

The effectiveness of social media for inclusion of women in computing

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Abstract—Despite the projection of an increase in the number of jobs in the computer science (CS) field by 13% from 2020 to 2030 in the United States (as reported by the Bureau of Labor Statistics), the representation of women, especially women of color, in the field remains low. Lack of representation for women in computer science negatively impacts the growth of this demographic as it becomes harder for prospective individuals to envision themselves in the field when they do not see others like them already succeeding in CS. Studies have found that the retention of women in the field is stronger when the representation of women is evident in their environment, however, it is hard to come by considering the low population of women computer scientists. While new prospects may find fewer women in their CS departments in their college experience, or at their workplaces, there is a plethora of social media personalities and communities for them to engage in and find like-minded individuals.

This full research paper investigates the experiences of women, or lack thereof, in CS communities centered around social media and how it contributes to their sense of belonging in the CS field at large. It is evident that there is limited scope in the existing literature that studies the impact social media participation has on CS women. This literature review distinguishes the narrow scope of literature focused on women’s experiences with open-source software communities in CS from women’s experiences with more generic widespread platforms such as Twitter, or Instagram. It argues for the expansion of knowledge for the effects of CS women’s participation on such platforms and provides insight into approaches, such as photovoice, that may be utilized to study this space. The outcomes of this review reveal the potential of utilizing online platforms in retaining women in the CS workforce effectively. Considering the current status of many organizations that have switched from in-person to remote engagement due to COVID, this review contributes to the analysis of the effective use of technology and its impact at a critical time.

Index Terms—computer science, social media, inclusion, women

I. INTRODUCTION

Although there have been many efforts over the years to increase the participation of women in Computer Science (CS), representation of women in the field remains low. According to

the U.S. Bureau of Labor Statistics, Computer and information technology occupations are projected to grow at a rate of 13% from the year 2020 to 2030 [1]. Studies have found that the retention of women in the field is stronger when the representation of women is evident in their environment [2], [3]. However, it is hard to come by considering the low population of women computer scientists. To complicate matters further, over the past couple of years many industries including CS have transitioned to remote modes of work and instruction, making in-person interactions and collaborative efforts among women less prevalent [4], [5].

The challenges associated with the remote transition provide a unique opportunity to consider virtual opportunities of engagement that women have through social media platforms to connect and interact with others in the industry. A number of studies have been conducted to study the participation and persistence of women in CS communities in education and industry with a focus on theoretical frameworks including, but not limited, to communities of practice [6], landscapes of practice [7], and community cultural wealth [8]. Those works provide insights into the professional benefits for women in CS communities through the theoretical lens but have not explicitly focused on the online communities for women in CS. The closest work in the space of CS communities online to some of the before-mentioned studies is that of women’s participation in open-source software (OSS) communities [9]–[11]. This literature review serves as a preliminary investigation into the impact participation on social media platforms have on women’s participation in CS, the benefits of other industries that have reaped from investigating online interactions to retain minorities [12]–[15], and potential approaches to broaden inspection of the plethora of data available online.

This literature review investigates publications for insight on the impact or lack thereof, that participation on social media platforms has on women in CS, and its potential to retain women in the professional CS community at a critical time. Given the age limitations required by many social media

platforms' regulations, the majority of users of such platforms are adults. Thus, we centered our population of this study on adult women that engage in activities directly or indirectly related to computer science, through a means of education, career, or hobby. Throughout this review we use the terms "women in CS" and "CS women" interchangeably.

The research questions that guided the search for literature include:

- 1) What literature currently exists to address if/how participation on social media platforms affects women in computer science?
- 2) What are some professional benefits that women and minorities from other industries may reap from participation in social media communities?
- 3) How can CS communities on social media be further investigated to determine their effectiveness in maintaining the persistence of women in CS?

The next section provides a formal definition of social media. After that section III outlines the methods used for this literature search. The following two sections after that provide an overview of the literature explored based on the research question they address. Section IV delves into a narrowed scope of existing research around CS women's participation in content communities and social networking sites. Section V summarizes research articles that highlight how social networking sites can be a tool for empowering and retaining women in their careers.

