. Some posts were subsequently removed from Instagram or creators made their accounts private, thereby removing access.

Table 1. Codes and code descriptions.

<i>Code</i>	<i>Code description</i>
Image	Each post was analyzed to determine whether the post included an image.
Text	Each post was analyzed to determine whether the post included text.
Video	Each post was analyzed to determine whether the post included a video.
Setting	The image or video still-shot in each post was analyzed for the setting or location where the image or video still-shot was taken.
Science- or STEM-related hashtags	Hashtags were coded as science or STEM-related hashtags when they related to the visual content of the post and a science or STEM field (e.g. #biology, #chemistry).
Not-science- or STEM-related hashtag	Hashtags were coded as not science or STEM related hashtags when they related to the visual content of the post but were not related to a STEM field or science (e.g., #football, #candy).
Identity-related hashtags	Hashtags were coded as identity-related hashtags when they referenced social identity groups with which an individual associated (e.g., #blackwomeninstem, #LGBTQ+).*
Overall attire	The overall appearance of the individual was coded into one of four categories: everyday or casual, professional, sexy or glamorous, and unstylish or nerdy or unattractive. Everyday clothing was coded for attire that was casual and not required for lab or fieldwork. Professional clothing was coded for graduation regalia, scrubs, business attire, or a specific uniform required for lab or fieldwork. Sexy or glamorous clothing was coded for attire not typically be considered workplace appropriate and/or sparse clothing where the amount of visible skin was high [Döring et al., 2016, see “body display”; Steinke & Tavarez, 2018]. Unstylish or “nerdy” or unattractive clothing was coded for attire that was blatantly unaesthetically pleasing or was a costume and was based on prior research on representations of “nerds” in popular culture [Kendall, 1999] and prior research on images of women scientists and STEM professionals [Steinke, 2005; Steinke & Tavarez, 2018].
Jewelry	The presence or absence of jewelry worn by an individual was coded (i.e., necklaces, rings, bracelets, anklets, ear and nose piercings).
Makeup	The presence or absence of obvious facial makeup worn by an individual was coded (i.e., lipstick, eyelashes, mascara, eye shadow).
Pink or purple attire	The presence or absence of wearing traditionally feminine colors was coded (i.e., pink or purple).
Kissing pout	The presence or absence of a common gendered facial expression — the kissing pout [Döring et al., 2016] or pursed lips was coded.
Imbalance	Based on work by Goffman [1979], Kang [1997] and Döring et al. [2016], the presence or absence of physical imbalance or looking over one’s shoulder or back at the camera, tilting the head, or standing with a popped hip was coded. Visuals of individuals “in action” or moving were not coded as imbalanced.
Downward or withdrawing gaze	Individuals who were looking away from the camera or who were not facing the camera were coded as having a downward or withdrawing gaze [Goffman, 1979; Kang, 1997; Döring et al., 2016].

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Table 1. *Continued from the previous page.*

<i>Code</i>	<i>Code description</i>
Presenting gender	Posts were coded based on “a person’s outward signification and performance of their gender identity” [Kosciesza, 2023, p. 3] and analyzed for the person in the photo or video still-shot following a procedure described by Webber and Farrar [2022]. Rather than categorizing individuals by gender (e.g., woman) or sex (e.g., female), features of the individual in the image or video still-shot were coded into masculine (e.g., broad shoulders, facial hair, shorter hair, strong jaw line, hair on body), feminine (e.g., narrow waist, breasts, long/flowing hair, big eyes, minimal body hair, androgynous (mix of both masculine and feminine characteristics), and unable to tell.
STEM identity recognition by others	STEM identity recognition by others was defined as receiving validation or affirmation from other people as being a science or STEM person in the post. This code was based on prior conceptualization of the dimensions of science or STEM identity by Carlone and Johnson [2007].
STEM identity recognition by self	STEM identity recognition by self was defined as an explicit statement by the individual in the post about being a STEM person or belonging in STEM. This code was an extension [Steinke, 2017] of prior conceptualization of the dimensions of science or STEM identity by Carlone and Johnson [2007].
STEM identity competence	<i>STEM identity competence</i> was defined as explicit statement by the individual that displayed having knowledge or understanding of a STEM field or a clear understanding of the state of their field. This code was based on prior conceptualization of the dimensions of science or STEM identity by Carlone and Johnson [2007].
STEM identity performance	STEM identity performance was defined as having or demonstrating knowledge or understanding of a STEM field or a clear understanding of the state of their field. This code was based on prior conceptualization of the dimensions of science or STEM identity by Carlone and Johnson [2007].
STEM identity interest	STEM identity interest was defined as providing an emphatic statement about desire, curiosity, and passion in STEM. It was expected that any individual posting to the hashtag #WomenInSTEM would be interested in STEM, thus the interest component of STEM identity was determined if posts explicitly indicated a particularly passionate expression of interest in STEM. This code was based on an extension by Hazari and colleagues [2010] of prior conceptualization of a science or STEM identity by Carlone and Johnson [2007].
STEM field or discipline	Each post was coded for explicit references by STEM field or discipline. Categories were based on STEM fields categorizations established and used by the National Science Foundation [NCSES, 2021].
Presenting age	Posts were coded based on explicit mentions of age or life stage (e.g., attending high school, life as a graduate student, beginning a career) as well as physical and facial features of the individual featured (e.g., height, skin texture or wrinkles, greying hair) to approximate the following life stages or developmental groups: children (under 12 years old), adolescents (13–17 years old), young adults (18–29), middle aged adults (30–50), and older adults (51+), and unable to tell. Coding categories were based on those described in prior research [Long et al., 2001; Long et al., 2010]
Mention of race and ethnicity	Posts were coded for explicit mention of race or ethnicity provided by the poster in the post text and/or hashtags (e.g. #blackwomeninmedicine, #latinasinstem, etc.). Categories included 0 = No explicit mention of race or ethnicity, 1 = Yes, at least 1 explicit mention of race or ethnicity.

