'It's hard to be the only girl': Obstacles facing adolescent girls in computer science contexts

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Abstract - Utilizing qualitative data gleaned from focus groups with adolescent girls attending computer science summer programs and competitions in cybersecurity (N=59, mean age = 16.3), this paper identifies psychological and institutional obstacles hindering girls in computer science contexts. Guided by ecological and social role theories, findings reveal psychological obstacles such as low feelings of confidence in the face of stereotype threat, low feelings of belonging due to experiences of exclusion in the classroom and perceptions of the computer science field as being masculine and isolating. Girls also reported low expectations from peers and teachers that discouraged their interest in pursuing computer science. Results have implications for educators, researchers and policy makers aiming to close gender gaps in

the field of computer science. This study is unique in its' emphasis on how subtle changes in the social context can diminish, or bolster, girls' interest and confidence in computing.

Categories and Subject Descriptors

Gender-related Obstacles

Keywords

Qualitative, Learning Environments, Gender, Cybersecurity, Adolescence

1. INTRODUCTION

The National Center for Women and Information Technology, NCWIT, (2012) reports that college women in the US are much less likely to earn degrees in computer and information sciences than in any other STEM related field, with only 18% of computer and information sciences undergraduate degrees earned by women. Evidence suggests that girls are becoming disengaged with computer science in adolescence. In a study of 6,000 college students, Sadler, Sonnert, Hazari & Tai (2012) found that girls' interest in STEM careers declined over the course of high school. Males were 2.9 times more likely to be interested in a STEM career at the end of high school than females. In the US, adolescent girls comprise 56% of all Advanced Placement (AP) test takers but only 19% of AP Computer Science test takers (NCWIT, 2012).

The research literature attributes the underrepresentation of women in computer science to a fear of fulfilling negative stereotypes about women in computing, limited access to female role models, masculine stereotypes about the field that deem it isolating and gender biases, including low teacher expectations and having to provide more evidence of competence than others to prove themselves (Aronson, Quinn & Spencer, 1998; Cheryan, Drury & Vichayapai, 2013; Cooper, 2006; Koch, Muller & Sieverding, 2008; NCWIT, 2012; Schapiro & Williams, 2012; Williams, Phillips & Hall, 2014). Teachers have been found to reinforce the idea that boys are more natural with computers and will often confuse

prior experience with innate ability (Margolis, Estrella, Goode, Holme & Nao, 2008). The transfers of these messages from teachers to girls have been found to put girls at risk for believing they are less capable (Shapiro & Williams, 2012) even though, with similar training and experience, girls and boys perform at comparable levels in computer science (Aronson, Quinn & Spencer, 1998). Girls tend to express less confidence and rate their ability lower than boys, even when actual achievement levels are similar (Moorman & Johnson, 2003), while boys tend to report being confident regardless of experience (Barron, 2004).

Stereotype threat has been identified as hindering females from engaging in computer science, out of fear of positively proving stereotypes that allege their lack of ability (Cooper, 2006; Logel, Peach & Spencer, 2011). Persistent stereotype threat, stereotypes that computing is isolating and low teacher expectations shape adolescent identities, academic confidence and expectations, and academic and professional choices (Margolis, et.al, 2008; Shapiro & Williams, 2012; Rhodewalt & Tragakis, 2002; Way, Hernandez, Rogers & Hughes, 2013). A recent study in Israel revealed that gender bias in primary school was negatively associated with academic achievement in middle and high school and predictive of girls' selection of STEM related courses in high school (Lavy & Sand, 2015). When girls select computer science classes in high school, gender biases are reinforced and stereotype threat is triggered when girls are minorities in their classrooms and when they are not exposed to female teachers or role models in the field (Cheryan 2012; Cheryan, Drury, Vichayapai, 2013, NCWIT, 2012).

Nonetheless, little is known about how adolescent girls perceive and make meaning of their experiences in computer science contexts, especially among those girls that are already interested in the field. There has been increasing awareness in the academic community that any scalable and sustainable effort to grow the computer science workforce cannot ignore high school students (Locasto, Ghosh, Jajodia & Stavrou, 2011), indicating a need for more knowledge on how to best support high school girls that exhibit interest in the field.

Guided by ecological and social role theories (Bronfenbrenner, 1979; Eagly, 1987), this study aims to fill that gap. Utilizing qualitative data gleaned from focus

groups with adolescent girls attending computer science summer programs and competitions in cybersecurity (N=59), this paper reveals the obstacles that are likely to inhibit adolescent girls' continued participation in computer science courses and careers. This study is unique in its' emphasis on how subtle changes in the social context can diminish, or bolster, girls' interest and confidence in computing.

