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Pushout, Persistence, Pullback, and Resistance: The Unnecessarily Complicated Experiences of Women of Color in STEM

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The Unnecessarily Complicated Experiences of Women of Color in STEM

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Abstract

In this thesis project, I explore the unnecessarily complicated path of persistence for women of color in STEM. I find that these students are pushed out by the larger culture and climate of STEM which is hostile to their existence. However, there are students that are not pushed out but rather chose to leave STEM in favor of other academic pursuits. For students that do persist, the strategies they engage in order to persist are strategic and agentic. These students are aware that they must navigate STEM carefully. Within persisting, students also resist and push back against the dominant STEM culture, many doing so in hopes of changing the landscape for the next generation of women of color in STEM.

Dedication

This thesis is dedicated to the women of color in STEM that did not persist, for whatever reason. Know that the path of persistence for you in STEM is unnecessarily complicated; that you shouldn't have been put through the animosity, racism, sexism, and abuse and that you should have been appreciated for your talents as scientists and engineers. Even the most positive supports cannot battle the climate and structures in STEM designed to keep you out. I am proud of those of you who made the tough choice of pulling yourself out of the toxic environments and culture that plague STEM departments. That decision, which likely meant letting go of dreams and facing disappointment, is also a success. You did what you had to do to survive, move on, and thrive.

This thesis is also dedicated to the women of color in STEM who did persist and moved onto become STEM professionals, professors, teachers, leaders. I am proud of you for sticking to your goal and battling through the unwelcoming STEM spaces you likely encountered either as a result of your race or gender or both or other salient identities. I want you to know that you never should have been put through the microaggressions, abuse, and harm you endured just to complete your STEM degree. We do not just receive our degrees in STEM, we double major in surviving the disciplines. We should not have to do this, and I hope that one day we get to just do science without watching over our shoulders.

And lastly, this thesis is for my parents and my sisters. My parents quite literally crossed a river for my future and managed to raise three successful daughters in a country not designed for them. Now that I think of it, it makes sense two people who survived and thrived in a country unwelcoming to them raised a woman who survived and thrived at a college made to keep people like her out and in a field especially hostile to people like her. To my sisters, for whom I hope I have been a good role model, thank you for putting up with me. One of you told me once that it is not easy being my sister. Know that I love you and that you make me proud. I miss you every day since the day I left home for the first time.

Acknowledgements

I want to thank all of my educators. To my kindergarten teacher who saw a future astronaut instead of an annoying space obsessed 4-year-old. Thank you for nourishing the scientist in me. To my high school robotics advisors who mentored a shy freshman into an intelligent, strategic, outspoken, leader and engineer, thank you for setting me up for success in college.

To my professors at Swarthmore, thank you for being my security net, my guidance, and support system. You were critical in making sure that I did not fall through the cracks.

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To my physics advisor, David, thank you for standing behind me from the very beginning. We could not be any more different in the positions we hold as scientists, but you always used your power and influence to advocate for me. You went from ally to accomplice and that is exactly what I needed to persist.

To my physics research advisor, Cacey, the first woman of color and Black physicist I met and had the honor of working with. Thank you for trusting me with our experiment and really letting me blossom into a physicist. It was through our work that I regained the scientist confidence I had lost when I first came to Swarthmore.

Introduction

In this thesis, I examine the experiences of women of color (WOC) in STEM (science, technology, engineering, and math) during their undergraduate degrees. I define WOC as Black, Hispanic, Asian[1], and Indigenous women. There are two relevant bodies of literature on persistence in STEM: persistence of people of color and persistence of women. However, I specifically searched for pieces on the intersectional experiences of WOC because assuming that the experiences of people of color or women alone map directly onto those of WOC, marginalizes them even further. This is because it ignores the unique experiences of their intersectional selves and as a result of that, the intersectional discrimination and pushout they experience, often referenced in the literature as the "double bind" (Ong, 2011, p.176; Tate, 2005, p.484).

With this framework in mind, I reviewed the literature around how the STEM disciplines pushout WOC, how and when WOC choose to pullback, and what persistence and resistance strategies they use. I find that while WOC are actively pushed out of STEM, sometimes even before reaching college, others decide to leave STEM for their own self-preservation or to pursue other passions STEM cannot fulfill. I also find that some persistence strategies identified in the literature can, ironically, contribute to the pushout of WOC, such as misaligned mentorship. And finally, I find that WOC agentically and strategically employ different persistence and resistance strategies in order to ensure their success.

[1] Asian and Asian American women are not always referred to as minorities in STEM in the literature. Though they are minorities in the US population, they have higher STEM bachelor's degree completion rates relative to their percentage of the US adult population. For example, Alfred (2019) found that Asian men and women represent 17% of "science and engineering populations" when their working age population representation is only 5% (p.116). The majority of my sources refer to WOC as only Black, Hispanic and Indigenous women. Given the statistics, I understand why Asian women are not always considered minorities in STEM, but the fact remains that their non-whiteness makes their experience in STEM that of WOC.

I approach this project from an incredibly personal place. I am a double major in Astrophysics and Educational Studies at Swarthmore College. I am also a first generation college student, low income, Chicana, and the oldest daughter, sister, cousin, etc. in a first-generation Mexican immigrant family. I am fairly light skinned, so even now I struggle with the label of WOC, but at the end of the day I know my experience in STEM has not been that of a white woman. I knew the odds I was against when I decided to major in Astrophysics but did not think much of them as the stubborn, strong-willed, *chingona* my parents raised. Seriously, I decided to study physics in college because it was the one science in high school I could not understand.