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Table 1. *Continued from the previous page.*

<i>Code</i>	<i>Code description</i>
Mention of specific racial or ethnic group	Posts were coded for explicit mention to racial or ethnic group as presented by the poster in the post text and/or hashtags (e.g. #poc, #blackwomeninstem, #LatinasinSTEM, etc.). The categories were generated from the racial and ethnic groups specifically mentioned in the data and not based on a priori categorization. Resulting categories included 0 = N/A (no explicit mention of race or ethnicity), 1 = Black, 2 = Latinx, 3 = Asian, 4 = Middle Eastern, 5 = Multiracial (multiple race categories mentioned by poster) and 6 = POC (person of color, e.g. #poc, #bipoc).
Family relationship	Posts were coded for explicit mention of a family relationship.
Family relationship type	Posts were coded for explicit mention of a specific family relationship (e.g., spouse, mother, daughter, etc.).
Professional position	Posts were coded for explicit mention of academic training, current level of education, or the professional position of the poster in the post text and/or hashtags (e.g. college student, graduate student, postdoc, engineer, etc.). Coding categories were based on those described in prior research [Steinke & Tavarez, 2018].
Sexual Orientation	Posts were coded for explicit mention of sexual orientation (e.g., gay, straight, LGBTQ+, etc.).
Religion or Spirituality	Posts were coded for explicit mention of religion or spirituality (e.g., Christianity, Muslim, spirituality, etc.).
Mental health	Posts were coded for explicit mention of mental health conditions or being differently abled physically (e.g., depression, anxiety, etc.).
Physical ability	Posts were coded for explicit mention of being differently abled physically (e.g., physical disability, etc.).
Culture	Posts were coded if it included a language other than English or referred to a specific culture or cultural practice (e.g., Spanish text; ethnic foods, etc.).
Informational	A post was coded as informational when it contained specific science or STEM-related information intended to educate.
Entertainment	A post was coded as entertainment when it was intentionally humorous and/or satirical.
Self-promotional	A post was coded as self-promotional when it promoted or introduced the content creator.
Lifestyle	A post was coded as lifestyle when it related to the day-to-day life of an individual in STEM or reflected on experiences as a woman in STEM.
Call to Action	A post was coded as a call to action when it asked viewers to engage with the post or take some action.
Acknowledgement of challenges	A post was coded as an acknowledgement of challenges when it asked described educational and/or professional barriers or obstacles faced and concerns about bias and discrimination. Each post was coded to reflect statements about barriers and challenges related to experiences as a woman in a male-dominated field, including work-life balance. Prior research on images of women scientists and STEM professionals was used to develop these categories [Steinke, 1997, 2013]

* Because #WomenInSTEM was the hashtag of interest and used as the sampling selection criterion, an individual was coded as having an identity-related hashtag only if another social group identity hashtag was present.

