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How an online women in technology group provides a locus of opposition

Wendy M. DuBow^{a,*}, Alexis Kaminsky^b^a University of Colorado, Boulder, United States^b Kaminsky Consulting, United States

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ABSTRACT

This paper analyzes conversation threads from a closed Facebook group for women in computing. The dataset contains more than 13,000 posts and spans five years during which time the group greatly expanded in membership. Drawing on research about online forums as well as the research on obstacles and supports for women in computing, the authors use qualitative analysis and take a feminist perspective to show the various ways in which the group provides a locus of oppositional discourse. This discourse highlights the systemic nature of exclusionary practices in the computing field at the secondary and post-secondary levels, providing a way for group members to see past individual circumstances and, thereby, find ways to oppose the cultures in which they live, study and work. Understanding how this oppositional discourse serves women, a group sorely underrepresented in the field of computing, can help identify promising levers for making the culture of computing more inclusive.

1. Introduction: Statement of the problem

1.1. Women are a minority in computing fields

Young women are typically in a minority situation while studying in computing fields.¹ In, 2017, 19% of all Computer and Information Sciences (CIS) degrees completed in the United States went to women. While some four-year institutions have higher proportions of women than others, the approximately 12,500 women who earned a CIS bachelor's degree in, 2017 were spread among about 1200 colleges and universities. In 191 public post-secondary institutions granting CIS bachelor's degrees, there weren't any female degree earners at all. For those schools that did have female CIS graduates, the average number of women who completed in, 2017 was about 12 (National Center for Educational Statistics: Integrated Post-secondary Education System, 2017). In US high schools, the best indicator of formal computer science exposure is the number of girls taking the Advanced Placement Computer Science exam. In 2011, the percentage of females taking the exam was 19% (the lowest female participation of any AP exam), although it has since grown to 24% as a result of a nationwide move to make rigorous CS classes more inclusive (College Board, 2018).

Drawing on the research around encouragement, belonging, and community support, one organization concerned about the

underrepresentation of women in computing, created a program to encourage and support girls around the United States who are interested in computing. In 2007, the National Center for Women & Information Technology (NCWIT), a national nonprofit organization, began the Aspirations in Computing award program for high school girls who were interested in computing. Girls applied online by completing an application that asked about their computing-related activities and achievements, their aspirations, and their leadership skills, and were awarded a cash prize, a trophy, and flown to a national award event. As the program grew, regional awards began to be established, and the number of applicants and awardees grew rapidly with each passing year.

The Award itself was developed as a form of encouragement and an antidote for the isolation many girls felt as the only one in their computer science classes, or seemingly the only girl in their area who expressed interested in computing. From 2007 to 2014, the Award program focused solely on women applicants who showed both interest and achievements in computing while in high school; in 2015, the program began offering awards to women college students as well. The award has both national and regional winners and runners up. National high school awardees receive a cash prize as well as a laptop, while regional awards vary in nature.

Understanding that the community in which young women live has

* Corresponding author.

E-mail address: dubow@colorado.edu (W.M. DuBow).

¹ We use the term “computing” to denote fields that are computer-intensive, and involve some computer science skills such as programming. Increasingly, other fields are becoming computer-science heavy such as biotechnology, thus we do not restrict our lens to computer science or engineering alone.

a profound influence on their exposure to other females who participate in nontraditional activities such as computing (Barker & Aspray, 2006), the Aspirations program sought to give these women a way to connect and be exposed to academic and career opportunities in computing. In late 2009, as online forums started gaining prominence in the mainstream, NCWIT started a closed awardee group on Facebook. All awardees are invited to join the Facebook group, where they can virtually meet like-minded women and be privy to networking and other academic, technical and professional opportunities in computing. While they all identify as women, awardees differ by race, geography, socioeconomic status, educational achievement, and many other important factors.

1.2. Study aims and research questions

The aims of this study are to understand the ways in which this online group for women in computing serves to support their continued participation in the field. The goal of this work is to further our understanding of what facilitates women's persistence in the field of computing. Such understanding helps those who seek to diversify the field be more successful in their efforts. Our research questions for this study are:

In what ways can this closed groups' online conversations help us understand the experiences of young women in computing in the US?

What kinds of conversations do they engage in, and how do these interchanges support their persistence in the field of computing?

How does this virtual women-in-computing group function for its participants?

2. Literature review

2.1. Environmental supports can counter problem of Women's underrepresentation in computing

We know from ample research on the topic that women experience explicit and implicit bias, suffer from the effects of stereotype threat, and often don't receive the support from administrators and teachers that is needed (Barker & Aspray, 2006; Blickenstaff, 2005; Margolis, Estrella, Goode, Holme, & Nao, 2008). These messages are reinforced by media representations of who “belongs” in computing that rarely include women or any people of color (Cheryan, Master, & Meltzoff, 2015; Google, 2014; Warschauer, Knobel, & Stone, 2004). Even well-meaning adults sometimes believe that boys and men have a “natural” talent for computing compared to girls and women. Racism also plays a role in keeping women out of computing-related fields (Fouad & Santana, 2016; Valadez & Duran, 2007).

The pressures experienced by women who study computing can lead to attrition in the major in college, even when they are doing as well as their male peers (Jenson, de Castell, & Bryson, 2003; Kugler, Tinsley & Ukhanvena, 2017). Women studying computing can also experience a sense of isolation as the obvious minority, which can in turn, influence their academic performance as well as computing self-efficacy (Cohoon, 2001).

