Peer Networks Built Around Common Experiences Stabilize Other Things Too: The Durability of Hegemonic Bias in Undergraduate Computer Science Education

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ABSTRACT

Despite increasing attention, the existence of inequality and bias towards underrepresented groups in STEM education and professions remains the status quo. We report research to incorporate professional morality and ethics into undergraduate Computer Science (CS) education. Our data come from interviews with undergraduate CS students following a course centered on topics of social justice and ethics in CS.

These interviews provide evidence that students acknowledge personal and professional value of diversity and inclusion in CS education and professional practice. Interviews also help us identify root causes of injustices in CS contexts. However, CS students also demonstrate network formation based on homophily, sometimes reinforcing and emphasizing durability of hegemonic bias.

Keywords: diversity, inclusion, homophily, social networks, higher education, computer science, STEM

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INTRODUCTION

According to the National Science Foundation (NSF), while the number of students graduating in Computer Science (CS) has been increasing each year, women and minority populations continue to represent a disproportionate minority. White men are the most common demographic group at a total of 45.1 percent of all bachelor's degrees awarded in this field (Data USA n.d.). Despite initiatives to increase the number of women,[2] the percent of bachelor's degrees earned by women in CS actually decreased from 25.1 percent in 2004 to 18.1 by 2014 (NSF 2017).

Lack of parity has existed in computer science for generations (Alfrey & Widdance Twine, 2017; Ceyer, Chisholm, Friedman, Hewitt, Hodges,Hopkins, & Stubbe, 1999; Fowler, 2017; Ko, 2017; Wu, 2017; Vassalo, Levy, Madansky, Porter, Leas, & Oberweis, 2016), and is associated with hostile work environments, competent individuals leaving the field (Alfrey & Widdance Twine, 2017; Ceyer, Chisholm, Friedman, Hewitt, Hodges,Hopkins, & Stubbe, J., 1999; Fowler, 2017; Ko, 2017; Wu, 2017; Vassalo, Levy, Madansky, Porter, Leas, & Oberweis, 2016) and revenue loss (Mims, 2017).

[2] https://www.nsf.gov/od/odi/diversity.jsp

According to Leaper (2015), this lack of participation from underrepresented groups arises from expression of sociocultural factors, including strength and persistence of various forms of microaggressions and even overt aggression toward underrepresented groups with respect to scientific, technological, educational, or mathematical achievements. Everyday experience of these phenomena affects students' success — or lack thereof — in college (McCabe 2016:7).

Peer groups provide emotional as well as intellectual support and stimulation across all subgroups in higher education and professional practice. Individuals with common interests and perspectives support each other in the face of threats to participation, maintaining certain properties and values important to the group. However, this can also work against inclusiveness, diversity, and social justice at multiple levels.

We report on how peer networks formed in early stages of higher education in CS may contribute in several ways to the durability of bias that affects lack of inclusion. First, we find the tendency for people to seek and form networks with individuals similar to themselves results in highly gendered networks. Next, it is apparent that not all networks are created equal. Network formation appears tied to social and cultural capital, allowing those with existing capital to build higher quality networks and further alienating those without. This is often invisible and unintentional (in terms of effects) to those in and out of the network, and adds to the idea of "natural merit" or "fitness" for some groups and a lack of fitness for others, thus reifying hegemonic bias already present in the field.

Our research provides evidence that many students acknowledge personal and professional value for ensuring diversity, inclusion, and social justice in CS. Further, they can successfully identify root causes of inequality, bias, and social injustice in the context of course assignments. However, when students are separated from guidance and leadership in support of these values, they often fall back on beliefs associated with gender stereotypes and individualism in technical fields that contain meritocratic fallacies, and which feed off of homophilous and often gendered and unequal peer networks. They commonly deflect or deny the existence of bias in CS by alluding to meritocracy thus maintaining the status quo, which they perceive to not be problematic.

METHODOLOGY

Our research is focused on experiences of undergraduate CS students during the period of fall semester 2017 through fall semester 2019. The majority of our data comes from a systematic set of open-ended and semi-structured interviews with students following an introductory *Foundational Values* course in which students (a) investigate topical instances of bias and loss of social justice in technology work and the social and technical factors that accompany it, and (b) apply a theory-and-practice-based tool to propose systemic solutions (Winiecki & Salzman, in review). Interviews are scheduled at roughly 1-per semester following that course, through a student's graduation from the program or choice to discontinue. During the period indicated, forty-six students have been interviewed at least once, and 18 students interviewed two or more times. 33 interviewees

are male, 13 are female. No interviewees identifed as non-binary or intersectional. Five students are Asian, four students are Latinx, and all others white.[3]

Interviews were recorded and transcribed, and subjected to inductive and deductive coding processes using the NVivo qualitative data analysis package. After the first several interviews were analyzed, researchers created a codebook based on the codes used. Over time we have expanded and refined this codebook to include new discoveries and concepts acquired from related research.

PRINCIPAL CONCEPTS AND RESEARCH ORIENTATION

In the project reported here, the CS department at a large public university undertakes a broad initiative that in part endeavors to improve diversity, inclusion, and social justice, with a goal to increase participation and retention of women and other underrepresented groups. Our research is conducted in the context of a five-year, NSF-funded project to 'revolutionize engineering and computer science programs.' This includes changes to make curricula more responsive to industry needs, and also to incorporate professional morality and ethics into undergraduate CS education with the goal of increasing enrollment and persistence of underrepresented groups in CS — individuals other than white and Asian males (National Science Foundation, 2017). These initiatives have led to

[3] These interviews are ongoing and participation rates are changing, but this manuscript reflects data from interviews as described here.

some successes, but are complicated by socialized and stereotyped biases students bring with them.