II. DEFINING SOCIAL MEDIA

According to Kaplan and Haenlein [16, p. 61], social media is "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content". In conjunction with their definition, Kaplan and Haenlein also provide a "Classification of Social Media by social presence/media richness and self-presentation/self-disclosure" (Fig 1). This literature review focuses on social media platforms belonging to the following categories: content communities (medium social presence, low self-presentation), and social networking sites (medium social presence, and high self-presentation) [16, p. 62]. The categories have been used to classify papers based on which platforms their research focuses. Some examples of content communities include Stack-Overflow, YouTube, Flickr, and Slideshare. Some examples of social networking sites include Twitter, Facebook, and Instagram.

In their own literature review Carr and Hayes [17, p. 50] highlight how existing definitions of social media may be problematic by highlighting how some definitions may be too broad and as a result inclusive of tools such as text messaging and email, while other definitions that focus on specifications of tools, and technical specs may be too restrictive and overlook the cultural impact of social media. In an attempt to refine the definition of social media they provide their own revised definition as follows: "Social media are Internet-based channels that allow users to opportunistically interact and

		Social presence/ Media richness		
		Low	Medium	High
Self-presentation/ Self-disclosure	High	Blogs	Social networking sites (e.g., Facebook)	Virtual social worlds (e.g., Second Life)
	Low	Collaborative projects (e.g., Wikipedia)	Content communities (e.g., YouTube)	Virtual game worlds (e.g., World of Warcraft)

Fig. 1. Classification of Social Media by social presence/media richness and self-presentation/self-disclosure [16, p. 62]

selectively self-present, either in real-time or asynchronously, with both broad and narrow audiences who derive value from user-generated content and the perception of interaction with others [17, p. 50]."

Carr and Hayes provide a more comprehensive explanation of the term social media, as they address the user's position as a voluntary contributor and consumer, the value of content to their respective communities, and interaction methods through social media platforms (including but not limited to photo-sharing, comments, posts, etc.).

III. METHODS

We began searching for literature using the following terms: "women" AND "computer science" AND "social media." Initial searches produced limited results that centered around women's experiences in open source software communities. To address our second research question we conducted a search using the following key terms: "social media" AND "women empowerment" AND "career". We also searched for "minorities" AND "social media" AND "career." As a means to mitigate limited results and broaden results for all searches we altered the choice of words in our search to include "computing" instead of "computer science," "online communities" instead of "social media," and "professional development" instead of "career." The articles included in this literature review have been restricted to having been published in the year 2010 and later to maintain relevance to the current times.

When investigating the third research question we began by searching for quantitative data to identify which social media networking applications are most popular. Sharing photos and captions online are the main approach to creating social interactions and we discovered that about 76% of adults 18- to 29-year-olds use Instagram [18] and the most popular mobile social networking apps are Facebook (169.76 million users per month) and Instagram (121.23 million users per month) [19]. There is also a higher percentage of female users on Instagram (56% in Dec 2021) [20]. Keeping in mind that there is higher activity on social media platforms that share the key component of sharing photos and captions we delved deeper into searching for studies that use visual methods, including participatory photography and photovoice, as a means to explore the participation and persistence of women in CS communities on social media. The articles included to address the third research question are from the year 1997 and later since the photovoice method was initially introduced in 1997.

IV. CS WOMEN'S PARTICIPATION IN SOCIAL MEDIA

The following section has been divided into two of Kaplan and Haenlein's "Classification of Social Media by social presence/media richness and self-presentation/self-disclosure" content communities in the form of open-source software (OSS) spaces such as Stack Overflow, and social networking sites in the form of Facebook, Twitter, etc [16, p. 62].

A. Content Communities (e.g., OSS Spaces, Github, etc.)

The most prevalent work-related to CS women's participation in online communities in social media is that of online communities in OSS platforms. OSS refers to "software for which the source code is accessible free of charge and the distribution, modification, and adoption of the source code is governed by licensing provisions from The Open Source Initiative" [10, p. 99]. OSS platforms differ from popular social media platforms in that they are targeted at a very niche population of people in the software development space. Unlike popular social networking platforms, OSS platforms are restricted in how many interests and personality traits users are able to share [9].

When investigating women's participation in OSS communities and their likelihood to persist in such communities, researchers have focused on studying the peer parity [9]–[11], [21], and its role in CS communities online. Ford et al. [11, p. 239] define peer parity as "when an individual can identify with at least one other peer when interacting in a community". Peer parity is important to consider in this area of research as it provides insight into how communities with like-minded individuals are formed.