However, there are mitigating environmental influences that enable the field to keep women in the face of all of these obstacles, such as when women are advised by a peer to pursue a computing-related occupation, when they belong to a friendship group (Jenson et al., 2003; Moorman & Johnson, 2003; Robnett & Leaper, 2012; Teague, 2002); or some other similarly supportive network (Cozza, 2011; DuBow et al., 2017; Goode, Estrella, & Margolis, 2006) that values STEM disciplines (Guzdial, Ericson, McKlin, & Engelman, 2012; Zarrett & Malanchuk, 2005). The outcome of such support is often referred to as an individual's sense of “belonging.” This can be positively reinforced by instructors, peers, and academic departments (Corbette & Hill, 2015;

Fisher & Margolis, 2002). Or, as has been shown in numerous studies, it can be undermined by cues like sexist posters or “geeky” paraphernalia in a computer lab (Barker, Snow, Garvin-Doxas, & Weston, 2006; Cheryan & Plaut, 2010).

Research has shown that building supportive networks for girls is critical because youth consider their peers to be guides, especially when they lack adult mentors or role models (Cozza, 2011; Goode et al., 2006). This peer support is an important factor in what young women choose to study (Fisher & Margolis, 2002; Jenson et al., 2003; Moorman & Johnson, 2003; Teague, 2002). According to one study, peer and near-peer mentoring doubled the retention rate of female students in male-dominated courses, as well as counteracted negative stereotypes (Graham & Latulipe, 2003). Encouragement, whether from peers or adult influencers, can be key to how likely women students are to complete a computing major/minor and choose a computing career — more important than their confidence in and perceptions of their ability (Teague, 2002).

2.2. How online groups function for marginalized populations

To contextualize our study of this online group, we must understand how online groups function in general. There is research especially focused on online groups with shared interests, health issues, or the same academic environment. Research has suggested that getting involved in online groups can be beneficial to people who lack sufficient offline social resources because it allows them to develop supportive virtual relationships (McKenna & Bargh, 1998). Because the community in which young women live has been shown to have a strong influence on their exposure to other females who participate in nontraditional activities such as computing, and because women often lack an offline group of women who share their computing interests, it follows then that an online women in computing group may play a useful role.

Across different fields, studies have shown that social interaction on the internet can be positively connected to the development of social capital (Best & Krueger, 2006; Ellison, Steinfield, & Lampe, 2007). Members of online social communities benefit in numerous ways, including increased sense of belonging and well-being in academic settings (Tomai et al., 2010) and strengthened social contact and community engagement (Kavanaugh, Carroll, Rosson, Zin, & Reese, 2005). Other studies have suggested, though, that how online communities affect individual well-being depends on the participants' goals, the type of communication they have, and how well they know one another (Burke & Kraut, 2013; Huang, 2010; Kraut & Burke, 2015). One meta-analysis concluded that there is contradictory evidence of the impact of social media on youth's well-being (Best, Manktelow, & Taylor, 2014).

Much research into online communities has been conducted in the area of health. Often groups of individuals are drawn to online forums to avoid the stigma of in-person encounters or because of ill health. In one study of the benefits and disadvantages of virtual communities for people with HIV-AIDS, Pendry and Salvatore (2015) identified “empowering outcomes,” including increased optimism, emotional well-being, social well-being, and being better informed. They and other researchers have also identified “potentially disempowering processes,” including an inability to physically connect, inappropriate behavior online, a decline in offline relationships, and misinformation/information overload (Mo & Coulson, 2014).

Other research has shown that the degree to which group participants identify with the group will influence their sense of well-being. “For those in more stigmatized groups ... [t]he more closely they identified, the better they felt” (Pendry & Salvatore, 2015, p. 217). Participants learn to anticipate what type of support they will receive from a group, and when it is provided, it reinforces the perception of supportive community (French & Bazarova, 2017). Several scholars have noted a self-reinforcing circle of support that emerges from a forum with high levels of trust and mass personal communication (French & Bazarova, 2017; Pendry & Salvatore, 2015; Radin, 2006).

Researchers who have focused on Facebook communication have noted that the strength of the ties between participants can influence the type of support provided. “Strong ties provide more effortful, empathic support, while weak ties are less willing to provide significant services, but instead provide access to new opportunities and ideas” (p. 269, [Burke & Kraut, 2016](#)). Thus, the strength of identification between individuals in an online group can mediate what benefits participants derive from a group.

2.3. A feminist perspective on women in computing groups

While women in computing groups are popular,² to date there has been little research done on these groups, and none as far as we know, on online women in computing groups. Because women in computing groups can inadvertently reinforce marginalization and/or segregation, they are not necessarily a helpful feminist tool ([National Center for Women and Information Technology, 2017](#)). Shared interest in computing and shared experiences of marginalization can be important bases for affinity bonds, but this is unlikely to move the field from an exclusionary culture to an inclusive one. Individual empowerment needs to lead to a collective understanding of systems and cultures in order to change the status quo.

The Facebook group discussed here is an example of what feminist theorist Donna [Haraway \(1985\)](#) once called a “conscious coalition,” a coming-together that provides “political kinship” (p. 123). Many of the participants grapple on a daily basis with their outsider status in computing and engineering fields. The group provides them a place to construct oppositional political arguments to both justify and support their existence in the field of computing. The conversations within the group demonstrate what feminist theorists would now call a “subaltern counterpublic” ([Fraser, 1990; Harris, 2008; Kelly, 2003](#)). A subaltern counterpublic, according to Fraser who coined the term (1990), is a place where “members of subordinated social groups invent and circulate counter-discourses, which in turn permit them to formulate oppositional interpretations of their identities, interests, and need” (p.67). The term “counterspace” has been used most recently to describe a similar safe conversational space “at the margins for groups outside the mainstream of STEM education” ([Ong, 2017](#), p. 206).