All of this reinforces the observation that entrenched social values, stereotypes, and aspirations remain substantive forces and cannot be seen as binary — not just supporting or inhibiting inclusion and diversity — instead sometimes offering possibilities for resistance or inclusion on a shifting basis. We find examples of how students perceive status differences rooted in gender and act to use these to reinforce bias. We also find instances of how groups of students form peer networks around gender, particular experiences, and values in ways that protect them as members of underrepresented groups by isolating themselves within the student body. In both cases students' actions reflect an expression of the common concept of homophily.

Homophily accounts for how people form connections through perceived similarities (e.g., race, ethnicity, sex, gender, age, religion, education, occupation, avocation, hobbies, etc.). Homophily also occurs through proximity when individuals who share locations form cooperative relations. Because people in homophilic networks experience or share characteristics, they normalize *those* characteristics while *other* characteristics may not be normalized or even be considered deviant. Thus, homophily produces connections, and also creates boundaries, shapes information received, skews or sensitizes attitudes, and affects how phenomena are experienced (McPherson, Smith-Lovin, and Cook 2001).

As suggested, connections commonly form into networks and friendships, and may also exacerbate hegemonic biases. For example, De Grove (2014) describes how friendships for young people commonly form around digital games. Although both young men and women talked about games in mixed-gender friendship networks, De Grove found that men were less likely to play digital games with women in their network. As a result, while De Grove's (2014) work suggests that gaming is inclusive, it is not necessarily inclusive across all factors that exist in the group overall. It is a well-known phenomenon that games provide a venue in which gender biases and harassment are expressed and even promoted, perhaps *because of* boundaries that separate members and non-members (De Grove, 2014; Fox and Tang 2017; Massanari 2017).

Individuals seek supportive networks and act to ensure and protect such networks, but this sometimes ends up producing sub-groups which may be insular (Stark and Flache 2012) and may inhibit inclusivity across larger heterogeneous groups. The result of this is a discounting of potential gains engendering inclusive and diverse homophilic outcomes, which can evolve into networks that are homogeneous and potentially even exclusive, insular and biased.

Homophily tends to preserve existing social and cultural capital, which simultaneously imposes a barrier for those who have not accumulated the same amount or same type of capital. Networks can be seen as investment strategies through which members establish or reproduce "social relationships that are directly usable in the short or the long term"

(Bourdieu 1986: 249). This transmission of capital is often not directly visible (rather only traceable through historical factors in lives and actions of members) which allows for success to be attributed to appearance of "natural qualities" or "merit." Failing to acknowledge differences in capital, thus perceiving successes or failures as a result of these immediately visible qualities, rather than capital that may make success possible, feeds into meritocratic fallacies and furthers bias (ibid, p. 254).

OUR EFFORTS, OUR CONTEXT, OUR RESEARCH

In this section we describe more about our attempts to influence students, our context and how well this context maps to existing demographics within STEM education, and what we are learning in our interviews. We introduce our data and analysis to develop an "inside out" picture of what is happening.

Influencing our Students, and Assessing that Influence

All informants are introduced to this research project on the last day of 'Foundational Values.' This course is required of all incoming students in the CS undergraduate program in which this research is being conducted. The course meets two days each week for five weeks, with each class period lasting 75 minutes.

In weeks 2-4 of this course, students are introduced to authentic case studies in which loss of inclusion, diversity, and social justice occurs in CS education and professional practice (Winiecki and Salzman Submitted for review). During semesters covered by this

research these cases include the experiences of Susan Fowler as an engineer at Uber (Fowler, 2017), effects of using biased data and biased assumptions in machine learning systems (Angwin et al. 2016; Angwin and Larson 2016), and effects of misplaced trust in 'big data' and biased assumptions in facial recognition systems (Buolamwini 2017, 2018).

Assignments are accomplished in-class in teams of four to five students. During the first class of the week, the instructor leads a discussion through which a case is analyzed to identify 'problems' and stakeholders. This analysis begins with a moral angle using Rawls' *original position* (Rawls, 1999) to identify and list intentional and unintentional wrongs suffered by victims in the case as understood through the commonsense that one would want to avoid those problems if he, she, or they were in the same situation.

Following this, students and the instructor approach these wrongs from the idea of a *wide reflective equilibrium* and *shared rights and duties* (Rawls, 1999) that could address the identified problems. This is expressed through the creation of lists of rights and duties for stakeholders in the situation in response to each wrong identified. The instructor guides students to curate these lists and explain the curatorial process as it is performed in order to expose the necessity of a symmetrical relationships between rights and duties. The result is creation of a list of wrongs and linked lists of rights and duties and rationale for how fulfillment of rights and duties has influence on remedying wrongs.

This sets the stage for the second class of the week, in which students complete their analysis and proposed interventions in teams of four to five with limited guidance from the instructor. One of the principal parts of this second day of work is completion of an 'elevator speech' that briefly describes how fulfillment of identified rights and duties can address the identified problems, and especially how this will benefit collaborative and collective goals of CS education or professional practice. The goal in this part of the activity is to give students practice in producing grounded statements in support of a valued moral and ethical position.