Intercoder training, intercoder reliability, and coding procedures

Two coders applied the codebook to analyze text (embedded text, captions, hashtags) and images (selfies and photographs) for Instagram posts by content creators. Comments by other Instagram users were excluded from this analysis. Two coders reviewed and discussed the codebook in collaboration with the first author and practiced identifying codes using a think-aloud procedure for 40 posts (not included in the final sample) during six practice sessions. Before the remainder of posts were coded, discrepancies were discussed between the two coders and the first author. All discrepancies were resolved based on these discussions, and the codebook was modified accordingly. The two trained coders then independently coded a random sample of 10% of the dataset ($n = 30$), which has been determined in prior research as sufficient for assessing intercoder reliability [Dimitrova & Strömbäck, 2009; Smith, Markowitz & Gilbert, 2022]. Scott's pi [Scott, 1955], a conservative measure of intercoder reliability that takes chance agreement into account, was calculated using the ReCal2 online calculator [Freelon, 2010]. Coders achieved a Scott's pi of .80 or higher for 34 of the 38 codes, with a Scott's pi of .90 or higher for 28 of the 38 codes, and a Scott's pi between .70 to .80 for only 4 codes, thus achieving an acceptable level of intercoder reliability overall [Lacy & Riffe, 1996; Lombard, Snyder-Duch & Bracken, 2002] (Table 2). Once intercoder reliability was established, the two trained coders coded the rest of the sample independently for all 38 codes.

Associations between categorical variables were calculated using crosstabulation in SPSS and reported using the Phi coefficient [Jarreau et al., 2019].

Results

Of the 300 Instagram posts analyzed in this study, 96% ($n = 288$) of posts included an image, 4% ($n = 12$) of posts included a video, and 99% ($n = 297$) of posts included text (in addition to hashtags). The setting of the image or video in the posts mostly depicted a STEM classroom or college or university context (21.3%), followed by an outside location (19.7%), STEM laboratory (11.7%), or home (10.7%). Settings that were presented in less than 10% of the sample included (in decreasing order): STEM field setting, office or home office, generic setting, conference setting, museum, and hospital setting. In examining the hashtags used by those posting to the #WomenInSTEM on Instagram, 89.7% of posts included content and science or STEM-related hashtags, 85.3% of posts contained identity related hashtags, and 74.0% of posts contained content-related, but not science or STEM-related hashtags.

The first series of research questions examined the self-presentation of individuals represented in the Instagram selfies or photographs associated with the #WomenInSTEM. RQ1a asked if stereotypical gender displays and feminine ideals were used to represent gender identity in Instagram posts. Results indicated the use of some, but not all, gender stereotypical identity displays. In examining the pose or positioning of individuals in the Instagram posts, 41.7% demonstrated an imbalance, 22.7% looked downward or away from the camera, and only 1% demonstrated a "kissing pout" In overall appearance, members of this hashtag community mostly had a professional (52.3%) or everyday or casual (46.0%) appearance, with minimal self-presentations of sexy or glamorous (1.0%) or unstylish or nerdy or unattractive (0.7%) appearance. The majority of individuals

Table 2. Intercoder reliability metrics for all codes.

<i>Code</i>	<i>Percentage agreement</i>	<i>Scott's Pi</i>
Image	100%	1.00
Text	100%	1.00
Video	100%	1.00
Setting	96.7%	.959
Science- or STEM-related hashtags	93.3%	.712
Not-science- or STEM-related hashtags	96.7%	.869
Identity-related hashtags	96.7%	.869
Overall attire	93.3%	.871
Jewelry	93.3%	.830
Make-up	90.0%	.794
Pink or purple attire	100%	1.00
Kissing pout	100%	1.00
Imbalance	86.7%	.713
Downward or withdrawing gaze	100%	1.00
Presenting gender	100%	1.00
STEM identity recognition by others	93.3%	.866
STEM identity recognition by self	100%	1.00
STEM identity competence	96.7%	.911
STEM identity performance	93.3%	.850
STEM identity interest	86.7%	.700
STEM field or discipline	93.3%	.920
Presenting age	100%	1.00
Mention of race or ethnicity	100%	1.00
Mention of specific racial or ethnic groups	100%	1.00
Family relationship	100%	1.00
Family relationship type	100%	1.00
Professional position	100%	1.00
Sexual orientation	100%	1.00
Religion or spirituality	100%	1.00
Mental health	100%	1.00
Physically able	100%	1.00
Culture	100%	1.00
Informational	96.7%	.902
Entertainment	100%	1.00
Self-promotional	100%	1.00
Lifestyle	100%	1.00
Call to action	100%	1.00
Acknowledgement of challenges	100%	1.00

wore jewelry or accessories (62.0%), while just about half wore makeup (51.0%). A small percentage of individuals wore pink- or purple-colored attire (6.3%).