However, I must admit that as these four years have passed by I have continuously thought about what it meant for me to persist in a discipline with some of the lowest numbers of WOC (Ong, 2005, p.596) and what it took from me. Primarily, I mourn the self-confidence I lost during my first two years as my abilities and intellect were seriously questioned by white male peers. This project, like my thought process, has also been an ongoing one, specifically since my sophomore spring. Back then I wrote a paper for my *Adolescence* class on the reasons why WOC and femme presenting people at Swarthmore left their STEM departments and examined them from a sociocultural and psychological framework (Olvera, 2019). In this paper, I conducted interviews with students at Swarthmore who initially chose STEM majors before switching to non-STEM majors. In my senior fall, for my *College for all?* seminar, I conducted a literature review on the reasons why college students choose their specific majors with a focus on the trends of women, people of color, WOC and low income students in STEM (Olvera, 2020). I learned during that review that WOC matriculate as STEM majors at rates comparable to their white peers. And yet, they have some of the lowest numbers in STEM degree completion. From personal experience and the stories told me during interviews for the *Adolescence* paper, I was

pretty sure I knew why. That then left me thinking, *what about the women who do persist? How do they do it?* That is how the idea for this thesis was born.

This thesis is organized in the following sections: Introduction, The Status Quo, Pushout vs Pullback, Persistence and Resistance, and the Conclusion: What now? In the Status Quo, I present recent statistics for WOC in STEM, the difference between the matriculation and persistence, and the frameworks and trends of overlap in the literature. In the Pushout vs Pullback section, I discuss what the literature has identified as factors that plague STEM environments that pushout and are unwelcoming to WOC and also when students themselves decide to pullback and leave STEM. In the persistence and resistance section, I discuss the strategies that WOC used to successfully finish their STEM undergraduate degrees with a focus on how they agentically and strategically employed these strategies as forms of resistance and to counter some of the emotional, physical, and mental costs of persisting in STEM.

I weave in my own experiences throughout this piece. It almost feels irresponsible of me not to share. I also think it adds a missing voice to what all the ethnographic studies I looked at attempted to do: investing in research on WOC in STEM and letting the voices of these students be heard. Some of the ethnographic pieces I reviewed worked on a constructivist grounded theory methodology (p. 215) like Ong et al's (2018) piece on counterspaces. Though many articles were written by women or WOC authors, I do not believe I encountered one where the authors themselves had the firsthand experience of being a WOC in STEM. This is the unique lens I bring to this research.

The Status Quo

In this section, I review the current numbers of WOC in STEM, the current climate and culture of STEM, the difference between the matriculation and persistence of these students, and frameworks used in the literature as well as common trends.

Women of Color in STEM Today

There is no doubt that WOC today hold significantly fewer STEM degrees and jobs compared to their relative makeup of the US population (Alfred, 2019, p.215). According to an NSF dataset from 2014, only 13.3% of science and engineering bachelor's degrees were awarded to WOC, far less than the 21.9% of the US population aged 18-24 (typical college age) they make up (Ong, 2018, p.207). At the doctoral level, WOC hold only 10.6% of STEM degrees (Wilkins-Yel, 2019, p.51; Ong, 2018, p.207). It should be mentioned that although "Asian American women may hold STEM doctorate degrees at a disproportionately higher rate than their respective US population, they are the lowest represented demographic group in academic tenure" (Ong, 2011, p.180). The statistics produced two important insights to further understanding the state of WOC in STEM. First, Asian American women are often left out of the WOC label because of their "overrepresentation" and likely their model minority status. Second, the further WOC climb through STEM higher education, the fewer and fewer of them persist.

During this statistics review, it also became clear that some fields are worse in their retention of WOC than others, particularly physics, computer science, and engineering. Between 1995 and 2001, only 1.5% of physics bachelors degrees went to Black women while only 0.6% went to Hispanic women (Ong, 2005, p.596). Both Lathem et al and Vasquez-Grinnell found that only 9 to 11% of engineering professionals are women, with the numbers of WOC just a fraction of the total. Hodari et al found that only 7% of all computing degrees were awarded to WOC

(Hodari, 2016, p.58). Regardless of the field, the number of STEM degrees awarded to WOC is not congruent with their makeup of the population. In the next section, it will become clear why.

The Current STEM Climate and Culture

Both my paper on why WOC leave the STEM departments at Swarthmore (2019) and my review of why students choose STEM majors (2020), in congruence with the literature review of this paper, found that the climate of STEM today can be largely described as "chilly" and generally unwelcoming to WOC. The "chillyness" is due to various factors including "...gender and racialized microaggressions...shown to delegitimize women of color's credibility, competency, and belongingness in STEM" (Wilkins-Yel, 2019, p.52), weeder classes, overt and covert messages of not belonging and exclusion, inflexible major requirements (Olvera, 2020, p.15), discrimination, isolation, culture of "old boys club" (Alfred, 2019, p.124), banking pedagogy and unapproachable professors (Espinosa, 2011, p.214), and individualistic culture just to name a few. These conditions negatively affect the identity development of WOC in STEM, particularly their scientist identities, during a time in which students are already doing heavy, critical identity development (Hodari, 2016, p.60; Olvera, 2019, p.10). Because of their intersectional identities, WOC in STEM face "multiple systems of oppression" (Ong, 2011, p.182) given that the fields have never been friendly or accommodating to people of color, women, dis/abled people, and other marginalized folks.

However, it is important to mention that not all undergraduate STEM departments are the same. Several pieces of the literature find that historically Black colleges and universities (HBCUs) and minority serving institutions (MSIs) have particularly high numbers of WOC bachelors graduates in STEM (Ong, 2011, p.183). These departments succeed in graduating more WOC in STEM because they were "...[open] toward alternative routes into the major, a

lack of stigma for remedial coursework, high expectations for student success, and a supportive and healthy relationships between students and faculty" (Ong, 2011, p.183). These departments are what the other STEM departments are not. Though I have personally had a relatively positive experience in my predominantly white institution's (PWI) physics department, that is not the case across the board. For example, Ong (2011, p.191) found that African American women who did their bachelors at an HBCU struggled during their transition to graduate programs at PWIs. Based on my findings, PWI STEM departments are more likely to promote the chilly climate.