1.1 Research Questions

- How do adolescent girls interested in computer science experience these contexts?
- What are some of the obstacles girls experience that might hinder their participation in the field?

1.2 Theoretical Framework

Human ecology theory considers how environmental settings and larger social contexts inform individual development throughout the life span (Bronfenbrenner 1979). Further, social role theory suggests that the creation of shared expectations, or social norms, about what constitutes suitable behavior for men and women establishes different social demands and distinct masculine and feminine roles (Eagly, 1987). Taken together, this study considers how gender roles and expectations shape girls' experiences in computer science.

In this paper, section two provides a description of the procedures and data collection and analysis methodologies used in this study; section three documents the results of the study and section four offers conclusions, including the limitations of this study, implications for practice and suggestions for future research.

2. METHODS

2.1 Sample

Fifty-nine girls (ages 15-18, mean age 16.3) participated in the study. Eighty-eight percent of these girls were from high schools throughout New York City and New Jersey. The other 12% were from Maryland, California and Illinois. Of the 50 girls that reported their ethnicity, 32% identified as White, 18% identified as Black

or Hispanic, 46% identified as Asian and 10% as 'Other'. Of the 45 girls that reported on indicators of socio-economic status, 31% reported being eligible for free lunch in school and 18% indicated that their mothers did not complete high school. The majority of these girls reported having an 'A' average in school and all planned to attend college. All of the participating girls had an interest in computer science.

2.2 Procedures

Girls in this study (N=59) were participants in two different types of cybersecurity programming sponsored by a private university in a northeast city: summer cybersecurity programming for girls and cybersecurity competitions.

Over the course of two weeks, faculty and students delivered an NSA sponsored Gen Cyber program to high school girls. These girls met at the university over the summer and worked together to solve cyber forensic problems and perform cryptographic hash, memory analysis, data recovery, stenography and more. During the fall semester, girls participated in the High School Cyber Forensics Challenge during Cybersecurity Awareness Week (CSAW).

All of the girls that attended the summer program in its' first two years of operation (N=38) and all female participants that attended the CSAW events over the course of two years (N=21) voluntarily participated in one of eight focus groups. Focus groups provide opportunities for insightful and contextual discussions about pertinent issues in adolescents' lives and are viewed as helpful in understanding how stakeholders regard specific experiences (Massey, 2011). Questions explored girls' experiences with computer science, their career goals and their perceptions about the role of gender in computer science industries. The 20-60 minute focus groups were held in private rooms, were recorded with the permission of the participants and were conducted by one of the authors, a trained qualitative researcher and developmental psychologist. Fifty-two of the girls completed a brief follow up survey that included demographic information (age, ethnicity, mother's schooling, grades, eligibility for free lunch).

Data analysis relied upon the qualitative methodology of open coding: a strategy that divides the narrative data into discrete units of analysis (quotes) reflective of the major themes that are embedded in the words of study participants (Miles & Huberman, 1994). First, verbatim transcripts of the focus groups (amounting to more than 150 transcribed pages) were read multiple times by a research team consisting of the lead researcher and four graduate students. Next, a coding scheme was developed to represent the emergent themes identified in the initial read-through of the transcripts (i.e. discrimination by peers) and to represent variables of interest including girls' attitudes and beliefs about computer science (i.e. gender stereotypes). See Table 1 for examples of codes and their definitions. Next, the transcripts were reread multiple times and, using Atlas ti software, the narrative data was coded to identify where, when and how often the girls discussed various themes. Finally, all of the data (quotes) assigned to each code were reviewed to identify overlapping patterns across individuals and transcripts. Matrices were created to summarize, consolidate and organize the central themes that revealed obstacles to engaging girls in computer science and were described by a majority of the participants. In order to reinforce the integrity of our findings, the team reviewed all coding matrices to discuss competing hypotheses or conclusions and conducted coding checks for adequate agreement until code-recode reliability and inter-coder reliability reached 90% (Miles & Huberman, 1994). Themes are presented in this paper with illustrative quotes drawn from the focus group texts, staying true to the language of both the participants and the interviewer. Participants have been given pseudonyms to protect confidentiality.