RQ1b asked if individuals who identified with the #WomenInSTEM used STEM identity dimensions (competence, performance, recognition, interest) to represent their STEM identity in Instagram posts. A large majority of the posts (96%,

$n = 288$) depicted recognition by self as a STEM-person, 47.7% ($n = 143$) of posts depicted recognition by others, 43.7% ($n = 131$) depicted interest, 34.3% ($n = 103$) depicted performance, and 19.7% ($n = 59$) depicted competence.

RQ1c asked if individuals who identified with the #WomenInSTEM self-presented by STEM discipline. The majority included in this sample were from biology fields (25.3%), followed by medicine (14.0%), computer science or technology (13.0%), engineering (8.7%), fields not specified (8.7%), multiple STEM fields (6.7%), social science (5.7%), ecology or environmental science fields (5.3%), chemistry (3.7%), physics (3.3%), astronomy (2.0%), pharmacology (1.3%), paleontology or natural history (1.3%), mathematics (0.3%), forensic science (0.3%), and general science (0.3%).

RQ1d asked how individuals who identified with the #WomenInSTEM presented other social identities. A majority presented their gender expression as feminine (99.7%) and age as young adult (18–29 years) (83.7%), followed by middle aged adults (30–50 years) (13.7%). Race was explicitly mentioned by posters in 15% ($n = 45$) of the posts. Racial and ethnic groups that were mentioned by posters included Black (5.3%; $n = 16$), Latinx (4.0%; $n = 12$), Asian (3.0%; $n = 9$), multiracial (1.0%; $n = 3$), person of color (1.0%; $n = 3$), and Middle Eastern (0.7%; $n = 2$). A small percent presented family relationship roles (8.0%), including roles as a mother, daughter, wife, sister, and granddaughter. In examining professional position, the majority were graduate students (42.3%), followed by industry (13.3%) and college students (12.3%). Professional positions that were presented in less than 10% of the sample included (in decreasing order): other positions, high school students, faculty members, post-doctoral fellows, and engineers. However, almost one-third did not indicate a professional position in their Instagram posts (26.0%). In examining additional social identities, 16.7% included nationality or cultural elements, 4.7% and 1.0% presented mental and physical disabilities, respectively, 4.3% demonstrated religious or spiritual beliefs, and 2.3% presented sexual orientation.

RQ2 examined the primary focus of the Instagram posts of individuals who identified with the #WomenInSTEM. Overall, 70.7% ($n = 212$) of posts were self-promotional, 42.7% ($n = 128$) were lifestyle, 19.7% ($n = 59$) were informational, and 5.3% ($n = 16$) were entertainment. Additionally, 26% ($n = 78$) included a call to action, and 29.3% ($n = 88$) recognized a challenge or an element of struggle. Posts that referred to a challenge or struggle also had a weak, positive association with the self-recognition dimension of STEM identity (Phi coefficient = .13, $p < .05$).

Discussion

Portrayals of women in STEM in posts that feature the #WomenInSTEM on Instagram may indeed be powerful communicative strategies for elevating the visibility and voices of those who advocate for social change for women in STEM. Beyond the obvious pragmatic benefits of providing ready access to a highly visible public space for building community and calling attention to gender bias in STEM, social identity theory [Tajfel, 1978; Tajfel & Turner, 1979] suggests additional psychological benefits for identity expression and identity integration for members of this virtual community. Findings from the present study indicated that through self-presentation manifested by posting and hashtagging on Instagram, members

of the #WomenInSTEM community *presented* and *negotiated* their gender identity and their STEM identity — identities historically endorsed as incompatible — to firmly position themselves as *women in STEM*. In addition, the topics addressed in the posts by members of this hashtag community have practical implications for science communicators and informal science educators interested in using social media to inspire future generations of women in STEM.