The influence of peer parity online has been explored by Ford et. al [11] in a study of women's participation on Stack Overflow. The authors first extracted 5,987,284 users and 32,209,817 posts from the site, and then identified 363,133 women, 2,139,305 men, 102,189 unisex and 3,382,657 undetermined names. Next, they randomly selected 1,000 users that they identified as women and analyzed their activity in discussion/question posts. Of the posts that were analyzed, the authors found that women who were on parity threads (discussion posts that had engagement from more than one woman) engaged in earlier time frames in Stack Overflow participation activities compared to those that were seen on non-parity threads. Their research suggested that the inclusion and participation of women increased when they noticed others like them already engaging in the virtual space.

In a mixed-methods study, Singh [9] investigated the experiences of women that participated in open source software, along with the initiatives taken by OSS to be more inclusive of women. Singh discussed the benefits of having a safe space for women on OSS as a means of retaining women. Through a search of 355 OSS websites found on a list from Wikipedia, only 12 sites had women-only spaces or a link to external sites that pertained to women and software. These external links included interactive platforms like Facebook and Twitter. From a survey conducted amongst 58 participants, Singh found that

women placing importance on persistence, skill, and mentorship were crucial elements to success in OSS communities. Through interviews conducted amongst 11 of the 58 women that had completed the survey, there was a consensus on how the applied concept of peer parity positively influenced women's participation online. Singh suggests that women-only spaces or safe spaces on these niche social media platforms can increase participation and be beneficial to women in CS. Singh and Brandon [21] extend this research further by investigating the inclusion initiatives OSS communities take to become more inclusive of women.

In a study conducted by Singh and Bongiovanni [10], the authors have extended the analysis of the in-depth interviews conducted by Singh in 2019. The article focused on 11 interviewees, all at a minimum holding a bachelor's degree. Through their analysis, they highlighted the underrepresentation of women in OSS communities, harassment faced by women in OSS communities, and the need for mentorship in these online spaces. Singh and Bongiovanni [10, p. 118] argued that understanding the "concept of peer parity is critical for organizations wanting to implement successful mentorship programs and in helping alleviate "imposter syndrome" for women in OSS". Mentorship is a critical tool for engaging women in these online communities, and increasing representation. If women in CS are supported by others to whom they can relate to they are more likely to persist in the field [6]–[8].

B. Social Networking Sites (e.g., Twitter, Facebook, etc.)

From our literature search, we found that very little research has been conducted to capture the experiences and influence of CS women's participation on popular social networking sites. We were able to find two studies that met the criteria for the search discussed below. The articles mentioned in this section are limited to specific sub-populations in CS (data scientists), and particular platforms (i.e. OSS communities, Twitter, and a closed Facebook group). These papers lay the groundwork for expansion into a larger population of women, and communities, both closed groups and open/public groups, on a variety of social media platforms.

A qualitative study conducted by Vaast [15] explored the social media connections of data scientists who were at intersections of gender and occupation, particularly on Twitter. The study found that this population of social media users participated in gender dynamics in the following three ways: towards promoting inclusion, towards co-producing equalizing resources, and towards fostering exclusive enclaves. One data scientist shared the following:

There are a lot of women who don't have a community [in their local environment] and don't talk about this stuff. They think that it is because they are not good at data science or at their job or something like that. I use Twitter to talk about gender issues. [...] Twitter is a very important platform for me and for speaking out about these feminist issues. You get a lot of support from other people. [...] You are connected with others. There will always be people

who will always support you, even if it is just one or two people [15, p. 1681].

Vaast also highlighted how the use of social media also allowed users to collectively generate lists of resources, and external links to increase gender equity in the data science field. Vaast provided evidence of how one tweet sharing resources is echoed with support multiple times by others on Twitter, showcasing peer parity in action. The research done in this study also extended to social media-enabled self-selected private groups that data scientists chose to join for empowerment.

Dubow and Kaminsky [12] also previously explored how private social media groups support the continuous participation of women in computing by studying posts and comments on a closed Facebook group, focused on women in computing, from 2011 to 2015. Most posts and comments analyzed for this study can be categorized into two types: sharing CS-related opportunities, and social-emotional support for other women in the group. Circling back to peer parity, the studied Facebook group demonstrated how women were able to connect, share, and persist in the group based on shared similarities of feeling underrepresented, relatable experiences of sexism, etc. Dubow and Kaminsky [12, p. 292] argued that conversations in the group create a counter-narrative that incorporates “an oppositional political discourse” that enables and equips women to traverse through the male-dominated field offline.