These counterpublics, or counterspaces, are necessary because, as [Cech \(2013\)](#) has argued, the computing field’s assumption of political neutrality (which she terms depoliticization) and its reverence for meritocracy “reproduce inequalities for underrepresented minorities in the profession” (p.81). The typical computing environment leaves little room for marginalized students to assert, from within the culture, what we call their “right to be” in these fields. To do so is to call attention to their gender, or their marginalization, or to seem to be asking for special attention, when what most students want is simply to learn and work in their chosen field. In the pages that follow, we will show how the Facebook group functions for its participants as a location for active affinity support, bolstering them as the computer scientists and engineers many of them hope to be.

3. Methods

3.1. Data description

When the Facebook group was first begun in late 2009, and when Facebook was not nearly as ubiquitous as it has since become, there were approximately 130 women in the Award community. The group was relatively quiet for the first two years (87 posts total) when there were only 390 winners awarded, but by 2011, the Aspirations in Computing Award program had reached 1133 recipients and social

media had gained wider societal use; consequently, the Facebook group saw a marked increase in posts, comments and like activity (788 posts). While the group was begun by staff and staff regularly posted opportunities, and even had offline contact with many of the participants at first, as the group grew, the postings by staff decreased and participant posts increased. What emerged was an online peer encouragement network that took on a life of its own.

This paper is based on analysis of conversations that took place in the group between 2011–2015.³ Following the familiar format of Facebook postings, these data consist of an initial post and comments written in response to that post.

[Table 1](#) describes the entire dataset from which our sample of top threads was drawn.

Table 1

Description of online group data (2011–2015).

Total posts	13,365
Total comments	59,406
Per year average # unique posters/commenters	626
Per year average # posts per poster	5.1
Per year average # comments per commenter	17.4

The Facebook conversations differ from other types of online support groups, or in-person communities, in that there is no accessible archival record of what has been discussed in the past. Despite the posts being in electronic format, Facebook groups are notoriously difficult to search. The patterns and repeated conversations discussed in this paper are only evident by exporting the data into a new format. As the participants themselves have noted, it is very difficult to retrace and use the various threads as a foundation for future conversations. As a consequence, when new women join, conversation topics repeat. Without a way to check previous threads, the organic repetition of topics is allowed to flourish. That said, the top posts analyzed here may not be the most frequently posted, since there may be repeat topics we did not capture because they didn’t attract as many comments the second or third or 20th time they were posted. Also, some very engaging topics are taken offline – for example, lists of “*where we work*,” “*things no one should say to a techie girl*” and others. While this is a limitation of this type of forum, it does provide a unique research opportunity in that we can observe the persistent themes over time.

3.2. Data analysis

Big data⁴ are notoriously difficult to work with for social science research and do not readily lend themselves to qualitative analysis ([Namey, Guest, Thairu, & Johnson, 2008; Tinati, Halford, Carr, & Pope, 2014](#)), so we reduced the data in two ways. First, we focused solely on the posts and comments between 2011 and 2015 (although the group continues to function to this day).⁵ We coded all 13,000 + posts (i.e., the original post itself, not comments or attachments or links) in this dataset. From among those coded posts, we did close textual analysis of only the top 25 posts and comments from each of the five years in our reduced dataset. The “top 25” were identified based on two criteria:

³ In late 2014, the program began offering a Collegiate Award. At this point, the Facebook group began to gradually include women in computing-related majors in college, who had not ever won an Aspirations in Computing award. The number of people in the group has grown in the ensuing years as more college students join and more high school students are awarded through an increase in regional events and the number of national awardees.

⁴ <https://www.forbes.com/sites/gilpress/2014/09/03/12-big-data-definitions-whats-yours/#53053a9513ae>.

⁵ We selected the sample of 2011–2015 threads to focus on the portion of the Facebook group timeline that overlaps most with the sample we have in our larger mixed methods study.

² See, for example, <https://www.bestcomputersciencedegrees.com/lists/5-great-professional-organizations-for-women-in-computer-science/>.

length of post and number of comments. Given the overlay of these two criteria, in some years, the number of posts and comments we examined exceeded 25. The rationale for using top 25 was to capture the topics that elicited the richest responses, reflecting both engagement across group members and support of one another. Thus, the close analysis presented here incorporates the entire thread stemming from the original post (e.g., the original post plus the ensuing comments).

All threads were exported into Excel through a custom written script. Data were analyzed in Access and R, depending on the question we were asking of the data. Access was primarily used for descriptions of the overall dataset, while R was used to conduct a social network analysis (not discussed in this paper). The top 25 posts were exported from the Access dataset into a PDF. The PDF was examined post by post, and a “table of contents” was written by the research team, with the year, post number, and a one-sentence description of the post-thread content. For example, “Participant posts about video for robotics team” or “Participant posts wanting to know about high school internships.”

We took a hybrid approach to analyzing the threaded conversations,⁶ including emergent coding (Creswell, 2012) and grounded theory (Corbin & Strauss, 2015; Glaser & Strauss, 1967) approaches. Qualitative analysis is useful for extending existing theory. Grounded theory is particularly well-suited for this (Corbin & Strauss, 2015), and in fact is designed specifically for this purpose. Strauss and Corbin observe that while extant theoretical frameworks are useful for guiding analyses, one should be wary of being constrained by unexamined assumptions. Hence their focus on process with its emphasis on iterative coding and analysis. Our analysis of the threaded conversations is the result of several years of iterative examination and refinement of our theoretical framework described in the literature review.