The final part of the assignment is creation of symmetrical lists of material incentives and disincentives that could be leveraged by an organization on each category of stakeholders in the case in order to improve the chances that each stakeholder will fulfill assigned rights and duties.

Over the three cases we gradually introduce formal frameworks of ethics, including virtue, common good, rights, justice, and utility. This is consistent with Rawls' own development of his theory of justice as an ordered and quasi-calculable means for producing socially-just environments in civil society (1999). We acknowledge criticisms of Rawls' constructs and existence of more nuanced theory regarding the creation of socially-just environments, but we also assert that our goal in this five-week course for first year undergraduates is to provide 'rough and ready' tools and concepts which can

produce quick gains and inspire confidence. It is not our goal to teach detailed knowledge of philosophical, sociological, feminist, and/or political theory and practice.

Because this course is often the first nominal CS course undertaken by incoming students, we intend to provide an intellectual scaffold with which students can continue to grow and build their professional and ethical selves as they proceed through other courses. From the inception of this course in fall semester 2017, 600 students (526 male, 74 female) have completed it. Over that time, 90 to 100 percent of students per term indicated agreement with the following questions on the culminating course evaluation:

- Are matters of professional morality and ethics relevant for computer scientists?
- Can professional morality and ethics contribute to becoming a better computer scientist?

From this we are optimistic the course is influential in orienting students to issues of professional morality and ethics, and successful in making the content relevant, practical, and even necessary for students. However, we are well aware of the isolated effects of instructional interventions. The interview research identified above and reported below serves to look more deeply at this by querying students each semester as they progressed through the degree to learn more about their experiences and their actions based on the course described above. Questions in these interviews focus on experiences as they relate to inclusion, diversity, and justice, but are often couched within questions that orient to

individual, social, and organizational factors facilitating or impeding their learning and satisfaction as students. We use these interviews to assess impact of attempts to affect conduct of students and influence the climate of CS, and in turn help us innovate to improve our ability to do so.

Describing The Way it Is

The popularity of STEM career fields continues to grow at an astonishing rate. Five years ago at our school there were fewer than 150 CS undergraduate students, and today there are over 800. Despite the growing population, there remains a disproportionate number of males throughout STEM and especially in CS. According to the National Science Foundation, across STEM fields CS has the lowest participation by women, with 28 percent for the year 2000 and 18.5 percent in 2012. A similar trend occurs across ethnic and racial groups. According to the National Center for Science and Engineering Statistics (NSF 2017), the lack of parity in 2016 for CS education in the U.S. is as follows (Table 1).

Table 1. Proportion of U.S. Graduates in Computer Science, 2016.

	White	Asian	Hispanic	Pacific Islander	Black	Multi-Racial	Unreported
Female	7.3%	4.8%	1.6%	0.017%	1%	0.8%	0.7%
Male	49.9%	15.5%	7.8%	0.2%	34%	3.3%	3.6%

The overall student population in CS in our university reflects participation common in NSF/NCSES statistics (NSF 2017) (Table 2).

Table 2. Proportion of Students in CS at our university, Fall Semester 2018.

	White	Asian	Hispanic	Pacific Islander	Black	Multi-Racial	Unreported
Female	10.1%	1.8%	2.2%	0%	0.02%	1.0%	0.5%
Male	61.1%	5.0%	10.2%	0.1%	0.9%	4.1%	3.9%

Given this, it is not uncommon to encounter the viewpoint that 'the way it is' (e.g., disparity in STEM fields) is somehow reflective of deeply seated truths about individuals represented in statistics. These are often communicated through a teleological narrative asserting that those who are not commonly represented in CS (or STEM) are somehow 'less fit' or 'self select' out of the field (for one recent case, see Damore 2017).

However, systematic investigation of these notions has found them to be evidence of bias themselves — those not represented in STEM careers or in successively higher levels of STEM education are definitely not 'less fit' than those who make up the stereotypical norm, and women who demonstrate high capacity and skill in mathematics and science demonstrate higher capacity and skills in other areas as well (Ceci, Williams, & Barnett

2009). From this, Ceci, Williams, and Barnett postulate that the notion of the 'leaky pipeline' metaphor[4] for women who leave STEM from K-12 through graduate school and professions is related to the conditions that (a) a more or less hostile social and cultural climate in STEM education and professions gives capable women good reason to leave, and (b) women's capacity and skills in other areas are more accepted in fields other than STEM. Tonso (2007) provides ethnographic evidence of this often microaggressive-intense environment. This evidence is reflected by others starting at the very beginning of computer science as a recognizable academic field of study and continuing to the present (Ceyer et al. 1999; Hill, Corbett, & St. Rose 2010; Natanson 2017; MIT Computer Science Female Graduate Students and Research Staff 1983; Wolfers 2017; Wu 2017). While disparity in STEM may be an effect of many personal choices, environments that obviate such choices are not related to lack of capacity and skill. Instead, this can be seen as the product of socialized behavior expressed forcefully in STEM (Ceci, Williams, & Barnett 2009; Seron, Silbey, Cech, & Rubineau 2016) which gives 'others' a reason to leave and achieve success elsewhere.