CODE	Definition	When NOT to Use	Examples
Low Confidence	Descriptions of how they struggle with feelings of confidence in	When participants describe feelings of confidence in other subjects	"The other students in my computer class are all very, very smart

CODE	Definition	When NOT to Use	Examples
	computer science contexts		and it's just very intimidating."
Gender Stereotypes	Perceptions of, and experiences with, gender stereotypes	When participants mention gender stereotypes in non-STEM domains	"Girls don't do computer science."
Discrimination **	References to experiences with discrimination in computer science contexts- could be from teachers or peers	When participant discusses discrimination unrelated to computer science	"Most teachers in high school are like 'why can't you catch up?'"
** This code was further broken down into 'exclusion' and 'expectations'			

Figure 1: Sample from Code Book

3. RESULTS

3.1 Psychological obstacles: Confidence in the face of stereotype threat

The girls in this study were interested in computer science but also experienced low feelings of confidence in their computer science skills. Even after the intensive cyber security training that some girls received during the two week summer camp,

they continued to have fears that they would feel" behind everyone else" when it came to entering the field of computer science "because like we don't know that much." Girls were aware of the stereotype that girls are inferior to boys at computers and some even believed it. One girl stated, "I don't know, maybe it's just something in our genes why we don't like computers." Girls frequently reported a fear of fulfilling these negative stereotypes about girls in computing when engaged in computer science activities. One girl stated,

I do like computers. I guess I'm okay with them but I don't know. My cousins are very technologically advanced. They've taken computer science courses before and I don't know. Well, they're male so I guess maybe that's why I've always felt like I was lesser in terms of like intelligence when it comes to computer science. So I wanted to show them that I could learn too. I could be like them… I was convincing myself [when attempting a cybersecurity competition] that I would know nothing and everyone else knew everything. I was completely nervous.

Research suggests that this pattern of feelings 'lesser' often leads to poor performance and disengagement from the field (Cooper, 2006).

3.2 Psychological Obstacles: Low feelings of belonging

Girls often explained that they had not previously considered computer science as a career because they thought the field was too masculine and isolating.

Whenever geeks like us are portrayed on TV, they won't wear dresses and heels to work. They wear jeans and crouch in the basement all day. So, even on TV, there are never any girls; it's always boys. So there is no inspiration or role model. And, it's not glamorous to the naked eye.

Many of these girls had faced an uphill battle to maintain their interest in technology. They experienced pressure to play with dolls as children and to participate in cheerleading or dance as adolescents. One girl stated, "*I actually know a pair of twins where the mother enrolled the boy in computer classes and the girl in dance class. I thought that was slightly weird.*" Gender specific roles and expectations limit opportunities and experiences and are disadvantageous to girls when they enter high

school with limited knowledge. One participant recognized the importance of early exposure and encouragement in computer science;

If you don't have that knowledge going in, of course girls are not going to do as well in competitions like this. So starting from a very young age like you encourage girls to do this and you encourage guys to do this and it's hard to kind of change it with like one decision. It has to be a long process.

When reflecting upon their experiences in other computer science contexts, the girls frequently identified the problems associated with being the only, or one of very few, girls and how these contextual problems solidified their masculine perceptions of the field and contributed to their low feelings of belonging.

3.3 Institutional Obstacles: Experience of exclusion

The experience of exclusion by teachers and peers exacerbated these already low feelings of belonging. Girls reported feeling the need to prove themselves to their male peers and teachers. One girl stated,

Classes where there are more men, they'll be like 'its so easy, how did you not get this'. So you obviously are not going to try because you are blocking my way… I cannot learn in an environment where I am being over shadowed or pushed down.

Another girl explained a time that the boys in her robotics class took credit for her achievements.

In my robotics class, I was the only girl and the teacher was a guy too. So that didn't even help and so it was me and 30 guys in one class for robotics. They took advantage that I was the only girl in the class. Like if I had the best part, they took away my best parts and it wasn't that they were better than me but just that they were a bunch of guys and I am one girl.

Gender norms led girls to believe that computer science is for boys, which limited their opportunities to build knowledge, and confidence, in the field. When also faced with low expectations and gender discrimination, girls needed to find their voices to resist being boxed out. Or, they may opt out of this field all together.

3.4 Institutional Obstacles: Low expectations by teachers and peers

Girls shared many experiences where they feared that teachers and boys held low expectations of them.

Guys think women are supposed to be in social science and English and men are supposed to be in science and math, so that's like the general things to follow. A lot of times when you get to more advanced mathematics classes it's mostly guys and like one girl. Sometimes that encourages me to take the class because I can be the only girl and be like awesome. But its' also kind of discouraging to be the only girl in class because if you are not doing as well as the other guys then they are like 'that's because you are a girl.' Sometimes they don't hold you at the same standard and it's really annoying.

Similarly, another participant explained that in her programming class she felt the pressure to be "good at it" and to be "really professional" if she wanted to be respected.

I do many hobbies that are also with a lot of guys. There aren't many girls in it. I feel that to be respected by them, and to be called one of them, you have to be good at it. So I feel that I am pressured to be a good programmer just to fit in and be respected because before I was good, they all looked down on me.