When presenting their gender identity, individuals who posted to the #WomenInSTEM on Instagram mostly featured counter-gender-stereotypical images that projected either a professional or an everyday or casual appearance. Images like these seek to normalize the presence of women in STEM and depict STEM as an attainable pursuit for women. These portrayals also mitigate against the effects of masculine defaults, a form of cultural bias that associates specific characteristics or behaviors with the male gender role [Cheryan & Markus, 2020]. These more realistic and inclusive portrayals of STEM professionals on Instagram were a marked departure from the glamorized and sexualized Hollywood portrayals of women STEM professionals often seen in popular films [Flicker, 2003; Steinke, 2005; Steinke & Tavarez, 2018]. However, some Instagram posts associated with the #WomenInSTEM still featured gender-stereotyped portrayals, although these typically were conveyed in subtle ways. Stereotypical gender displays occasionally appeared in images that either showed an individual in poses that reflected imbalance or looking downward or away from the camera. These gender displays were similar to those found in studies of Facebook and Instagram selfies posted by women [Butkowski et al., 2020; Döring et al., 2016], and as such, appeared to be aligned with the conventions, trends, and vernacular associated with social media [Gibbs et al., 2015; Keller, 2019]. In addition, stereotyped feminine ideals were reinforced in some of the images associated with the #WomenInSTEM through attire and accessories: more than half of those shown on Instagram wore jewelry, accessories, or makeup. The images presented in Instagram posts that featured stereotypical gender displays and stereotyped feminine ideals were similar to fictionalized portrayals of women scientists and STEM professionals often seen on popular television sitcoms like *The Big Bang Theory* [McIntosh, 2014; Weitekamp, 2015] and in popular films [Steinke & Tavarez, 2018].

When presenting their STEM identity, individuals who posted to the #WomenInSTEM on Instagram most often used self-recognition to express their STEM identity [Carlone & Johnson, 2007; Hazari et al., 2010]. This finding is interesting because prior research has noted recognition by *others* in STEM contexts (i.e., educational or professional settings) as most important for achievement of a science or STEM identity [Johnson, 2011b]. However, findings from the present study suggest that in social media contexts, recognition by one's *self* may just as important if not even more important for those who identify with the #WomenInSTEM. This finding also has implications for extending prior research and extant conceptualizations [Carlone & Johnson, 2007; Hazari et al., 2010] of science or STEM identity, calling for the need to add self-recognition as a distinct dimension of STEM identity. Current conceptualizations focus only on recognition by others [Carlone & Johnson, 2007; Hazari et al., 2010; Herrera et al., 2012], thus failing to recognize the important role of self-agency during STEM identity development. Other findings related to STEM-identity expression in the Instagram posts associated with the #WomenInSTEM revealed an overall lack of focus on

competence in highlighting dimensions of STEM identity on Instagram. The dearth of Instagram posts focused on competence has practical implications for social media content creators, science influencers, science communicators, and informal science educators who utilize social media to highlight the accomplishments of women STEM role models. Prior research has shown that early adolescent girls' perceptions of the competence of women STEM role models, in particular, has been associated with increases in their science identity [Merritt et al., 2021].

Social identity theory [Tajfel, 1978; Tajfel & Turner, 1979] offers insights on how members of this community negotiated their gender and STEM identities in this virtual space. First, the action of posting to this hashtag community would activate the salience of both group identities. Second, the use of this hashtag, plus the presentation of gender identity and STEM identity together, would signal identity negotiation or identity achievement between two group identities often viewed as incompatible because of historical cultural bias [Cheryan & Markus, 2020]. Further, because social identity theory [Tajfel & Turner, 1979] maintains that successful identity integration of an outgroup can be achieved through active repositioning of an outgroup as an ingroup, posting and hashtagging to the #WomenInSTEM suggests a reassignment of value to attributes typically assigned to an outgroup (STEM) so that previously perceived negative attributes (i.e., women do not belong in STEM) are now perceived as positive attributes (i.e., women belong in STEM). Because social comparison of one's ingroup in reference to other social groups is used to evaluate potential groups prior to identity integration, this reassignment of values can be identity-affirming whenever social comparisons result in negative perceptions that cause conflict [Tajfel & Turner, 1979]. For the present study, this active repositioning was evident through the intentional visual representations of both of group identities (i.e., gender identity and STEM identity) in the Instagram posts associated with the #WomenInSTEM. These visual representations could be interpreted as both intentional and successful identity integration.