These observations set the stage for the following data and analysis from our project that allows us to begin to understand some aspects of how these socialized behaviors form and express themselves, and why they are so durable in the face of efforts to change. We

[4] This metaphor is itself a problematic example of dehumanizing the issue by characterizing those who choose to leave as a substance unavoidably affected by 'natural forces' in a clunky system rather than as capable individuals in their own right.

begin with data from interviews that helps us understand parts of the social systems from which our students come, and follow with data that helps us understand how what they are learning in college courses has limited purchase in the face of inertia from their own experiences.

Hegemonic Status Quo. In our interviews, we found that hegemonic bias persists and is reproduced in everyday events. This is problematic as one's experiences in courses and in direct or indirect contact with others are strong influences on how one learns to be a CS student and aspiring professional. This feeds the personal and social trajectory that creates and increases social capital. Courses are especially important because faculty members are a strong professional and moral influence on students. Faculty have a warrant to say that they know what CS is as a discipline, and their actions (and inactions) can powerfully represent particular beliefs and norms. Adopting those actions and inactions links a student to the faculty-ratified network through which this professional capital flows.

An example of a faculty member perpetuating male normativity was disclosed in an interview with a student who goes by the pseudonym of Five.[5] Five — a first year, middle-class, white, and female student — described a classroom activity in her second CS course that required everyone to use the Linux operating system, which she had never used. While others (in this instance, all male) did not admit difficulty in the process, she

[5] The names of all informants are pseudonyms selected by themselves.

appealed to the instructor when she got lost in the directions. The instructor quickly reviewed her computer screen and, noticing the problem asked the class if anyone else was having difficulty. When no other students admitted troubles the instructor obliquely (and micro-aggressively) said to Five, loud enough for others to hear, "...okay, it's only you…"

Five indicated this experience left her feeling singled-out and implicitly identified as a less capable student. She admitted to deciding that she would never ask a question in class again, and only ask questions of the female learning assistant in the tutor center or with her all-female cohort of students. This experience and decision to protect herself has had durable impact on Five and her cohort, as will be shown in more detail below.

Five's experience shows how unprepared or insensitive instructors reflect the status quo of CS, where unverified assumptions about prior experiences are treated as the default, leaving anything else outside the norm — a case of 'othering' that threatens and harms one's identity as a student and future professional.

Many students in interviews repeated meritocratic beliefs through assertions of gender-blind and color-blind ideals. Meritocratic fallacies identified in data below parrot the notion that anyone, regardless of gender, race, or ethnicity, can be successful in CS as long as they demonstrate technical expertise expected of members. This is often supplemented with claims that CS *in this university* does not contain any bias. Neglected are pervasive forces that continually disadvantage women and members of

underrepresented groups. Especially absent is acknowledgement the speaker is himself (and this is always so) channeling those forces.

When it comes to explaining why (more) women aren't there, in interviews both female and male students have a tendency to normalize the gender gap as a 'natural' effect of something outside CS. For instance, they explain it away by saying things like women don't want to pursue CS or that 'they' think differently. Our informants do not often critically reflect on the environment of CS. In fact, they negatively regard those (regardless of race, ethnicity, or gender presentation) who challenge the status quo, and often refer to them pejoratively as 'social justice warriors' (SJW) and criticize social justice initiatives.

For example, Belle — a first year, white female CS student — speaking about SJWs states "I don't necessarily think it's bad. I personally want to be a social justice warrior. I just think that there's a stigma associated with it. It is very indicative." Belle's labeling of stigma as 'indicative' alludes to the negative connotation of 'social justice warrior'.

Belle is not the only student who mentions the stigma around being a SJW. Robbie — a white male CS student — provided a bit more background for what it means for him and how his understanding appears to be very different from others. He describes that while growing up, family dinner conversations often touched on issues of bias as experienced by his mother and sister, or noticed by his father in day to day activities. Robbie notes that while "social justice [...] has always meant standing up for people who are essentially

less privileged than you" the context in which he hears it most often "is the idea of the social justice warrior." This, he describes is a "[stereotype] from high school: people making fun of the idea of someone who [is] the person with the dyed hair, who is morbidly obese, who has a tumblr blog, and walks around and screams at people," though he quickly added "that is not what social justice is to me".

Robbie's statements show his personal history has provided a different view from that of his peers. Regardless, the stereotype is persistent as can be seen in Turtle's description. Turtle — a white, male first-year CS student — states that he'd heard of social justice "in usually derogatory types of things on the Internet, where somebody would say that they are like a social justice warrior, and it is usually used in derogatory ways for people who are overly aggressive about ensuring [equal treatment]." He continues "It's hard because it uses derogatory [sic] in a lot of things, because what I am saying is that it sounds good, but it is used in a negative way. Like they are overly aggressive about ensuring that everyone has justice."

Belle's and Turtle's comments that the goal of SJW is itself positive — that it 'sounds good' — *but* that it is 'used in a negative way' highlights a conflict between interpretations of the *purpose* for social justice and how stereotyped SJW tactics are used to disparage its goal. They suggest SJWers have become part of the problem.

From experiences in the "Foundational Values" course, we know students can identify instances of injustice and inequality in examples provided in class and under guidance by

the instructor. However, in interviews we also learn they are often unaware of such bias in their own social milieu, and when they are aware, not knowing how to address it.

In order to better understand how hegemonic bias persists we have to look at how it is possible for students to be simultaneously aware of bias in CS while actively rejecting social justice, or denying the need for it in their immediate surroundings. As will be shown, the formation of homophilous networks contributes to bias in CS.