Our analysis of the Facebook threads focused on (1) coding the initial posts with descriptive codes such as Technical, Work-related, and/or Gender-related; (2) reviewing the types of comments made by others on the post to develop a typology of support; and (3) looking at patterns of communication within the threads (i.e., synchronous/asynchronous, single comments from multiple persons/conversations between one or two persons). External factors we knew to be important to women's sense of belonging in computing also informed our coding. These include the ways in which unwelcoming or antagonistic environments, access to resources (human, technical, and financial), and community support or lack thereof, influence individual choices about areas of study and help to explain the underrepresentation of women in male-dominated fields (Ashcraft, Eager, & Friend, 2012; DuBow, 2014; DuBow, Kaminsky, & Wiedler-Lewis, 2017). We analyzed and discussed the top posts and then selected excerpts that illustrated the key themes that came up in the data repeatedly across time, including those posts that would be the most illustrative of what community support “looks like” and how it presents in an oppositional narrative.

This study was submitted to the university Institutional Review Board (IRB). They determined that the Facebook group analysis did not constitute human subjects research because they concluded that there was no expectation of privacy in the Facebook group. Despite this ruling, as ethical researchers, we conducted our research and analysis such that it would not cause harm to the subjects. We also took every precaution to protect subjects' privacy. In sharing our analyses, we have made sure to present the data in a way to ensure the respondents remained unidentifiable. All winners of the high school award had signed an informed consent acknowledging that they may be included in research. Before undertaking the analysis, we posted messages to the group describing this study and soliciting comments and any requests to be excluded from the dataset; we also emailed the entire Aspirations community, including those who were not part of the Facebook group. We received no responses.

⁶ In this context, a conversation is defined as a post and the comments it generated.

4. Results

In the sections that follow, we provide description and analyses of key conversations exploring themes of affinity, community support and oppositional discourse. Excerpts quoted were left in their original format to retain the authenticity of these online discussions, although all identifying information was omitted.

4.1. The two types of support shared in the group

There are two overarching ways the Aspirations in Computing Facebook group provides an alternative community to that experienced by the women at their high schools and universities: They share CS-related opportunities, as a women-only professional networking group, and they exchange reliable social-emotional support. In Pendry and Salvatore's words (2015), the group facilitates both instrumental (i.e., informational) and social interactions.

4.1.1. Computer science- or technology-related posts

The computer science/technology-related posts in the group include awards, software development opportunities, scholarships, internships, media opportunities, contests, job openings, hackathons, and technical help, among other discipline-related posts. Other network-enhancing opportunities posted by staff and participants helped community members connect in the offline world. These include regional meet-ups, roommate requests for tech conferences or for out-of-town internships, invitations or queries about visiting colleges pre-application. In 2013, there was a thread that eventually went offline, where participants created a “Where We Work” list, so everyone could see which companies had any Aspirations awardees. Many of these were explicit efforts to grow their professional networks. Participants also posted when they were conducting research for a class related to gender or tech and when they wanted their computing projects voted up by peers for a contest or class. These were attempts to leverage the built-in network they had in the group.

4.1.2. Social-emotional support posts

The top 25 threads demonstrate explicit social-emotional support. The women talk about mental health concerns, including burnout, anxiety, relationship issues, which college to choose, whether or not to take a gap year or drop out of college, and other pressing life-transforming issues.

Research on communication expectations within social media have noted that online messages are “crafted in anticipation of not only the imagined audience but in anticipation of the responsive nature of that audience” (French & Bazarova, 2017). As a social media group evolves, the tone and type of content is shaped by each poster in an organically molded, cooperatively built community that comes to manifest the assumptions each has about the type of people participating, and what they all share in common. The self-reinforcing dynamic this creates is evident in many of the top 25 threads. For example, in a 43-comment thread, a young woman posted that she had failed academically and literally asked for others to allay her anxiety: “*I may have just failed a test for the first time in college. Not sure; probably got just enough partial credit to pass but idk Someone tell me this is ok and it's possible to change your life around etc < 3.*” She specifically names the kind of response she wants to receive: “*someone tell me this is OK.*” She does so trusting that she will indeed receive the support she seeks, advice she clearly already knows but wants to hear it from others in her field.

This poster's comment elicits a number of reactions, all of which seem to fit her expectation. Commenters suggest reframing what happened to diminish the impact, such as taking a longer range perspective, encouraging her to be resilient through hardship, presenting a wide variety of concrete solutions (transfer, drop the lowest grade, get tutoring, go to office hours), along with other lessons the women said they “*learned in college.*” But most striking about the long exchange is

that it drew many others to share their sometimes similar and sometimes quite different bad college experiences. The original poster's vulnerability created a space for others to express their vulnerability as well: *"I failed a class and kept retaking it 3 times until I passed. Not just with a C or a B but with a freakin' A! So it's totally okay to fail as long as you pick yourself up 'cause one class isn't a measure of your worth! < 3"*.

These kinds of conversations serve to deepen the conversations present in the group, and thereby strengthen the connective fabric of the group: *"Thank you for posting this. I'm also having some issues adjusting to college level academics. You are definitely not the only one."* Indeed, there is a pattern in the longer threads of women sharing their vulnerabilities – whether it is about their anxiety, depression, or a bad personal or academic experience – and in turn others share their own concerns or shortcomings. In a field where it is often dangerous to expose vulnerabilities, the group members offer each other encouragement and specific advice for how to handle the circumstances that could keep them from feeling – or being – successful in the field.