Matriculation vs Persistence and the Myth of the Missing Women

Given the low numbers of WOC completing STEM bachelors degrees, it might be surprising to learn that they often matriculate as STEM majors at similar rates as their white counterparts (Olvera, 2020, p.16). For example, Vasquez-Grinnell's (2019) literature review found that 32% of WOC enter higher education with an interest in pursuing STEM degrees which is comparable to the 31% of their white peers that also planned on pursuing STEM (p.9). And yet only 10.6% of STEM undergraduate degrees go to WOC. This discrepancy is often explained away with the myth that WOC "are just not interested or capable" of doing STEM. I heard it in my own department when a slew of positions opened up during my freshman and sophomore years and few WOC candidates appeared in the final rounds. This myth is sometimes referred to as the "leaky pipeline" (Hodari, 2016, p.59). The danger is that this myth blames all WOC who leave STEM for their own departures when really many are pushed out by their institutions. This myth also positions WOC as powerless victims against their pushout of STEM (Hodari, 2016, p.59) which in my experience could not be further from the truth and only marginalizes them further. The reality is that due to the climate and culture described above, WOC are siphoned out of STEM very early on such that their numbers decline between the

bachelors and doctoral level as previously stated. It is especially clear in the case of Asian women who have high STEM bachelor's degree attainment but the lowest numbers in the STEM professoriate.

It is important, therefore, to distinguish between matriculation and persistence (Olvera, 2020). While a lot of the literature on student major choice reports positively about the high numbers of freshmen WOC and other marginalized students declaring STEM majors, these studies do not look at completion numbers. This leads to an incomplete picture about how students ultimately decide on their majors and often makes it seem like a totally individual decision when there really is a fair amount of pushing out students on behalf of institutions and the STEM academy. If we really want to increase the numbers of WOC in STEM, we need to focus on the factors of persistence and non-persistence rather than just entry numbers.

A Disturbing Narrative

One of the strongest critiques I have of this body of literature is the narrative they use to justify why we should do more research on WOC in STEM and invest in their retainment. The narrative is two-fold. First, invest in STEM WOC so that their innovation and intelligence can lead to their own self-improvement and that of other marginalized communities. Second, investing in increasing the numbers of WOC in STEM is necessary for the US to move forward in globalization and stay at the forefront of technological and scientific advancement. It is the second part of this Narrative that really disturbs me and makes me mad. Authors use words like "untapped human capital" and "underutilized" (Ong, 2011) to describe why we should invest in STEM WOC. And though they might be true, what disturbs me about this, is that this kind of language is extractive and exploitative of an already marginalized group of people and reduces them down to what they can produce. Further, last I knew, none of my white male counterparts in

physics were expected to take on the burden of improving the US's global technology and science status. They just get to do physics, for the sake and challenge of doing it. Instead, WOC are entrusted extra responsibilities in addition to their coursework. This should not be the expectation for WOC in STEM.

Theoretical Frameworks

Below is a brief synthesis of the theoretical frameworks used by authors in this review. Starting with intersectionality and critical race theory (CRT), which are two of the most common frameworks in this particular body of literature. Critical race theory comes from critical legal scholarship and "examines phenomena in society and culture by applying a critical analysis of race, law, and power, to expose how racism exists presently and historically at the institutional level" (Ong, 2018, p.211). Intersectionality descended from CRT to examine how different and intersecting identities experience oppression (Alfred, 2019, p.119). Ong (2018), Wilkins-Yel (2019), Olvera (2020), Alfred et al. (2019), and Vasquez-Grinnell (2019) primarily use CRT and intersectionality.

The most common frameworks used by the scholars in this review are social identity development including fragmentation and multiplicity and socialization. Fragmentation and multiplicity are explained in detail in the *persistence* section. Social identity development is the theory of how identities are formed by an individual through their interactions with social groups. Alfred et al. (2019), Espinosa (2011), Hodari et al. (2016), Lathem et al. (2016), Ong et al. (2005), Olvera (2019), Reyes (2011), and Tate & Linn (2005) use some variation of social identity development theory to examine the experiences of WOC in STEM. All the frameworks mentioned largely map out onto how I analyze these issues. The main difference is that within intersectionality I often also consider socioeconomic status (SES) alongside race and gender.

Pushout versus Pullback

The factors that explain the low representation of WOC in STEM are "complex and multidimensional." (Alfred, 2019, p.210) because *we* are complex and multidimensional and intersectional. In this section, I explore all the factors responsible for the pushout of WOC in STEM. Following this, I include a discussion about when WOC are not pushed out but rather decide to pullback from the disciplines themselves[2], since these decisions also impact the attrition of WOC from STEM fields. The factors discussed in the pushout are: treatment of WOC before college, STEM culture, lack of connection and support (peers and mentors), lack of support for WOC STEM identities, stereotype threat and imposter syndrome, and family expectations and support. The factors discussed in the pullback section are: discovering non-STEM learning and career goals and discovering their identities do not align with STEM. My argument here is that WOC are sometimes agentic in deciding when to pullback from STEM while others are actively pushed out. However, both groups of students experience negative treatment in STEM because of their intersectional and multidimensional identities.