Peer Network Formation Dependent Upon Sociocultural Backgrounds

Students in our study form peer networks based on personal backgrounds, interests, and new experiences. Their personal histories occur within social systems that are the product of supervening norms and not something they can necessarily control or are even aware of.[6] For example, friendships always rely in some way on shared experiences, interests and values. At the same time, we know these are not enough to provide durable relationships with others unless we assume individuals will never grow beyond their

[6] Such lack of awareness helps to account for the common reaction favoring a meritocratic ideology that an individual's successes are principally a result of one's own efforts and brilliance, and not from the 'brute luck' of happenstance and accidents that put an individual into conditions that just so happen to provide unequal advantages (Vallentyne 2002). This makes the argument that views and beliefs asserting that *the way it is* in computer science is the result of merit rewards to those who are current *in* computer science are themselves inaccurate. Regardless, the meritocratic fallacy remains common and even one of the origin fables of computer science (Coleman 2013), and for many of our students.

current positions. Long term relationships rely on adapting with others and upon development of new and emerging links and opportunities (McPherson, Smith-Lovin, and Cook 2001).

In interviews, we found networks around existing high school friendships, gaming, the marching band, and other experiences. These networks usually occur with lack of strategic intent for success in CS, such as those that carried over from highschool or participation in band. However, as shown below, other networks are created intentionally with this purpose in mind.

In one case this is specifically aimed at selection of individuals for membership in an online gaming group that also functions as an ad hoc study network for CS students. Whether purposefully or inadvertently, these networks provide limited inclusion for some, but perpetuate exclusion for others. Further, network formation for women, unlike that for male peers, appeared to be separate and actually *based on gender* as a protective quality rather than friendships or shared interests. Male networks appear to be built around existing social capital or actively seeking social capital, whereas female networks appear to have more of an emotionally supportive or protective role.

High School into College: Building on existing Capital. Friendships are often carried into college when high school friends attend the same university. This allows for some to build on existing social capital while further alienating those who do not bring with them similar capital. Contrasting three interviewees' responses gives us an overview of different types of social capital.

Ashton, whose parents are both educators, is an example of someone who entered college with established social capital. He describes how high-school friends continue as a principal part of his peer network. This was not just happenstance because he was active in influencing others from high school to attend CS at this university. When asked whether he planned this or it was an accident, Ashton stated it was "a little bit of both" as he "originally planned on coming [here] and [...] I basically convinced them both about the CS program here and how many opportunities there are". "Since they are both doing the same major, it kind of just works that we have the same classes."

In describing study habits, Ashton details how he relies on friends more than the department-sponsored tutoring center. Having friends double as study partners and a support system shows how Ashton gains support from existing social capital. He states that he and his friends have a group chat and while they will start a project or study for an exam individually, when they are "struggling to figure out how to get to the next step" they "kind of just ask each other if they want to meet up at one of the labs or at someone's place and work on it" because "two heads is better than one".

Similarly, Skimwax, a foreign-born Asian male who attended high school in the U.S. describes several ways his peer network from high school has carried into his college experience. Skimwax describes a friendship with a nursing student that carried over from highschool. “We’re more than just friends, because with that individual we decided to take classes together [...]having friends in the classroom, I feel more, what should I say, backed up?”

Both Aston and Skimwax are describing how peer networks carry into college. For them, the fact is that high school friends can offer support not only for curricular activities but add stability and emotional support. This may be especially the case for Skimwax, because unlike Ashton, the friendships he maintains from high school exist largely outside of CS. While he and his friends do take classes together, these do not appear to be major-specific classes — friendships provide emotional and school support.

Not all students come with social capital. Joe is a student who changed majors after his first interview. He did not feel he belonged in CS. Joe is a Latinx male with a rural upbringing whose parents had not attended college. He describes how his high school was not able to provide advantages equal to others who come from schools with more resources. He described lacking “...that sense of belongingness in the classes” because he felt “intimidated by other people because they have been to bigger schools and they had more opportunities, um, in learning CS”. He continues “while I came from a very rural

school where there really wasn't much opportunities so I somewhat kinda doubted myself. I was like "should I be here?"

Joe provides us with a good example of the durability of meritocratic expectations in CS for students who don't come in with technical experience. Taken in the abstract, Joe describes experiences that are associated with 'imposter syndrome' — he literally questions his place and belonging in CS and feels he is an outsider. When he describes his new major he emphasizes that there are more students "...like me… without lots of technical experience."

All of the above is not just a set of examples of connectedness or lack of connectedness. Students use socio-cultural resources to build social capital, and lack of resources is an impediment. Krackhardt and Friedman explain that one of the things that impedes building of social capital is the "tendency for people to interact with similar others, or homophily" which in turn creates a "natural and unintended barrier" between minority and majority groups (Krackhardt & Friedman 1997: 321). Joe is an example of someone who, partly due to these barriers, chose to leave CS.

Peer networks can sprout spontaneously, but existing networks and stability of expectations and assumptions that flow and follow from them exert an inertia that members can use to initiate and maintain them. Biscuit, a white, male middle-class CS student, summed it up well when he observed in classes and the tutor lab, people mostly pairing up with people they already know: "I don't think it was intentional to exclude

anybody. It's more just, this is who they know and they're not gonna change that." With the above, we can suggest that lack of intent and ignorance of effects is as much implicated in facilitating hegemony as is any intentional bias.