Posting to the #WomenInSTEM on Instagram set clear expectations that guided the content created for posts that associated with this hashtag. Prior research has described hashtags as "markers of collective identity" [Konnelly, 2015, p. 11] that enable users to form communities of collective group identity and shared ideological affiliation" [Konnelly, 2015, p. 15]. While it was expected that Instagram posts would focus on the two group identities evoked by the #WomenInSTEM, the expression of other social group identities — even though expected to appear less frequently — is also important to consider in order to assess the overall diversity of portrayals associated with this hashtag. The typical image of individuals posting to the #WomenInSTEM on Instagram was that of a white, young adult, mentally healthy, physically abled, Biology graduate student who displayed a feminine-presenting gender expression. It is important to consider the potential benefits that more diverse representation of individuals posting to the #WomenInSTEM can provide for promoting broader inclusion in STEM. For example, greater representation of portrayals of racially and ethnically diverse groups are important because prior research has underscored the need to promote inclusion and a sense of belonging in STEM for individuals from marginalized racial and ethnic groups [Alfred, Ray & Johnson, 2019; McGee, 2016; Wilkins-Yel et al., 2019]. Similarly, greater representation of gender diverse and LGBTQ+ people also is important for facilitating a sense of belonging in STEM [Cech & Waidzunas, 2021; Sinton, Baines, Thornalley, Ilangovan & Kurt, 2021]. In

addition, greater visual representation of a wider variety of STEM fields or disciplines is important because women are well-represented in biology but underrepresented in other STEM fields such as engineering, physics, computer science, and mathematics [NCSES, 2023].

Findings from the present study identified specific topics most often addressed by the content creators of Instagram posts associated with the #WomenInSTEM. Findings revealed that most posts were self-promotional and lifestyle-focused. Posts often celebrated women's work and successes in STEM and work-life balance. These findings matched well with the type of use and platform vernaculars that Instagram cultivates [Gibbs et al., 2015]. Given Instagram's focus on aesthetic visuals, platform vernaculars documenting everyday life highlights the type of communicative practices of members of this community [Gibbs et al., 2015; Keller, 2019]. While some posts acknowledged the struggles and challenges of an identity as a woman and a STEM person, and this acknowledgment was positively associated with self-recognition in STEM identity, the majority of posts included positive messages that suggested successful identity negotiation. Of note, posts focused on adversities may have indicated that some members of this community sought to present a more realistic and accurate view of their identities by sharing personal setbacks they experienced as STEM professionals while still recognizing their contributions to STEM. Another possible interpretation is that the content creators of these posts may have sought to provide a realistic look of STEM careers in order to engage more authentically with their audiences [Steinke, n.d.; Tsay-Vogel & Schwartz, 2014]. Overall, posts using the #WomenInSTEM on Instagram presented positive messages about the role of women in STEM and challenged historical cultural bias that promotes STEM careers as more appropriate for men [Cheryan & Markus, 2020; Prieto-Rodriguez et al., 2022].

Social identity theory offers additional possible explanations for why members of this #WomenInSTEM hashtag community often posted content focused on self-promotion or their lifestyles. Social identity theory [Tajfel, 1978; Tajfel & Turner, 1979] suggests that depictions like these were intentionally selected and crafted to challenge existing stereotyped cultural representations of gender and STEM in attempts to influence public opinion. These actions may have been intentional communicative strategies by the content creators to reposition what has often been publicly endorsed as an outgroup in STEM as an ingroup in STEM. Self-promotional posts, in particular, appeared to be intentional communication by those associating with this hashtag to claim and celebrate their positions as ingroup members of the STEM community. While these positive expressions of ingroup membership are important for asserting the legitimacy of women in STEM, interestingly, few Instagram posts were informational in nature. Because early adolescent girls' perceptions of the competence of women STEM role models has been associated with increases in their science identity [Merritt et al., 2021], this suggests a missed opportunity for practitioners and educators interested in using social media to promote inclusive science communication [Canfield & Menezes, 2020] and informal science educational opportunities for adolescent girls — an especially active and interested social media audience [Anderson & Jiang, 2018].

Given the opportunities for STEM outreach through social media, findings from the present study have important implications for science communicators and informal science educators who seek to foster STEM identity development for

adolescent girls. Prior studies have found that viewing traditional STEM media (i.e., television shows, videos, and video games) has a significant effect in fostering STEM career interest for adolescents through indirect effects on STEM identity [Chen et al., 2023]. Findings from the present study highlight the potential for even more pronounced effects from social media STEM content because of adolescent girls' attraction to and frequent use of social media [Anderson & Jiang, 2018]. Indeed, Instagram posts that express successful integration of gender identity and STEM identity, like those described in this study, offer potentially meaningful STEM role models to challenge extant gender-STEM stereotypes. In addition, these findings highlight potential benefits of the practice of hashtagging on social media, especially if the hashtags selected are associated with content adolescent girls are most likely to view. Prior research suggests that use of trending and popular platform features are effective in attracting the attention of adolescent girls because they are well-aware of variations in platform vernaculars and carefully weigh the unique features and benefits of each platform [Keller, 2019]. A future challenge for science communicators and informal science educators, however, will be to discover the most effective ways for connecting on social media with this young audience most likely to benefit from these portrayals.