Pushout

Treatment of WOC before college

Like for many other students of marginalized backgrounds, the pushout of WOC in STEM starts early on in their educational journeys. I determine that the pre-college pushout happens through two avenues: socially and academically. The social aspect of the pushout is closely tied to the criminalization of these students through what most of us know as the school to prison pipeline or nexus. It has been shown that students of color routinely experience punitive school "discipline" measures at higher rates than white students. The book and film *Pushout:*

[2] This was a finding that resulted from my 2019 paper on why WOC left the STEM departments at Swarthmore for non-STEM departments.

The Criminalization of Black Girls in Schools by Monique Morris (1972, 2020) tells some of the stories of Black girls being pushed out of the education system. We have all seen the horrifying headlines of adults calling the cops on 5 and 6 year-old little Black girls in school for throwing a tantrum. According to a report by the NAACP 12% of all African American girls in public K-12 were suspended in 2014 (Alfred, 2019, p.122). When the girls miss school, they fall behind, only to be blamed and reprimanded for falling behind, and therein a cycle begins. From early on in their childhood, these Black girls and other girls of color are told that they do not belong in school. How could we ever expect for more of them to persist in such hostile environments?

Even girls that are not pushed out socially can be pushed out academically through the practice of academic tracking. Academic tracking is the practice of siphoning out students into different academic tracks like AP, honors, regular, and remedial on the basis of their standardized test scores, GPAs, and other academic measures[3]. Tracking contributes to the leaky pipeline of WOC in STEM as "future interests in STEM fields are thwarted because of [early] tracking decisions" (Alfred, 2019, p.122). For example, tracking decisions could place a student in the regular track with no access to STEM electives. Girls of color often do not get to explore STEM, because that door is never opened for them. And then, even for girls who do make it to college with a STEM interest, many are academically siphoned out later due to "deficits of prior knowledge" (Neumann, 2016, p.151).

The "deficits of prior knowledge" and lack of academic preparation can be tied to a student's negative school experiences, both social and academic, alongside other obstacles they may face due to other intersecting identities like SES and parental involvement. For example, for the first two years of my physics coursework, I always felt behind and routinely did terribly on

[3] Research has shown that many standardized tests are inherently written to be racist and classist. Academic tracking itself is also racist and classist. Using standardized tests to determine such academic track placements says nothing about a student's true intellect and ability.

exams, once scoring a 2/15[4] on a multiple choice test. I had many conversations with peers that involved a lot of "Oh, I did this in high school...Yeah, I did it in AP…" And yet, I once tutored a WOC in physics who had only seen [5]*F=ma* for the first time in college. Though it was not her fault that her high school did not teach physics, she paid for it. Finally, during junior year I caught up on material while everyone else hit a plateau. One of my professors told me this was because we had finally started learning physics you would only encounter in college. The playing field had finally leveled, but it did not remediate the mental turmoil I endured those first two years and all the confidence I lost in the meantime.

I took a very linear, traditional 4-year path into STEM. However, due to their affordability, flexibility, locality, and convenience, many WOC start their undergraduate STEM careers at community college (Vasquez-Grinnell, 2019, p.50-51). Reyes (2011) did a study on WOC in STEM at a community college before they transferred to the University of Arizona. Among the usual barriers WOC face in STEM, these women faced additional barriers as transfers including: transfer shock, "subtle and explicit discrimination" (p.252) not only due to their race and gender but also age and immigrant status, and lack of campus capital. These WOC thrived at their community colleges. By the looks of it, they had managed to circumvent the pre-college academic pushout until they transferred to 4-year institutions. This points to a larger trend that 4-year colleges might be more responsible for the pushout of WOC in STEM.

Girls of color are not just pushed out of STEM before they get to college, sometimes, as in the case of many Black girls, they are often pushed out of the educational system altogether. And for WOC who manage to persist through to community college, a new series of barriers arises, starting with the culture of STEM at four year institutions.

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[4] Yes, you read that correctly. A 2/15. I could have scored higher just by guessing.
[5] This Newton's first law of motion, where the force (F) exerted by a body is equal to its mass (m) times its acceleration (a).

STEM culture

Many of the authors in my review found that the academic culture of STEM in US universities was made for and caters to stereotypical white, male identities. This is really a historical pattern as western science, which dominates US STEM curricula at every level of education, arose first as the hobby and pastime of rich Europeans with too much (stolen) money and time on their hands. And since STEM was not made for us, "WOC in STEM confront a myriad of systemic barriers resulting from an academic culture reinforced by elite, White men as authoritative, determinist, and with pretense to objectivity and neutrality" (Espinosa, 2011, p.212). Consequently, this culture leads to "outright hostility, harassment, discouraging interactions and verbal abuse" (Neumann, 2016, p.139-140). Sometimes, these barriers are even a stronger pushout factor for WOC than other tangible barriers one might think would be more impactful like financial aid or recruitment (Ong, 2005, p.600).

As I conducted my literature review and reflected on my own experiences, I started formulating my own definition of STEM academic culture. I found that it is a culture that values meritocracy; is collaborative but cutthroat; is sexist, ableist, and racist; and strives for objectivity, neutrality, and the truth. Collaborative, meritocratic, neutral, and objective do not sound like bad qualities, but it is the way that they are employed in STEM that turn these traits into barriers for WOC. For example, collaboration is generally a good thing, and the world of scientific research necessitates it, but it also ends in situations where gender or race (or both) minority students go uncredited for their labor. For example, astrophysicist Jocelyn Bell Burnell, a white woman, was the first to discover radio pulsars. The Nobel Prize for this discovery went to her white male thesis supervisor and his white male colleague, completely snubbing her. On a totally different scale, my brilliant friend, a WOC in computer science, told me about her terrible lab partner who

routinely did all the labs himself ahead of time and refused to listen to her recommendations because he did not trust her abilities. The current STEM culture positions white men, like my friends' lab partner and Bell Burnell's advisor and colleague, as neutral and objective, recognizing their authority and legitimizing their science identities while denying WOC theirs.