Girls explained that they are often assumed to not have adequate skills or understanding of computer science material, or to have earned their place in the class on their own merit. They felt the need to "work harder" to counteract this discrimination and to change perceptions about their skill, ability, and their place in computer science. This constant polarization did not allow the girls to simply be on par with the rest of their peers and led many to struggle with their own confidence. One girl stated, "*I think that men in this field are so confident that we feel a little over shadowed and intimidated and feel less capable*." Lack of confidence coupled with the pressure to prove themselves to their male peers and teachers is likely to lead many to disengage from computer science fields.

3.5 Female mentors challenge gender bias and discrimination

Exposure to female mentors challenged masculine and isolating perceptions of the field and revealed the collaborative nature of the field.

I think something that I really liked about the program was the fact that a lot of women speakers came in to talk to us… Some of what really stuck out to me was that they all talked about how you just need to be really fearless and it was interesting. Like in my science and technology class, my group is all guys and I think there are 4 girls in my class. Our teachers don't put us together, so I am always forced to work with the guys. I have kind of gained respect to this point but it took a while and I kind of had to work extra hard to gain my respect. I mean it was worth it in the end but it was kind of interesting because what they were saying like really applied to me and I could learn from them.

Female speakers also affirmed experiences of gender discrimination and that it could be overcome.

I think that my preconceptions about being a female have kind of almost completely dissolved. Like I feel like it still exists, but we met a few software engineers that are females and they were saying that although they do have to put in a lot of time and effort, everybody is capable of it. I think we all have that potential and I think we can prevail past the stereotypes behind these kinds of careers.

Having female mentors validate the girls' experiences in other computer science settings encouraged the participants to continue in the field despite the challenges. Female mentors validate the experience of stereotype threat and discrimination and assure girls that their gender and social identity will not be a liability in the field (Murphy & Taylor, 2015). Success was perceived as attainable. One girl stated, "*I can start out with knowing nothing and work at Google too.*"

4. CONCLUSION

Overall, these findings align with other research findings that suggest that girls are often viewed by teachers as deficient in terms of academic ability in computer science and other STEM-related fields (Shapiro & Williams, 2012). Stereotype

threat masks true potential because it leads to the underestimation of ability (Walton & Spencer, 2009) which can shape adolescent identities, academic confidence and expectations (Rhodewalt & Tragakis, 2002; Way, Hernandez, Rogers & Hughes, 2013). Because of stereotype threat, women need to be stronger in math and science than their male classmates in order to succeed. Williams, Phillips & Hal (2014) refer to this opposing assumption as the "Prove It Again Bias." When a woman faces this bias, she must do more work than a man to be considered equally competent, which can take an emotional toll among adolescents that are formulating their academic and social identities.

The effect of girls' increased efforts to compensate and prove themselves in the midst of exclusion and stereotype threat is decreased performance (Aronson, Quinn & Spencer, 1998; Davies, Spencer, Quinn & Gerhardstein, 2002). Research suggests that when a girl enters a computer science class, as a minority, and fears that her peers and teachers have low expectations for her, her working memory efficiency is focused on regulating these emotions rather than completing the computer science task at hand, thereby hindering her performance (Conway, et al., 2007).

By adolescence, students begin to see ability as more of a fixed quality and tend to handicap themselves by withdrawing from subjects they do not feel confident in (Rhodewalt & Tragakis, 2002). Knowledge about stereotype threat and the fact that it elicits anxiety is helpful for girls and women as it allows them to correctly attribute their anxieties to stereotype threat and not to poor ability (Johns, Inzlict & Schmader, 2008). Results suggest that effective professional development for teachers of girls in computer science must include exposure to the negative effects of stereotype threat and the environmental stereotypes that hinder girls' engagement with the material and field. Interventions that aim to engage girls in computer science need to build knowledge and confidence and challenge these stereotypes, and help girls develop skills for resistance to discrimination (Jethwani, Memon, Seo & Richer, In Press).

This study contributes to our understanding of the important ways in which educators may break the barriers of stereotype threat and close gender gaps in the field of computer science, but the generalizability of the results are limited. This

study took place in a particular geographic location with a relatively small sample size of girls. Additional data about racial variation in the experience of computer science contexts would offer a more complete look at the psychological and systemic obstacles facing girls in computer science. Recent research reveals a concern among girls of color that are interested in STEM related fields that they might be alienated from their families and friends (Kumar, 2016). Finally, future research might also consider the gender-specific beliefs and behaviors of high school computer science teachers.

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