Future research in this area also should focus on uncovering specific role model attributes of those who identify as women in STEM on social media. This research is crucial because girls still turn away from STEM careers even though their perceptions of STEM as masculine careers have decreased over time [Jones & Hite, 2022]. Portrayals on social media are likely to be especially memorable for adolescent girls because content creators on Instagram portray themselves and express their identities in a highly visual manner, thus adolescent girls are more likely to be influenced by visual cues that convey "identity relevant characteristics of media models" [Steinke, 2017, p. 10]. In addition, social identity theory [Tajfel, 1982; Tajfel & Turner, 1979] maintains that Instagram self-portraits and selfies are likely to appear more relevant and relatable when both content creators and adolescent girls share the same or similar characteristics and *ingroup* status [Allen & Collisson, 2020; Buckley, Farrell & Tyndall, 2022]. Findings from the present study also suggest that it is essential to not only consider the *social media content* about the experiences reported by individuals who associated with the #WomenInSTEM but also the (1) *social media platform* used in order to better understand the most influential communicative spaces for featuring women STEM role models best aligned with adolescent girls' social media preferences and practices and (2) *platform design features* most likely to attract adolescent girls' attention. It is important that science communicators and informal science educators recognize that communication through social media and engagement with social media are complex processes. Thus, simply posting to the #WomenInSTEM or providing a steady series of posts featuring portrayals of women in STEM role models will not guarantee user interest or engagement.

In sum, this study advanced understanding of identity presentation and identity negotiation by individuals posting to #WomenInSTEM on Instagram. Posts reflected how social media became a site of identity negotiation as content creators embraced both their gender and STEM identities. Many of the posts represented intentional discursive actions to present these two group identities as compatible. In addition, through the topics addressed in posts associated with this hashtag, content creators also challenged gender-STEM stereotypes that historically have

positioned these identities as incompatible, sending a clear message about women's rightful presence in STEM. In so doing, posts associated with this hashtag provided an array of highly visible and potentially inspirational women STEM role models on social media. Moreover, findings from the present study provided insights on how this hashtag community organized online to address gender bias and advocate for social change.

Indeed, the #WomenInSTEM hashtag provided members of this community with access to a highly visible online public space for amplifying the voices of this community as they engaged in discursive activism [Clark, 2016]. By using the platform features and platform vernacular of Instagram, content creators called public attention to the need for social change. This online platform created a virtual space for members of this community to call attention to the harassment [Leaper & Starr, 2019; Roper, 2019] and gender bias [Cyr, Bergsieker, Dennehy & Schmader, 2021; Leaper & Starr, 2019; Moss-Racusin, Sanzari, Caluori & Rabasco, 2018; Roper, 2019] often experienced in physical STEM contexts. Prior research has also highlighted social media users' conscious, deliberate, and strategic use of platform vernacular to participate in feminist engagement and promote feminist resistance online [Keller, 2019]. In the present study, use of the #WomenInSTEM facilitated a safe space where content creators could not only freely assert their concerns as members of this community but also negotiate and celebrate their gender and professional identities.

Importantly, this study provided baseline data to advance future research and understanding of social media portrayals of individuals identifying as women in STEM. Better understanding of these visual portrayals on social media may be important in fostering shifts in cultural bias by altering *public* perceptions of women in STEM. Like all studies, and in particular analyses of visual content, this study is not without its limitations. Whenever possible when analyzing visual content for this study, manifest content or explicit mentions included with or embedded in Instagram posts were coded to promote accuracy in coding and interpretation. In addition, many of the coding categories and coding definitions were derived from prior research [i.e., Goffman, 1979] applied in other contexts [i.e., Döring et al., 2016]. However, the coding of some coding categories involved analyzing latent rather than manifest content, and thus, findings for these coding categories represent visual approximations that may have been biased by the backgrounds, experiences, and identities of the coders. To help mitigate potential bias, coders were carefully trained in use of all codes; however, despite the coders' best efforts to be objective and consistent, subjectivity in the interpretation and application of these codes may have affected the accuracy of coding. It is important for future research to continue to explore best practices for coding latent content and to compare latent and manifest coding for this type of media content to determine if the results are the same. Despite these limitations, analyses of visual representation online are important because of the pervasiveness of visual content on social media and the potential effects of this visual content on public opinion.