Another problem with STEM culture is the idea of meritocracy which is rooted in white supremacy. Meritocracy "ignores the social realities of racism and sexism in science environments" (Ong, 2011, p.183). These are realities that WOC confront every day when because of sexism and racism they are often excluded from collaborations (research or study groups) or arrive at their programs academically under prepared due to the quality of their previous education access, both factors that affect students academic performance. The idea that STEM is meritocratic is totally antithetical to the way it functions with practices like weeder and gatekeeper courses, grade curves, and survival of the fittest mentality (Reyes, 2011, p.249; Espinosa, 2011, p.214; Vasquez-Grinnell, 2019, p.63-65). The culture of STEM is an oxymoron that struggles to accommodate non-stereotypical scientists, including WOC, because it was founded on their exclusion.

Lack of connection and support (peers and mentors)

Another major factor that drives the pushout of WOC in STEM is a lack of connection and support. Though it can be argued that it is up to students to seek support and make connections, it is not always that easy for WOC in STEM. For example, I found in my 2019 study that WOC found it hard to connect "due to feeling like they cannot relate to their STEM professors both because they are often not like them in their identities and because there is no room to really get personal and connect with them." (p.6). The women in my study felt like they had to compete with other students for help and attention and complained of large and

impersonal classes where the professors were unapproachable. This was not an uncommon critique of WOC (Espinosa, 2011, p.214; Reyes, 2011). This kind of lack of connection is not always due to professors overtly refusing to support or care for WOC. Professors cannot help that they have 100 students in each section of a class and may not always be educated enough to know how to support STEM students like WOC, especially if they do not share any identities.

However, sometimes faculty do refuse to support WOC outright. I have myself seen fellow WOC in STEM on Twitter talk about how bad their reviews on applications are compared to those of their peers. In fact, it has been shown that "...in rating NSF (National Science Foundation) fellowship applicants, faculty systematically gave lower assessments of minority women relative to those of their White and male counterparts" (Ong, 2011, p.194). Another example of faculty refusing to support WOC can be recommending that students not apply to certain graduate programs. One could argue this could be coming from a place of care and concern in trying to save the student some disappointment and might even be something a *good* mentor would say. However, what this really communicates to the student is that their advisor does not believe in them or their abilities, which can be demoralizing.

Whether intentional or not, this lack of support and connection leaves WOC further out in the open, "Vulnerable to harassment and discrimination...and [they] must contend with isolation, marginalization and racialization" (Alfred, 2019, p.124). Personally, I know that if it was not for my professors like Cacey and David (see acknowledgements), I would not have persisted.

Lack of support for WOC STEM identities

Another set of pushout factors fall under the umbrella of lack of support for WOC STEM identities. These factors fall into two categories: the psychological lack of support for developing

STEM identities and messages of exclusion and lack of belonging. The messages of exclusion and lack of belonging contribute to the lack of support for developing STEM identities.

The development of social identities such as race and gender identities is a lifelong ongoing psychosocial project, one that is especially salient in college (Olvera, 2019, p.6). STEM identities can be thought of as another kind of social identity. In order for one to be considered an engineer for example, one has to feel like it (psychological) and also be accepted by other engineers as one (social). Ways of developing these STEM identities go beyond acceptance in the classroom. Espinosa (2011, p.230) and Hodari (2016, p.60) found that WOC who participate in research internships, STEM clubs, and conferences were more likely to persist than those who did not. This is because their STEM identities were validated through their work at internships or by others in the STEM community. If these identities are not nurtured and validated the way other social identities are, WOC do not persist further along the pipeline (Alfred, 2019, p.117).

It is also worth mentioning that when WOC STEM identity development is not supported, these women not only often do not persist, they also lose self-confidence. The women engineers in Neumann's study recounted that, "Their experiences as engineering and science majors cause a significant drop in their confidence level their first two years of college" (2016, p.144). I also experienced confidence loss in my first two years. Thankfully, I had the unique and powerful experience of building my own granular physics experiment from the ground up the summer after my sophomore year. Granted, I had the privilege of easy access to several paid research opportunities at my college and surrounding institutions with professors who were willing to take me under their supervision. Though I will not be in a physics PhD program come Fall 2021, if it was not for my advisor, a fellow WOC, who trusted me as a physicist enough to let me do whatever I wanted with our experiment, I do not think I would have recuperated from

those first two years. All I had felt during those first two years was the judging gaze of a group of white men in my cohort who sent subliminal messages of not respecting me as a fellow student. I was able to regain confidence through doing research because I was able to show myself and everyone around me, I could do physics.

Messages of exclusion and alienation are other ways in which WOC's identities are not supported. These messages come in many forms including: macro and micro aggressions, being isolated from the dominant group, and hyper/in/visibility. Because of their gender and race, WOC are subjected to a double burden and "judged by the standards of femininity and scientific competence" (Ong, 2005, 599) which are at odds under the current STEM culture. For example, being assertive might be unappealing as a woman per the standards of the patriarchy but necessary in order to be taken seriously as a scientist (Neumann, 2016, p.142). When stuck in this double bind, it is easy to see why many WOC depart.

Throughout my review, there were many recounted instances of macro and micro aggressions against WOC. There were of course sexist and racist remarks like comments made to WOC grad students about finding husbands in their lab (Wilkins-Yel, 2019, p.56). Then there are more subtle microaggressions, "institutional microaggressions" (Ong, 2018, p.210) like how STEM often dismisses the lived experiences of WOC (Wilkins-Yel, 2019, p.55), embodied and cultural knowledge for the empirical and experimental. And then there are not so subtle microagressions, as described above. Another common example is how people do not listen WOC until a white man repeats their statements, sometimes word for word. Basically what these micro and macro aggressions signal to WOC is that they are not valued, appreciated, or even needed. These micro and macro aggressions "instill a sense of self-doubt" (2011, p.251) in WOC which further delegitimizes their STEM identities.