Even seemingly innocuous posts often include support for others. For instance, in 2014 one woman posted, *"What would you buy for yourself if someone gave you \$100?"* The comments that followed included exchanges where several women explored shared non-technology interests and joked about getting together for sushi, despite being spread all around the country. These lightweight posts serve as avenues for women to get to know and show affection for one another, strengthening the connective tissue between them, and perhaps more importantly, demonstrating to lurkers that the group is welcoming and friendly.

4.2. The counter-narrative in action

While the number of participants and who participates via posts, comments or likes, varies across the years, certain topics come up repeatedly. Three of these topics take on the very real dilemmas faced by marginalized individuals who need to negotiate with societal norms or discipline-specific norms in order to belong and/or persist in the field.

4.2.1. Making college choices

Among the most commented on posts are those from high school juniors and rising seniors asking for guidance about colleges. These young women asked how others weighed the benefits and limitations of big-name schools, state schools, schools with lesser-known computing or engineering programs, and liberal arts colleges. The following post from 2015 typifies the types of concerns raised:

Fellow NCWITers! I am trying to make a college decision and have reached an impasse so I am desperately asking for help - I'm trying to decide between [a state school] and a small liberal arts (full tuition paid). Basically i made a pro con list, but it made everything more confusing. [The state school] offers a great program, but I would miss out on some classes that I'm interested in because of the rigid course restrictions (ie. music classes only for music majors etc.). [The liberal arts college] on the other hand would allow me to take more classes (at a cheaper price point), however there are fewer experts there on [certain computing areas]. If anyone out there has advice, an opinion, or expertise on the subject of these schools in particular or small vs big school in general, I would GREATLY appreciate it.

This post elicited 38 comments. These included many women writing in suggesting their college is the one she should choose for CS, and then listing off reasons why—"because of the individualized attention," "our CS department is amazing and known throughout campus for being rigorous as well as having tons of funding and connections," "two computer science tracks, one in the school of engineering and one in the school of arts and sciences so you can choose how much you want to focus on other subjects. Also, ...tons of opportunities if you want to get involved in research." Most ended their comments with an invitation to talk more: *"Feel free to message me if you have questions!"*

Through comments, the group disrupted the either/or dilemma posed by the poster by suggesting schools that would enable the young woman to pursue rigorous computer science while also having opportunities to experience a broader liberal arts curriculum. While their concerns are similar to many college-bound students, when examined from a feminist perspective, one sees that they are actually negotiating the terms of success in computing: Which degrees will help make them credible computer scientists or engineers despite their gender? Which schools will feed them as whole human beings not only as technology lovers?

Participant A: *I'd pick [this school] over [that school] in the blink of an eye, no matter the cost difference.*

Participant B: *Why?*

Participant A: *[This school] because it's ranked better (even though they're both top ten). I know that sounds like a horrible way to pick schools, but going to the best ranked school opens up so many doors for graduate schools and for jobs. My advising professor and I had a very long chat about this (for graduate school) about a month ago.*

Participant C: *Grad school rankings do matter, yes. Undergrad doesn't. You can be successful anywhere. I decided on a big state school instead of a specialized tech school and I've had 4 internships (one was [well-known tech company]) and some companies are interested in talking to me about full time already, and I'm a junior. Rankings don't matter. Don't get stuck in that mindset.*

Despite the advice, for some, getting into a top-tier, elite university was essential to their perception of success. Worries about lesser-known programs seem to be rooted in the women's perception of how others perceived them. This concern about perceptions is particularly acute for those under-represented in computing, as they can feel a precarious sense of belonging in response to an exclusionary environment. For example:

Need some support from the ladies here who aren't going to top universities. I chose to go to [xyz] University since I'm super into [this area] and feel I can get a /ton/ done there, but I keep getting asked if it's a technical school (like, [institution name]). It's a four-year, accredited university, and I'm really starting to internalize it. I probably would have gotten into a top university if I had applied to them, but suddenly people are treating me "way" differently than they did when I answered the "Where are you applying?" question leading with "[Big-name school] ... ' It's just so sad. And I just can't right now.:(

Many women expressed empathy in response to this post: *"Girl I can take you out and we can cry about it together."* Others sought to bolster the poster's confidence: *"Chin up though, if you love what you're studying... you'll probably find others more attuned to your interests too."* One woman confided to the group:

I was in a similar situation...in my senior year of high school The two things I would say are: 1) It shouldn't matter what others think of you. As long as the people who are important to you in your life are supportive of your decision, then you should be proud of it! 2) Have no regret ... I found, the day I stopped regretting how things worked out, I became happier and I stopped caring about other people's reaction.

Similarly, another wrote, *"Don't be ashamed. I ended up going to a public state school and their computer science program is better than I thought. Don't let others act like you are worth less because of the college or university you attend. You're worth more than that ^^."*

Like many college-bound students, college choice and funding were often inseparable: *"Having a hard time finding \$ to pay for college. Not eligible on need basis (family considered middle class) and only get a portion of funds through federal/school-based loans. Only options that can see is second mortgage or private loan for 10% interest and parents aren't interested in either of these options."* Although details differed, other women's posts about funding read similarly. Comments back to these posters included naming specific funding sources (with links), describing alternative pathways such as community college, listing different ways

computer-savvy people can make money, and opinions about how debt should or should not influence one's college choices. Periodically, these debates heated up as those from less well-off families argued over the role funding should have in determining where one goes to college.

In the face of their very real differences of race, class, geography, and others, they return again and again to what they have in common. Being part of this Facebook group surfaces repeatedly in reassurances they give each other about their futures in computing. For example: *“Being in this group will help a lot, and if you're confident that you've done well in school and have been involved you'll be fine.”* Comments like this makes explicit the importance of the group identification and how that can mediate against insecurities they may have about their future credentials and counter the forces telling them they do not belong.