V. BENEFITS OF SOCIAL MEDIA FOR WOMEN AND MINORITIES IN OTHER INDUSTRIES

Just as Dubow and Kaminsky have highlighted how popular social media platforms can support women in CS in their careers, there exists a plethora of research on how they can be a tool that empowers women’s careers in different industries all over the world [13], [14], [22]–[25]. This section serves to support why it is critical we expand our research in the area of women’s participation in online computing communities through analysis of their participation on popular social networking sites. We aim to do this by outlining how participation on popular social networking sites has helped other marginalized groups in their career paths. As shown above there is a limited scope of research available around women in CS and their participation on social networking sites. This section focuses on why it is crucial to expand the scope to further our understanding of the benefits of participation on popular platforms (as defined in Section II) for women and minorities by providing examples of how it has helped them in other disciplines.

A. Psychological Benefits

Platforms like Instagram allow for users, especially those that are minorities in their profession to promote counter-narratives, separated from mainstream media to promote representation and push for social change in their fields. In their study of women-led artistic movements on Instagram, Caldeira et al. [13] found that the promotion and visibility of artists on these accounts created visibility for minority

artists, while also providing a space for them to cultivate self-representation. Caldeira et al. [13] argued that the promotion of these self-representations is a form of reclaiming agency for artists that may not fit the mold. This study is an example of participation in social media that has the potential to be a tool for persistence for women in CS as they make efforts to reclaim their agency and counter stereotypical views of what it means to be a computer scientist. Riquelme et al. [14] also argued that participation on Instagram is a successful means of empowering women [14]. Their study suggests that participation on Instagram through sharing images, and writing captions can validate their self-efficacy and give them a sense of community. Riquelme et al. [14] have focused on studying Instagram posts of women on a variety of topics including but not limited to fashion, personal, political, etc. They found that having a sense of community also created the perception of psychological empowerment for women, allowing them to express themselves, sometimes even challenging cultural norms.

B. Expansion of Career Opportunities

Mainstream social networking platforms can also benefit women by exposing them to more career opportunities. Riquelme et al.’s [14] inquiry found that Kuwaiti women were able to start businesses and have careers through Instagram. Meanwhile, Caldeira [13] focused on Instagram pages that promoted the work of artists that gave them a space to promote their work to an audience.

VI. DISCUSSION

While some methods of inquiry noted from the literature analyzed so far have included quantitative and qualitative assessment of social media content itself [12]–[15] most inquiry in regards to CS women has included, or solely focused on traditional instruments such as surveys and interviews. There have been some quantitative papers that have attempted to measure engagement on platforms [10], [11]. The third research question alludes to the potential of studying engagement on social networking platforms as a participatory research approach itself.

Ford et al. [11, p. 241] suggested that “one way to inspire and increase others to participate is to showcase top-rated questions asked by women”. This suggestion made by the authors reiterates Singh’s observation of how women’s participation on software-based social platforms seems to be more of a “daring endeavor” than an intellectual contribution:

One of the things that was striking in this research was the way women characterized how they approach and how other women should approach contributing to OSS communities. It did not seem like they were contributing to something intellectually but rather seemed more like a daring endeavor. The advice for newcomers included comments such as “you have to be brave; you have to be strong; you have to ignore; you have to be extra smart; etc.” This kind of advice made the author wonder

why participation in a community where you are contributing your skills, often without pay, should be such a crusade [9]!

Social media is a broad research space, and while much work has been done in the space of open-source software we encourage potential comparative inquiry into this social culture of OSS communities, to discover why it is that women in CS may find this space more intimidating than more generic social networking sites such as Twitter, or Facebook. It is also important to note the irony that OSS platforms, while specific to topics and fields of interest, do not leave as much space for exposure of a person's identity in the same ways that social networking sites do. As it is classified as a content community, we can see there is low self-presentation as users are limited to posting about things pertaining to technical CS topics (e.g. coding concepts, troubleshooting, etc.) and not about themselves or their experiences in CS.

It is evident that Instagram is a very popular and prevalent platform for engagement, especially for women in the United States. A study conducted by Blight et al. [26, p. 318] argued the following:

The finding that social interaction motives were stronger for Instagram users than for Twitter users, combined with the finding that social interaction motives were positively associated with SOC for users of both sites, suggests that the visual focus of Instagram might promote more satisfying social interactions and, by extension, greater SOC.