Because there are so few WOC in STEM, many of us experience being "the only one" often. This lack of seeing others like you further complicates the process of developing a STEM identity because there are often no easily accessible examples of people to follow. Being the "only one" creates a superposition of both being easily overlooked (invisible) while also constantly being under the microscope (hypervisible). And we only know what state we occupy depending on who is or is not watching us and how, much like Schrödinger's cat, half dead and alive until someone opens the box[6]. The hyper/in/visibility is due to the fact that WOC are at all times seen as representatives of both their race and gender (Wikins-Yel, 2019, p.52). Because STEM has been historically exclusionary to both people of color and women, it is evident why WOC are overlooked. On the other hand, those that persist and progress further up the STEM pipeline, become hypervisible by nature of being the "only one" or one of the few.

A student's STEM identity develops if both the individual and their peers validate that identity. For in/hyper/visible students like WOC, obtaining the acceptance of the ingroup is a difficult task. Ong (2005) describes the ingroup as a club that has membership which is "ongoing, complex, and [an] embodied cultural process" (p.602). If invisible, the WOC are just overlooked. If hypervisible, they may not be desirable to the group because "part of being a minority is that people don't want to work with you" (Hodari, 2016, p.62). A common example that came up in the literature of how this membership is negotiated was the idea of study groups. Study groups are particularly important in STEM as a lot of the work in STEM like labs and long problem sets require you to work with others to perform well.

I remember a distinct experience, sophomore spring when our quantum physics professor gave us group tests, and you chose your group. A group of 3 or 4 white men I perceived to be the top academic performers took the exam together. I sat at the table with the only 3 other people of

[6] If you know any physics or sci-fi, I hope you got that reference. If you don't, Google it.

color in the class and took the test together. We got a higher score than the group of white men. A year later, our junior spring, when our cosmology professor gave us a group test, I took it with *that* group of white men. The group I worked with a year before either dropped the major or was not in cosmology with me. I should not have had to negotiate my status as a valuable group member to the white men, but at that moment I knew they had finally accepted my membership to the ingroup.

At the end of the day, my identity as a physicist was eventually legitimized by myself, through my research experience, and through my peers who eventually started coming to me for help, after battling covert and overt messages of exclusion and not belonging. However, this is not the experience of all WOC in STEM, as clearly evidenced by the "leaky pipeline." The problem is not the WOC; the problem is that STEM does not care enough to nurture the STEM identities of WOC. One such solution is to set aside research internships specifically for WOC students or for professors to connect their WOC students with their colleagues when they may not be able to provide research experiences or relate to students as well.

Stereotype threat and imposter syndrome

Stereotype threat and imposter syndrome also contribute to the delegitimization of WOC STEM identities and are driven by messages of exclusion, isolation, and the treatment of WOC by the broader STEM culture. Stereotype threat occurs when someone is aware of a stereotype that applies to them which causes anxiety for the person out of fear that they may confirm the stereotype. The anxiety and fear can then actually lead to the person confirming the stereotype (Neumann, 2016, p.142). There is a commonly cited study in the literature about two groups of women who were given a math test: one group was asked to identify their gender before starting

the exam, the other was not. Can you guess the stereotype? And can you guess what group of women did better on the test?

Stereotype threat compounded with the chilly climate of STEM can lead to WOC experiencing imposter syndrome. Vasquez-Grinnell (2019) found that "Imposter syndrome leads to feelings of anxiety, depression, burn out, and other effects that can impact the persistence of [WOC] in STEM fields." (p.110). WOC can experience gender and race stereotype threats separately or compounded. Whether race or gender stereotypes are a bigger threat to students can depend on the demographics of their departments. For example, at an HBCU or MSI STEM department, gender stereotype threat might be a bigger concern for WOC if they are surrounded by most/majority students of color. In the literature, I found fewer examples of WOC experiencing race stereotype threat than gender stereotype threat. However, when it came to micro and macro aggressions the occurrence rate seemed to be relatively equal between race and gender aggressions. The most frequent race stereotype students encountered were faculty "expressing low expectations of the abilities of students of color" (Reyes, 2011, p.245).

On the other hand, there were several recurring stereotypes regarding the gender identities of WOC. These included how science is not for women and how femininity and womanhood are at odds with science. The latter was briefly mentioned earlier and has to do with how women being assertive and defending their work and themselves, a quality valued in a scientist, does not seem "ladylike" (Neumann, 2016, p.142). However, the stereotype that women do not belong in STEM seemed to be the most damaging if the girls and women believed it. Neumann (2016) found that "women who believed in gender stereotypes and thought of themselves as more feminine did not persist as science or engineering majors" (p.141). The stereotype threat WOC encounter makes it hard to persist because it further questions their

STEM identities, which are already scrutinized. For some, the effects of stereotype threat and imposter syndrome are enough to push them out.

Family expectations and support

Lastly, families of WOC can sometimes also contribute to their pushout. This factor manifests itself in two ways: through WOC having their own families and through interactions between WOC and their families back home (their parents, siblings, etc.). In the case of the WOC having their own families, the problem is that society expects them to be able to raise a family and be a successful scientist at the same time while not asking the same of men in science (Alfred, 2019, p.125). STEM, like many other fields, is not accommodating to working moms and matriarchs. Ask any WOC professor, and they will tell you that they are judged more harshly than their white male peers both as scientists and parents. The other aspect of family as a pushout factor is when families of WOC back home do not understand or even discourage students' STEM aspirations because they too have been signaled by society that STEM is not for their WOC children. Sometimes families do not understand the demands of STEM coursework (Ong, 2011, p.186; Reyes, 2011, p.246 & 254) and why their students cannot come back home early to help babysit or pick up more hours at a job to help the family. Though family is certainly a motivator for students, it can sometimes be another obstacle because of how STEM is structured.