In the next section, we discuss these external pressures to leave the field.

4.2.2. Sexism in computing fields

Within the group, there are numerous conversations about the sexism the women encounter in computing fields. This includes their fellow male students treating them poorly, sexist assumptions about how they got into their degree program or their internship, poor support from teachers, and comments about their looks. Snippets from these conversations illustrate the range of sexism these young women (mostly high school and college-aged) have already experienced, as well as the various ways the online community counters these exclusionary cultures.

In one top thread, a participant posted about her male friends in CS hassling her when she mentioned wanting to learn a new programming language. She said that they listed a whole host of reasons why she wouldn't be able to learn the language, including her lack of experience in CS and her lack of knowledge of hardware. Her male friends then pointed out that she needn't worry because she was *“pretty”* and would succeed simply *“because she was a girl.”* She felt a wide range of emotions in response – angry at being betrayed by people she considered friends, tired of fighting for her worth, and triggered to feel like an *“imposter”* as a result of the doubt these male students prompted. While most responses suggested that her experiences were rather common, *“this happens to me all the time,”* at least one person said: *“I've been fortunate enough to never have come across something as direct as that.”* Regardless, or perhaps because of, their own experiences, the women in the group offered her unqualified support. This was manifested in a variety of ways but primarily through suggesting ways she could respond and regain power (see Table 2).

The post also prompted others to share similar situations, including one woman who shared that her lab partner was calling her *“stupid,”* and even when she took the issue to the professor, she was not supported. Despite the serious nature of the posts about sexism, participants also included humorous, empowering posts like this one wherein a woman listed three reasons the male students' comments were *“bullshit,”* ending with: *“Third, those men will never find love being that rude to women, and they will have no choice but to die alone. Have fun*

advancing your computer science skills and swaggin your way through your amazing life, bae!!! < 33333” About halfway through this sexism thread, a poster wrote: *“omg you all are amazing. I'm so happy to hear all of your guys' support for [participant name]. A lot of us have been in a situation like this. I love having a community of girls like me who support each other like this!!”* Once again, the positive group identity is made explicit and reinforced.

Another posting about sexism described a woman going to office hours for her CS class in college and her TAs saying they didn't have time to help her, even though the lab was empty. She reported that when her male friend went in with his computer and asked the same question, they helped him. She wrote: *“This is blatant discrimination and needs to be addressed ...”* Most of the suggestions encouraged her to tell her professor or equity offices on campus, disclosing these participants' still optimistic hope that if the discrimination were made public, the university infrastructure would be helpful. Others, though, shared their experiences when the college or high school administration was not at all helpful in the face of gender discrimination. For some, going to the department helped, but for others, it made them more hopeless, particularly if the encounter reinscribed sexism they had already experienced.

As with the threads about college choice, the group offers practical advice and emotional support. Regarding sexism, though, they explicitly discuss the systemic nature of the discrimination and what they see as an unavoidable part of being in computing fields. As one poster commented: *“Who hasn't felt this way/been told this?”* She goes on to say, *“First time I heard it, it was from my best guy friend my senior year of high school, also a CS major and who I almost dated before college separated us, telling me that the only reason I'd gotten into the [name omitted] honors program and [name omitted scholarship], was because I am a girl.”*

Recognizing the discrimination as systemic, she is able to counteract its effects:

I knew what I was capable of, but when I found myself struggling through my first semester of honors classes, I thought back to that [insulting] sentence and felt even lower than ever. I still struggle with it, some days more than others. But then I realize the trap I'm falling into. I've had the symptoms of Impostor Syndrome pounded into my brain enough that I can stop and think about what I'm doing. I feel like Impostor Syndrome is a disease that needs awareness raised like Breast Cancer.

By knowing her individual experience was not only shared, but a phenomenon that had a name, she could fight back against the exclusionary culture she was experiencing. And she shared this technique with others in the group.

4.2.3. To pursue computing or not

A third top conversation theme in the Facebook group are discussions about whether or not to stay in computing and what turns some girls away in the first place. The thread below describes what happens when girls attracted to computing perceive the pushback from society.

Participant X: *I've been the captain of an all-girls middle school robotics*

Table 2
Oppositional frames to sexism.

Reframing	“They're just jealous”
Ignoring	“I learned it's best to ignore them and try to move on with what you can. Outshine them, don't feed them.”
Getting motivated	“Try not to let comments like that get to you. They suck, but the people who say them win if you start to believe them. Prove them wrong.”
Encouraging	“Definitely don't let their harsh ignorance stop you from doing what you want to do!! > : O”
Seeking outside help	“I'd tell a professor so they can talk to these guys”
Confronting the illogic	“BTW, I've been doing computer security since high school and have taken computer science classes and I still don't know the parts of a computer... BUT DOESN'T MEAN I'M STUPID OR INCOMPETENT OR THAT I HAVE NO FUTURE IN THIS FIELD.;D It just means there's more for me to learn.”
Building gender identity-based confidence	“Think to the facts: more women graduate college. Also, most of the most talented people in my grade are women. 3/5 of the kids going to ivies are girls.”

team for 6 years now. The problem I have experienced when recruiting girls has never been disinterest, but no support. Dozens of girls have wanted to join the team, but they've never been able to because their parents don't recognize exactly what opportunities it opens for the girls.