Gaming as a Gateway: Building Capital. Participation in computer games, or 'gaming,' is popular with young adults whether one is a technically-minded CS major or not. In interviews with CS students, we found that some technologies at the center of modern multiplayer online games play a supporting role in connecting people in unique ways during game play, and these connections extend to academic experiences.

A common example of this is the 'Discord' system. Discord is a networked software system through which dynamic voice and text interactions can be accomplished during gaming. Discord runs from servers that are hosted by gamers themselves. Setting up a Discord server is not difficult, and setting up a server puts one in a good position to gain some control over what one can do. For example, Robbie says, "I have like a Discord server where me and my friends play video games, so I invited them to that, and then, uh, we started working on our assignments there, and now we all play games together. Things like that."

So an interest in gaming led Robbie to install a software system (Discord) that facilitates collaborative action in games, and has in turn afforded connections to others sharing interest in games. This also made it possible for Robbie and others to communicate about both gaming and college studies within the same context. The relationship is not solely

centered on games, but now games and CS become part of the same online activity. This expands and reinforces developing relationships, with relationships now based on multiple common interests.

With the Discord system, it is now possible for members to do more than just participate in games because it has a social cohesion-building function. Another example Robbie gives is “when people were absent they'd send like a group [a group message] [...] we have a big server with like 30 or so people on it[...] someone would go in the School subchannel and message and say hey I wasn't in class today, what did we cover?” This demonstrates the ability to use Discord for multiple purposes (e.g., gaming and schoolwork) such that it reinforces a multi-faceted social network between members.

Robbie also describes that this enclave of gamers was selected by him, and that they are patient with his concerns for social justice. This group even occasionally serves as a sheltered place for him to “rant.”

This network is not fixed or closed, because new individuals can be added to the group, and individuals can leave the group. However, one has to know channels are ‘there’ to join. Channels and related peer networks are semi-private, and use of those channels is purposive to members while also pliable to immediate needs and interests.

The fact some CS students are gamers who have installed and run Discord servers makes this a sociocultural attribute shared by many of our informants. Games are a popular

pastime for many, and in this case the underlying technology of Discord affords a conduit through which games and CS subject matter are discussed at the whim of members. Robbie's Discord server allows him and his friends to shape their network so it facilitates what they want to do both in the moment and over time. While people can come and go from the server, Robbie reports that everyone he has invited into it has stayed and that newcomers bring new information, knowledge, and skills about CS, even while not all of them share the same personal history. Social capital is thus created for Robbie and his invited members as an outgrowth of their common gaming.

He explains "I have like a Discord server where me and my friends play video games, so I invited them to that, and then, uh, we started working on our assignments there, and now we all play games together. Things like that." When prompted for more information regarding inviting people to Discord, he goes on to state: "To do better on assignments, yeah [...] I mean we certainly help each other gain a better understanding of the material".

Gaming is an example of an intentional network formation. Robbie chooses who to invite and uses it to strengthen social capital. The people he invites are people with whom he shares classes and has noted they appear to be knowledgeable. He is looking to draw on their experience. In his latest interview we asked about demographics of the group. Robbie admitted that only one member is female.

What is interesting about this is that Robbie, unlike other many CS students, considers himself concerned with social justice, and in fact he has brought this up in other courses

that touch on content related to ethics in technology. In one of these the class explored issues particular to the fact that Facebook provided disparate access to advertisements — making them available to whites and not to women, ethnic and racial minorities.[7, 8] Robbie described how the instructor seemed to allow students to argue without any guidance or critical supervision. In a case focusing on the way Facebook placed job advertisements differentially depending on the sex of the subscriber, leading to claims of bias and violation of laws related to hiring practice, the 'discussion' digressed to the point where most class members fell silent out of — Robbie conjectured — an effort to keep out of the tense setting in which sex-based bias was topical. When Robbie argued that this was a violation of federal laws, he says that the most vocal individual in the class raised his voice to a near shout "...just because something is illegal doesn't mean the law is correct!"

When Robbie gestured to the instructor for guidance, he said the instructor "...smirked and shrugged," which he interpreted as siding with the shouter. The shouter's tactic is not unique — don't attack the empirical facts of the bias itself, but muddy the waters at a level of abstraction to create doubt and in turn make any kind of direct question

[7] https://www.nytimes.com/2018/03/27/nyregion/facebook-housing-ads-discrimination-lawsuit.html

[8] Note that Facebook subsequently agreed to comply with a court ruling to pay fines amounting to $5M USD for its culpability in this matter <https://www.telegraph.co.uk/technology/2019/03/19/facebook-pays-5m-claims-allowed-job-adverts-block-ethnic-minorities/>.

impossible (Sehgal, 2019). In response, Robbie was direct in describing how this has led him to feel ganged-up-on, and to rethink his pursuit of a computer science degree. He says "...I'm not even sure I belong [in CS] anymore…" — an expression perhaps analogous to that of Five in her previously described encounter with an instructor.[9]

The lack of pushback on the shouter came off as silent ratification of his position, and demonstrates that not being explicitly anti-bias is actually support for biased conduct. "Safety in silence" builds homophilic support that binds together those who remain silent. So, while Robbie is able to see bias in the abstract, and has first-hand experience of what it feels like to press against silence-supported-shouts — even if temporarily — he is still perhaps unaware of the ways in which unintentional network formation, including his own, may exhibit exclusion.