An examination of the most prevalent pushout factors in the literature illustrates how unnecessarily complicated it is to just exist as a WOC in STEM. It also helps explain why the current intervention and retention initiatives for WOC in STEM are structured the way they are. Ong (2018) characterizes these initiatives as deficit model based where the students are seen as broken when in fact the problem is the academy and the institutions (p.208). Instead of characterizing the WOC as victims and "dropouts" we must listen to why they were pushed out

or how they persisted because out of that will come initiatives that will hold institutions responsible for their pushout of WOC and hopefully improve the climate for the next generation of STEM WOC.

Pullback

What I call in this section, "WOC pulling back from STEM" others might just consider "dropping out." The word "dropout" insinuates that the WOC did not "try/work hard enough" which could not be further from the truth. It also insinuates a passive stance on behalf of students which again could not be further from the truth. Clearly, as the pushout section illustrates, regardless of how hard any student works, there are still many institutional and systemic barriers that bar their entrance and persistence in STEM. Further, because I have seen and experienced firsthand the isolation, abuse, racism, and sexism that comes with being a WOC in STEM, I consider the decision to leave an agentic one, rooted not in persistence but rather in the need to self-preserve and follow a path more fulfilling.

The existing literature includes very little about WOC leaving STEM on their own except for my 2019 paper. I also want to acknowledge that the decision to pull back is never a simple or easy one. The pushout factors are always acting. Some WOC are just proactive and intentional about when they leave, perhaps waiting until they find another course of study or after getting enough credits for a STEM minor rather than a full major.

Discovering non-STEM learning and career goals

In my 2019 study on why womnxn and femme presenting people of color leave the STEM departments at Swarthmore, I interviewed 6 people who had enrolled and persisted as STEM majors for at least one semester before switching into non-STEM majors. I approached this paper under the assumption that all of these students had been forced out of their respective

departments, so it was enlightening to find that some students left STEM because they simply did not enjoy it and found other academic pursuits. Even for students who felt supported by their STEM faculty and peers, like Angie[7] who left biology for studio art after taking a gap year (p.8), the desire to pursue other interests had finally won over all the other factors that had originally motivated their STEM decisions. Several of them "[realized] they had gone in only for familial pressures" (p.5), under the lure of prestige and job security. Kacey for example had been pushed towards Biology and Chemistry by her mom who desperately wanted Kacey to go to medical school. Kacey tried sticking with some sort of STEM, a minor even, until her junior year before finally switching fully over to her other major, Peace and Conflict Studies (pg.8-9). Her reason for leaving was simply that she enjoyed Peace and Conflict Studies classes more than STEM courses and also performed well in them. This aligns with what Espinosa (2011) found in their study about WOC reporting satisfaction in their coursework, but only after switching out of STEM (p.230).

At the same time, these students were performing the heavy identity development work that occurs in emerging adulthood. This helped them discover their intellectual interests as well as redefine their career goals. Kacey, for example, actually wanted to become a physical therapist (a field which draws on STEM content and skills), but did not find Swarthmore STEM departments to be very helpful for non-PhD aspiring students like her. Another student, Dani, switched from Chemistry to Psychology and changed her original goal of being a doctor to becoming a social worker (p.11). Dani discovered that her goal was to use her talents to help people, and she realized she could do that in other careers outside of medicine. Women like Kacey and Dani routinely leave STEM on their own after discovering new interests and goals.

[7] All students in this study have been given pseudonyms.

Rather than try to push through coursework they do not enjoy, at the risk of disappointing family and themselves, they make the choice to leave.

Discovering their identities do not align with STEM

Womxn in my study doing identity work during college that eventually led to their departure also discovered their own personalities did not align with STEM culture. For example, Joceline, who switched from chemistry to political science and education, recounted that she left because she just did not see herself sitting at the bench alone doing chemistry. She wanted to work with people instead of being isolated off in a lab somewhere (p.11). Angie liked that in their new major, studio art, they could use their work to explore their identity more (p.12) and weave in their subjective and embodied knowledge, something their biology coursework did not leave much room for.

Regardless of how the womxn and femme people came to their decision to leave STEM, none of them regretted their choice (p.12). This supports my claim that leaving is not always a pushout process but an agentic choice to pullback. I argue that in this case the self-preservation these students were after was to nurture their newfound interests and developing identities which were no longer being nurtured and supported in their STEM environments. Of course, like other WOC in my review, these students experienced their fair share of pushback factors, again illustrating that the experiences of WOC in STEM are complex and multidimensional.

Persistence and Resistance

In this section, I write about the strategies WOC in STEM use to persist in the disciplines and, in some cases, to resist the dominant STEM culture. I group the resistance and persistence strategies based on how they were presented in the literature, but that does not mean there is no crossover. Underneath these strategies lies the strong will and determination of WOC to persist and perhaps change their STEM environments for the better.

As with the pushout and pullback section, this section is not an exhaustive list of all possible persistence and resistance strategies of WOC in STEM. The first part of this section discusses persistence strategies present in the literature which include: choosing safe and nurturing environments, building supportive relationships with mentors and peers in and outside their fields, participating in research programs, institution type, culturally relevant pedagogy and curricula, gender and racial passing, and support of family and community. Following this, I write about when persistence strategies can be misused by people around the students and function as part of the pushout scheme. This section concludes with a discussion on the resistance strategies WOC in STEM employ which include: self-isolation as self-preservation, existing as a different kind of scientist, strategic use of stereotypes, existing outside of STEM, finding motivation in challenges, and being activists.