Participant Y: *One thing that I've noticed seems to push girls away is everyone's surprise or shock when they learn you major/are interested in CS or tech, which might make you feel like you maybe shouldn't be. Also the minority of girls makes you feel a little more isolated*

Participant Z: *I second the idea that the lack of support and encouragement is incredibly powerful, and the whole "shocked reaction" people give is not only discouraging, but awkward and uncomfortable as well. People don't want to go into something that makes them feel like that.*

Later in the thread, the group laments that other girls may lack a community such as theirs to compensate for an absence of local support and encouragement.

Many of the women in the group see computing as their passion, and yet they express misgivings about their choice. There are a number of reasons and circumstances for these moments of indecision or doubt expressed in the group, some personal and some systemic. What is illustrative in all cases, though, is that their reasons for (thinking of) leaving CS, resonate with other women who participate in the conversations. The post below illustrates some of the considerations common to this theme:

I need some help on school issues and they're kind of personal. I'm struggling so much with my computer science courses and am beginning to think it's not for me. I think I've developed severe depression/anxiety from the stress of my CS courses and feel so inferior to my classmates sometimes, since I don't have any real prior coding experience before college. I actually hate computers now, which is probably not a good trait in a CS major. I try and remember NCWIT and it helps, but I still can't take the stress anymore. I'm considering switching to Applied Mathematics (Comp Sci track) with a minor in Statistics because I have a deep passion for math. Is it a bad idea to "run away" from the stress just to pursue something that's easier for me? I have to do something different from what I'm doing now.

This emotional duress from CS-specific academic stress, exacerbated by peer comparisons, is confirmed repeatedly by others: *"exact same thing happened to me in sophomore year of hs. i hated cs cause everybody was better than me. some of my classmates kind of 'bullied' me and said that I wasn't really good at it."*

The group responds to depression or anxiety relative to CS with encouragement to regain perspective before changing majors: *"try to not to make decisions when you're not in the right frame of mind. If that means taking a semester of medical leave, that's what I'd do."* This poster and others noted that while it may be that CS is not a good fit for the poster, they wanted her to consider what else was influencing her perspective.

Nearly all the posters in response to "thinking about leaving CS" posts share their own mental health challenges relative to CS and/or school stress. The group offers numerous, different options to alleviate the distress, most of which focus on changes to environment or culture. These include transferring to a different university or to a community college, switching to a math-related major, or another major that can be completed in a short time. They tell her that she should talk to other students or the professors, and see that she may be doing better in classes than she realizes. The phenomenon of "imposter syndrome" emerges again as a helpful framing of what may be going on:

First off, let's not forget our unwanted companion, imposter syndrome. It's something my dean in engineering used to tell me about without giving it a name formal name. She explained to me that often girls would leave the college of engineering because they believed they were doing a horrible job when in reality, they often walked away with grades significantly higher than their male counterparts who ended up staying. So, remember imposter syndrome is a thing and make an effort to see if you can better gauge how you're really performing before you let it scare you

off.

Consistently in this topic area (and others), the women are quick to point out that each poster is not alone. Both explicitly and implicitly, they assume that knowing you are not alone and keeping in mind that everyone else is also struggling is a critical support. The following excerpt captures the tone of this sort of group gesture:

often times we get the impression that everyone else is doing fine, when actually everyone is totally struggl[ing] and we just don't realize it... when you're having a hard time, just keep doing your best, because chances are everyone else is right there with you. and it's your resilience and continued efforts over giving up that eventually help you make it ahead, because actually pretty much everyone is struggling and not giving up is what keeps you from falling behind.

The advice the community shares is not only supportive, but also often actually based on social science research—that female students tend to leave CS/engineering with higher grades than male students who stay (Fortsch, Gartig-Daug, Buchholz, & Schmid, 2018; Taylor & Mounfield, 1994), that making big decisions during mental health crises is a bad idea, and that it may be fruitful to leave CS if pursuing a CS minor or integrating CS in some other way at her college will allow her to more successfully pursue a computing career.

Across this five-year period, the tenor of the conversations remains remarkably consistent. Not only do similar themes emerge each year, but similar kinds of support are given to posting participants. Thus, even with the annual addition of new winners, and even after 2014, with the influx of college-aged non-Awardees, the group continues to share the terrible and terrific experiences they have had with teachers and classes; advice on CS-related and personal topics are sought and provided; and internship, job or other visibility opportunities are presented to and enthusiastically received.

5. Discussion

The threaded conversations shared here illustrate the myriad ways that women in this Facebook group provide each other the encouragement to be computer scientists or engineers, as discussed in the research about combating the underrepresentation of women in computing. Through this encouragement, participants develop an empowering discourse that serves to oppose the bias many experience in the field. Participants give and receive concrete computer science-related support as well as social-emotional support. Computer science-related support includes opportunities such as hackathons and other competitions, conferences and media events focused on women in technology, scholarships, internships, company visits and introductions to VIPs, technical support for programming languages, and specific advice on which laptop to buy for robust programming. While these computing opportunity posts did not always develop into longer threads (and so did not appear in our top 25), they are important contributions to the women's professional lives, as they open up networks and access to resources the women may not otherwise have had. When people are underrepresented in a field, they often find themselves excluded from powerful networks and career-changing opportunities (Hewlett et al., 2008; Hewlett, Sherbin, Dieudonné, Fargnoli, & Fredman, 2014), and this group counters that. Further, having a place where they can ask for technical support without being shamed, or revealing their pockets of inexperience, is another important benefit of this group, and one often missing from competitive academic or work cultures. Both the tangible opportunities and the social support shared in the group enhance participants' social capital, an effect common in many online groups for marginalized persons. Their co-identification as marginalized, in fact, creates strong ties within the group even when they have no offline interactions and sometimes very little else in common. As other research has shown, these strong ties lead to enhanced well-being which supports their field persistence.