Another limitation is the sample used for this study. Because coding of visual media content is conducted manually by human coders, this results in smaller samples than possible for studies that involve computational analyses of larger samples of media content. In addition, while the sampling procedures followed were a best attempt to imitate the Instagram user experience, clearly, this

experience varies by user. Relatedly, social media content changes constantly, requiring continuous monitoring of social media over time. Future research should also consider additional hashtags used by members of this community.

While careful and thorough documentation of user-created social media content is an important first step in media research, future research is needed to examine 1) content creators' intrinsic motivations and goals and 2) attention, interpretation, understanding, and behavioral responses to content by audience members. Future work should directly examine and assess content creators' intent for posting to the #WomenInSTEM hashtag. In addition, future research should directly investigate interpretation of this content by adolescent girls, in particular, who may view the representations of women in STEM on social media as vicarious role models. A related line of research could explore how identity-motivated reasoning [Boyer, Lecheler & Aaldering, 2022] influences audience members' perceptions of these posts. In addition, future research could examine a larger sample that includes and compares other social media platforms (Twitter, Facebook, SnapChat, TikTok, LinkedIn, BeReal) in order to determine whether differences exist in portrayals by platform. Many of the posts in current sample included images from higher education graduation ceremonies that took place during May and June, which overlapped with our sample collection dates. Based on the timing of collection, there may be an overrepresentation of certain types of portrayals and themes. In future research, collecting samples throughout the year may help reduce the oversampling of any single event.

Conclusion

Social media is a potentially powerful tool for showcasing STEM as accessible and appealing careers for women. Science communicators and informal science educators who feature women STEM role models on social media may play a crucial role in encouraging adolescent girls to consider future STEM careers. However, it is important for science communicators and informal science educators to recognize that STEM-promoting social media content and social media campaigns designed to inspire adolescent girls' interest in STEM *must* (1) be informed by an understanding of the nature of social media content, and (2) be designed based on evidence-based, best practices that capitalize on the power of social media for effective outreach. No single content creator, image, or post nor even a carefully curated collection of individuals, images, or posts will be sufficient in promoting STEM interest and STEM identity for the vast number of adolescent girls who represent a diverse array of identities. While social media may prove to be one of the most powerful tools for attracting future generations of women in STEM, it is essential to advance understanding of the multitude of images of individuals who identify with STEM on social media that emerge daily on social media to best determine *when, why, and which ones* are most effective and inspirational role models.

Funding

Funding for obtaining the sample of Instagram posts was provided by a "Research Funding in Academic Themes" grant provided by College of Liberal Arts and Sciences (CLAS) at the University of Connecticut, Storrs.

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Authors

Jocelyn Steinke is an associate professor at the University of Connecticut. Dr. Steinke's research focuses on the influence of media images of women scientists and engineers on adolescent girls' interest in science, technology, and mathematics (STEM). Dr. Steinke's work has been funded by the National Science Foundation (NSF), and she is an American Association for the Advancement of Science (AAAS) fellow, recognized for her contributions to the public understanding of science.

 jocelyn.steinke@uconn.edu

Amanda Coletti is a Ph.D. Candidate in the Department of Communication at the University of Connecticut. She earned her M.S. degree in Physiology & Neurobiology, also at the University of Connecticut. Her research interests include science communication, training and development, and narrative storytelling. Amanda also has experience programming and delivering storytelling workshops related to developing science communication skills.

  amanda.coletti@uconn.edu

Christine Gilbert is an assistant professor of climate communication at Stony Brook University. She holds a joint appointment in the School of Communication and Journalism and the School of Marine and Atmospheric sciences. Dr. Gilbert's research focuses on public perceptions of science, environmental, and health risks, and how to most effectively communicate uncertainty to the public. Much of her work has utilized content analyses to better understand the current communication environment.

  christine.gilbert.1@stonybrook.edu

How to cite

Steinke, J., Coletti, A. and Gilbert, C. (2024). '#WomenInSTEM: exploring self-presentation of identity on Instagram'. *JCOM* 23 (01), A03. <https://doi.org/10.22323/2.23010203>.

Supplementary material

Available at <https://doi.org/10.22323/2.23010203>
Instagram Women in STEM Codebook



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