Boys in the Band: Solidifying Social Capital. Participation in marching band presented another common shared activity around which computer science students built homophilous networks. In our first interview, Schwinn — a first-year middle-class white male CS student — indicated that he joined the school marching band following his experiences in high school.

[9] Robbie remains a student in CS. We can say that he was noticeably buoyed when one of the co-authors of this paper told him about the court ruling against Facebook. He said it effectively ratified the position he took in that class, even if he did not receive any support for it at the time.

Schwinn also told us he is the first in his family to attend college. He emphasized that for him membership in band is not so much about music as it is the collaboration required to create the music and the marching formations. When asked if his social network within CS was similar to that in band, Schwinn laughed and stated "I don't know very many computer science students, actually — except those in band."

However, this changed dramatically by the time of our second interview only a few months later. By the beginning of his third semester, Schwinn had three housemates — one of them a CS major and two of them band members. The CS student was a member of band in high school. Schwinn's links to band and CS have come together in a way that now characterizes his living arrangement and through that arrangement his self-described social and economic stability. This has created a more tightly-knit social and scholastic network that affects principal facets of his current life.

For example, Biscuit (Schwinn's fellow CS student and housemate), was a member of band in high school. At the time they met, neither knew of the other's past or present participation in band, but when they met in instructor-organized learning teams, their in-class and out-of-class commonalities emerged. They first began sitting together in the study lab made available by the CS department, and eventually began interacting with each other outside of their study efforts. Through this, Biscuit became part of Schwinn's broader "band enhanced" network and they became housemates with two other students

studying music — all living and studying together in a cohort through current and past connections with band.

Band also provides support and being part of a community may make it more likely that someone may complete the program. For example, Schwinn makes a point to say "I think, um, probably the biggest thing would be the community that I'm in. Like, just the fact that I know so many people in the band is again a huge part of what's keeping me here is the band and um, I think the [...] CS program".

Female Networks. While male student's networks are based largely on existing networks that carried over from high school or created based on shared interests, female network formations appear different. Female network formation features some social capital in the form of emotional support and study partners, but simultaneously limits capital by insulating females from the predominantly male environment in CS.

For example, Books lives on a dormitory floor designated for engineering and CS students. The dormitory resident assistant is a faculty member in the College of Engineering, and there are regular planned activities built around students' common academic pursuits. Books describes herself as shy, but also admits her peer network in the dorm is 'comfortably large' and cohesive. Her peer network is also almost exclusively female. She describes "there aren't many of us" (i.e., female students in engineering and CS) and that a lot of female students in CS do not have the same personal history (i.e., cultural capital) with CS as male peers, such as all-night-long coding sessions,

long-duration-gaming-sessions, and support from parents or other family members who are engineers or computer programmers, and that *this dissimilarity from other, stereotypically 'normal' CS students* serves as a basis for their friendship and study partnerships. Books tells us that not being one of the stereotypical "normal" students in CS is a feature that binds them together.

When asked if it was the female-ness, different experiences in computer activities, or the relative lack of role models that motivated her attachment to this group she said, "...well, all of them. I mean, we're all different from the stereotypical CS geek,[10] and that difference makes us all the same — sort of." In this statement Books is describing how comfort, if not success, for "others" in CS is afforded by avoiding contact with the majority.

So we see how groups of gamer friends, or study partners, or dorm suite-mates, or housemates, coalesce around some common socio-cultural resources, or, notably, the relative absence of some sort of unified resource around the fact that they are studying CS. What we see here is that having the same pursuit (e.g., CS major) does not mean the group is <u>just</u> built around shared interest in the technical aspects of CS. One's

[10] In our interviews, the stereotype of "computer geek" appears to be fading even though it remains as a symbol. Increasingly, students are pursuing STEM careers because it appears to have good employment prospects and not because they are "a geek." Regardless, many students use the image of the person who eats, breathes, and sleeps CS as something against which they struggle.

sociocultural experiences can be seen as contributing to their identities and how they fit, what they have to do to find a way to fit, or what makes a fit impossible.

When one does not know of or happen upon groups such as that described by Books, large social gaps exist. Amsterdam — a female student of far-Eastern heritage — describes the difficulty in making connections when it appears that so many already have existing networks "I'm slowly — in the CS department — slowly getting to know faces, but I feel like everyone's already made pairs. [...] and then I'm just kind of like, I don't know where to go. I'm just gonna awkwardly cower here."[11]

Another issue female students face when they attempt to form networks with the dominant male group, is that their desire for networking is perceived as a dating interest. Alex — a white female student studying CS — speaks to this difficulty and having to be clear that there is no interest in anything unrelated to studies. Alex states that "it happens a lot" and "[...] in this specific degree, you're just [more noticeable] in general" and that "a certain stereotype of guys" that doesn't talk to or interact with girls often mistake a girl simply talking to them as liking them... I consider you a friend but that's it."

The experiences of Books, Amsterdam, and Alex demonstrate difficulties female CS students face when networking with the dominant group either because of a lack of

[11] Remarkably, this is not actually true! In a related research project we are not yet ready to report fully, we have discovered that a majority of CS students express only weak bonds to others.

belonging and feeling out of place in what are already established networks, or the potential of having study interests misconstrued. Additionally, the situation Five described above in which a professor singled her out for having a question, can be threatening and harmful to one's identity as a student and as a future professional. Five is the focus of a statement that could be interpreted as a simple fact, but by assuming expertise that is assumed to be met by all male students in the room, the instructor's comments carry the weight of gendered othering. This need not be the instructor's intention for it to be starkly apparent in context (for more examples focused on race, see Rankine 2019).