Here the acronym 'SOC' stands for a sense of community. Keeping in mind the popularity of Instagram, the effectiveness of visual research methods, and the impact of visual sharing platforms on communities in mind, we see great potential for further research in the space of CS women's participation on Instagram. One common means of using photographs for research is known as photovoice [27], a sub-categorization within-participant photography. The concept of photovoice as a tool for participatory research was first introduced by Wang and Burris in 1997, before photo and video sharing social media platforms were developed. However, it is evident that the content shared on these platforms by users is closely related to the implementation of photovoice as a participatory research method. Along with documenting experiences through visual means, another important aspect of photovoice is the facilitation of discussions to make meaning of the images. Platforms like Instagram both give space for documentation of experiences through images and the facilitation of discussion through comment sections and direct messaging.

It is apparent through our literature search that there is limited research conducted on the participation of CS women on social networking sites. Social media platforms have a broader scope of topics allowing for a user to share multiple aspects of their lives and experience peer parity. It is worth expanding research to explore whether connecting with other women on the basis of gender and other interests helps women feel more comfortable in contributing to the online CS

community in public spaces on popular platforms, including but not limited to Facebook, and Instagram. Current studies focus on an even smaller population within CS [15], i.e., data scientists, or closed Facebook groups [12]. However, a plethora of public data exists to be analyzed through public forums. We urge researchers to expand and contribute to this larger gap of knowledge in the CS community by using the data provided on these platforms to study the platforms themselves. Photovoice may be an effective method to further study this space because the content shared on these platforms by users is closely related to the implementation of photovoice. Along with documenting experiences through visual means, another important aspect of photovoice is the facilitation of discussions to make meaning of the images. Social media platforms like Facebook and Instagram include a comment section in which act as a space for discussion where the photographer, and other members of the online community may work together to collectively analyze and understand what a post may represent.

Along with its popularity, platforms like Instagram have been shown to be effective in countering mainstream narratives and stereotypes [13], [14]. Platforms such as Instagram and Twitter [15], [26] are less restricted than OSS communities when it comes to developing multifaceted identities online. For example, Caldeira's (2019) research [13] showed that often the artists' online identities were at intersections such as interests, race, and gender along with their occupation. They were not restricted to showcasing just their professional work as is evident through their portraits of self-representation. It would be interesting to see if such freedom to cultivate an identity online may support CS women's positive experiences and participation in online communities on such platforms. We encourage researchers to consider comparing OSS communities to Instagram communities to see how they can push beyond improving the code of conduct and providing a list of resources to women. Further investigation in this space can result in positive implications for CS educators as they will have gained another tool to engage women in the field, and connect women students to the larger CS communities to other participants that they can identify.

Through our literature search we have come across some articles alluding to the idea of safe spaces for women on OSS platforms [9], [10], [21], and closed Facebook groups [12]. Our initial search terms did not focus on that, however found it important to highlight the existence of such counter-spaces. The topic of women's safety online can be further explored to extend our investigation into the third research question for the future as well.

VII. CONCLUSION

In this paper, we conducted a literature review that began by first refining the ambiguous definition of what constitutes social media. We then explored existing research in three distinct areas: CS women's participation on social media platforms and their effectiveness for empowerment and persistence, the benefits of social media for women and minorities

in other industries, and potential approaches to study the space of visual-based social media platforms. This review may act as a stepping stone for researchers who aim to implement relatively newer research approaches that analyze knowledge/engagement online.

We found there is limited scope in the space of CS women's participation in social networking platforms that require medium social presence and high self-presentation. The main limitation we have faced is that there is a limited number of articles that focus on CS women's participation on social networking platforms. We also recognize there is potential for analysis of many types of mediums on social media platforms including but not limited to audio applications such as Clubhouse, video applications such as YouTube, etc. however due to limitations of space and time we have chosen to focus solely on visual-based platforms.

We note there has been some work that includes studying public content on social media platforms for analysis, and are encouraging researchers to continue incorporating this research instrument into their future research to better understand communities of practice, and participation in social media. The results from this review may be useful for future studies that seek to expand their understanding of the implications of social media in CS communities as engagement online continues to grow exponentially.

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