With some of the topics the women discuss, it is clear that being underrepresented in this field and having to combat the many well-documented barriers such as sexism and stereotype threat, adds a layer of complication to their decisions and actions. Whether or not they understand why, the women often feel they are being stigmatized. As previous research has stated, they feel they have to prove themselves academically and technically, to show others that they do belong in computing. Because of the unwelcoming climate many are in, it becomes even more important to have a computing community to belong to that supports them as a technical person, regardless of their identifying as female. Indeed, many participants commented on the importance of the Aspirations Award as not only lending them all credibility (*"The fact that you're even in this group tells me you're an amazing and unique person!"*) but also as giving them a safe space to deal with emotional issues (*"That's why we have these groups, to give minorities a safe place to talk about anything."*) and to seek technical help. Just as other stigmatized groups have found empowerment from online groups, so do these women. The content and tone of the group's conversations help participants counter the stigma many feel as a minority in computing.

As in other online groups discussed in the literature, participants converse primarily through one-to-many, asynchronous discourse, but sometimes their written conversations take place in real time, particularly during outpourings of support for one another during hardship (as evidenced by time stamps on comments). Support in the face of field exclusion takes many forms in this community, ranging from empathy to cheerleading to outrage, and includes problem-specific recommendations. Even when there are disagreements among the individuals, comments are primarily empathetic and uplifting. Group participants enact near-peer mentoring through encouraging each other to look at different aspects of an issue, invite each other to come visit them at their universities, and encourage each other to recognize the systemic factors at play rather than interpret situations as one-off problems. These are important redirecting conversations because they take the onus off of the individual to counter negative influences and instead put them where they belong, on systemic sexism. They share their knowledge and experiences so that what formerly seemed like an individual issue is recast as a systemic issue, something outside of them and against which they can push. This emerges as a critical factor in their ability to understand and cope with their situations, and affirms their right to be in computing.

Not every individual who is a member of the Facebook group participates in the conversations, and not everyone posts more than once. Still, the supportive tenor of the discourse is sustained, even though there are hundreds of new women added annually to the group. For in-person interactions—whether academic, social, or professional—differences such as race, socio-economic status and geography, can interfere with affinity bonding. But the women in this group are able to create an affinity bond and develop a safe and sustaining community because they are united by a shared passion, relieved of face-to-face interactions, and recognized by an organization whose mission is to make computing a welcoming sphere for them. Thus, their private conversations build a political discourse that they can use to sustain the assault of judgement, sexism and doubts they encounter in the computing world, and in society in general, since sexism and racism are, of course, not restricted to computing fields.

6. Conclusions

In this group participants have a variety of strong and weak ties, and because each year brings new members, the ties continue to shift. While most do not have an offline relationship, some do, and the conversations between these women may at times provide a sense of closeness to everyone who witnesses their exchanges. At the same time, those who don't know any others offline (i.e., those with weaker ties) still express a feeling of closeness to everyone (*"if you are in the area let me know!"*).

would love to meet you"). Some of the posts lead to offline connections, as the young women room with each other at conferences, or visit one another's campuses. Some have no chance of ever connecting offline, and yet seem to forge an authentic and supportive connection with each other, and with the group as an entity.

The virtual community, thus, works well for enabling conversations between women from around the country, who may never have met otherwise, who find solace with each other in a number of different ways and are exposed to countless tech opportunities they may otherwise not have known about. The group inculcates a feeling of camaraderie through sharing a gender identity and an uncommon interest. The posts and threads create a robust sense of community through providing advice that is both actionable and encouraging. The group offers a blend of social-emotional and practical support that develops and reinforces community and a sense that they belong in computing—messages many of them lack in their home environments.

The interactions they have in the group work as a reinforcing mechanism to create both consciousness and coalition. The counterpublic here offers them the framing and language to understand that not only are they not alone in their interests and experiences, but instead that they are part of a system that is not set up to include them, or any others that lie outside the traditional mold. Thus, because the group conversations are both practical and empathetic, rooted in experiences and countering systemic biases, they comprise an oppositional political discourse. This discourse is oppositional because it pushes against systemic cultural and disciplinary biases that send the women exclusionary messages at nearly every juncture in their computing trajectories. And it is political because it challenges the status quo.

While the medium for their discourse (Facebook) does not enable us to know what actions they take offline, we are privy to the oppositional discourse wherein they outline the path for each other to take action in the offline world. Often this path leads them to stay in the face of the challenges they encounter in computing fields. Only time will tell whether such discourse, and the actions it may produce, will be sufficient to change the culture of computing. Ultimately, it is up to the computing discipline to shift in significant ways in order to retain high-achieving, technically skilled women like those in this group and explicitly confirm their right to be in computing.

7. Limitations and future research

As with any research project, there are limitations to this analysis. Our generalizations may not apply to all women in technology for the following reasons: First, the women in this group expressed interest in computing while in high school and were awarded, and thus encouraged, for their aspirations and achievements. Second, many of the women in the group during the time period we studied would be considered high-achievers, and therefore, their concerns and experiences may be most generalizable to other high-achieving students. However, given the research suggesting that often it is actually those high-achieving female students that enter computing degree programs (Lehman, Sax, & Zimmerman, 2017), this group does reflect the current population of women in computing in the US. The strength of our conclusions are based on the fact that our dataset includes posts from a wide variety of women, at a wide variety of academic institutions across the United States. Given this broad range of participants, our future research plans include completing a social network analysis based on characteristics such as award status (national or regional), year of award, and content of post (based on our coding schema).

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