We find female networks are more protective in nature in they insulate from an unwelcoming environment and potential undesired advances or bias. However, a side effect of these insulated environments is that they also limit the amount of social capital women can acquire in the dominant male network. While this is in part attributed to women's choosing, as we can see from Book's experience, it's also due to exclusion by the male peers. Robbie is an example of someone who has built additional capital via the discord server, but by his own admission, this network is mostly male. As he plays an active role in inviting members to join, it happens that female students are often not invited. Gendered networks are perpetuated by both the male and female CS students but this arises for different reasons.

DISCUSSION AND CONCLUSION

Peer Networks Built Around Shared Experiences Have the Effect of Stabilizing and Supporting Norms

As indicated above, existing and new peer networks, hobbies, and extracurricular activities along with experiences in undergraduate CS classrooms are sociocultural factors through which individuals create, maintain, and grow collaborations, and also realize their potential fragility. Those networks and collaborations serve several functions. They are personal support systems, fluid avocational and study groups, and relationships that span personal, academic and even economic interdependencies. They further function to build on existing social capital and create new capital. In the latter case, new capital typically comes to individuals who already come with social capital.

In a way analogous to the possibilities realized in and through Robbie's Discord server and cohort of gamers and CS students, band was a common thread that ended up being a link through which Biscuit, Schwinn and friends from band formed a network. In both cases, these common threads of gaming or band were part of the shared-but-initially-separate sociocultural history for eventual friends, housemates, and study partners.

Uniquely, while Schwinn is the first individual in his family to attend college, by joining the marching band he immediately tapped into an existing social network. Joe — the

other first-in-family student in our informant cohort — did not have this opportunity to form connections. He cites this as one of several factors that led him to switch majors.

Different from Robbie's and Schwinn's, Biscuit's, and even Joe's experiences and paths, Books illustrates how the status of female CS students can be seen as a linking factor in a peer network. This has allowed Books and her cohort to have some of the benefits that come with a network — such as emotional support and study groups — but simultaneously insulates them from the dominant male environment and isolates them from the majority of their fellow computer science students. This protective networking thus both increases but simultaneously limits social capital. It also renders invisible their technical knowledge and skills from others.

In their isolation, Books and peers have a haven free from whatever they see as counter to preferred approaches to learning and success, and Robbie's gamer group affords protection from obtuse or pointed attacks inside or outside the classroom, against an inclination to social justice in CS. Skimwax and Joe and high school peers escape what they perceive to be an unhealthy concentration of competitiveness by being members with links outside of CS, and in so doing perhaps activate the spirit of inclusion and diversity at a scale that transcends the CS department alone. Schwinn, Biscuit, and their cohort connecting CS and marching band, and new members outside those groups, may find the same.

At the same time, even with the possibility of some form of escape, one may actually be playing into the normalizing and segregating aspects of those forces by intentionally avoiding them. Robbie admits to silencing himself in class, thus limiting his stated aspirations to be a social justice warrior. Doing so has the perverse effect of appearing to submit-to and ratify the shouters. Books and her friends may be countable as members of the whole body of CS students, even while they isolate themselves to protect their preferred enclave of interpersonal support and for learning together. Avoiding opportunities to point out acts of microaggression and other kinds of bias may not help overall, but it does build space between *that world* and the world they have created for themselves.

Curiously, separations and otherness that work against institutional interests in diversity and inclusion persist when individuals with diverse characteristics choose to be part of sub-groups hidden or separate from the whole. These groups appear both not to draw the attention of others, and by being present in the whole as members of underrepresented groups it is possible for many to see that there *is no overt contestation against the idea of* nominal, demographic inclusiveness. However, at the same time their enclaving does not contest their socialized and stereotyped ideas of what 'is normal' in CS.

In all the examples above, we see specific examples from our interviews with computer science undergraduates how peer networks form and stabilize around factors that include shared personal experiences. Sometimes these networks operate as conduits or pockets of

resistance and sometimes as a means to realize a localized opportunity that facilitates success for an isolated group, even though it might also strangely reinforce stereotypes.

Because we live in a world where socialized norms saturate every aspect of life, we should expect that forces existing in the worlds from which such peer networks arise will also be part of networks at college and in computer science — including forces that manifest in issues of bias, lack of inclusivity, and loss of justice for members of underrepresented groups in computer science. However, because these things may be part of what appears as *unproblematically normal* for majority members of these groups, even when those members accept our curricular efforts, we should also expect that members of these groups may not be (a) sensitive of them in their everyday lives, (b) able to identify what they signify, and (c) able to describe how such things are manifestations of particular hegemonic forces that themselves constitute a major part of 'the way it is'.

This occurs through many mechanisms, including a pervasive uncritical acceptance of those things to which we are accustomed, even if we use that acceptance as a reason to create subgroups that afford protection from those on the side of hegemonic bias. Books' girls-only group, and Robbie's boys/gamers group that is patient to his stated aspirations to be a social justice warrior, are two such examples. That is, where most people seem to dismiss anything someone might claim to be 'abnormal' about their 'normal world' by lazily referencing "that's just the way it is," we want to make it very clear that *'the way it is' is more appropriately considered to be 'the way we have allowed it to become.'*

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