The ways WOC employ these strategies is entirely agentic, which counters the narrative that WOC are just passively existing in STEM. Since the WOC employ such agency, there is a lot of back and forth between how they use persistence strategies as resistance modes and vice versa.

Persistence

Choosing safe and nurturing environments

Seeking out safe and nurturing environments to work and learn in is a persistence strategy deployed by WOC in STEM in two primary ways. In the first, WOC seek STEM departments and institutions with reputations for treating well and retaining WOC students. Second, regardless of how supportive their departments and programs are, WOC create safe refuges within and outside their STEM environments. Often the creation of these spaces is triggered by how un/supportive the programs students attend are.

As WOC start their college STEM careers, Ong found that many choose undergraduate programs with the most possible diverse student bodies or those that felt like a "family" (Milli, 2019, p.186). I can definitely attest to the strategic choosing of a program that would give me the best chances at persistence. When I was choosing my college, I specifically looked for small liberal arts colleges that had accredited engineering programs because I wanted a small, supportive community. For the WOC who did not have supportive and nurturing environments in their undergraduate programs, Ong found that it was important to them to choose graduate programs with better rates of graduating WOC and other minority students or programs with good advising reputations (p.186). The role of the advisor and the importance of their mentorship increases in graduate school because of the curricula of a PhD, where students typically spend 2 years taking courses before spending 3-5 years doing original research under the supervision of their advisor or doing research for their advisor's projects to use as the subject of their thesis.

Regardless of how supportive their programs are, WOC often find themselves building their own safe and nurturing refuges in and outside of STEM, otherwise known as "counterspaces" in the literature. Counterspaces are defined as:

> ...academic and social safe spaces that allow underrepresented students to: promote their own learning wherein their experiences are validated and viewed as critical knowledge, vent frustrations...and challenge deficit notions of people of color (and other marginalized groups)...and establish and maintain a positive collegiate...climate for themselves. (Ong, 2018, p.209)

Counterspaces are places where students can counter the feelings of lack of belonging and messages of exclusion and isolation prevalent in their experiences in STEM. Counterspaces are also spaces where students can wholly exist and bring together and express their intellectual, cultural, and social selves.

Counterspaces can take several forms including: mentorship relationships, peer to peer connections, national STEM diversity conferences (Milli, 2019, p.187-188), campus student groups, and even students' own STEM departments if these are supportive and nurturing. National STEM diversity conferences like Grace Hopper, Richard Tapia, the National Society of Black Physicists, and SACNAS, serve as counterspaces because WOC are able to express all of their identities (intellectual, racial, and gender) among others who share identities, without their abilities being challenged. Campus student groups, even if not STEM related, are one way for WOC to feel validated in their existence at their institutions, which can then positively impact how they feel in their STEM departments. For example, for Valencia, an engineering student in Ong's 2018 study on counterspaces, the Native American Drummers club was essential to her persistence in engineering because it allowed her to meet "other 'brown'scholars with whom she could engage both academic and cultural aspects of herself," much like students at diversity conferences did (p.226). For Valencia, her STEM department also became a counterspace when they allowed and encouraged her to do her thesis on indigenous engineering methodologies, an example of culturally relevant pedagogy. This again allowed Valencia to engage both her

intellectual and cultural self. Counterspaces allow WOC in STEM to exist as their full selves, without having to only focus on the intellectual or fight to maintain their multiple identities.

WOC seeking supportive and nurturing undergraduate and graduate programs is a completely agentic persistence strategy as it takes deep reflection, honesty, and care for oneself to determine what is needed to succeed. Once in their programs, the women continue to employ their agency as they create their own counterspaces to exist within.

Building supportive relationships with mentors and peers in and outside their fields

Building supportive relationships can take many forms, but the most prevalent in the literature were mentorship relationships with faculty, graduate students, and otherwise more experienced STEM professionals and peer-to-peer relationships. Throughout the literature I came across infinite examples of good mentorship, and I myself have also had invaluable mentors help me persist (you can read about two of them in my acknowledgements page). Mentors can also be bad and not have a students' best interest at heart, accidentally or purposefully. These kinds of bad mentors are further described in the following subsection on *persistence strategies as pushout factors*. Mentors can offer "social support" and technical knowledge, but their impact on the persistence of WOC in STEM happens most when they demonstrate "confidence in [students'] ability to be successful" (Neumann, 2016, p.144).

The positive impact of good mentorship is compounded when students "see themselves in the faculty" and other mentors (Vasquez-Grinnell, 2019, p.47). This is why it is critical for WOC in STEM to have WOC mentors and why it matters that we hold institutions accountable for the pushout of WOC. One of the ways to encourage the persistence of WOC is to recruit and retain more WOC faculty, lecturers, graduate students, etc. While two articles in the literature specifically cited that for WOC and white women, the positive impact of women mentors was

key to their persistence (Alfred, 2019, p.123; Neumann, 2016, 152), there was no similar finding for WOC and mentors of color. I believe this is related to the experiences of WOC in the *stereotype threat and imposter syndrome* subsection of the pushout vs pullback section above which explains how WOC's gender identities are more often at the forefront of stereotypes in STEM. However, it is also possible that the percentage of WOC STEM professors and professionals is still so low that recent WOC undergraduates only have STEM white women as the next closest mentors whose identities they share.

In addition to mentorship relationships, peer to peer relationships are critical to the persistence of WOC. These relationships are cultivated in several ways. One of them is creating these connections within the context of campus STEM clubs and chapters of national STEM societies (Espinosa, 2011, p.209; Hodari, 2016, p.60; Ong, 2018, p.209). Espinosa found that WOC in STEM clubs were 7% more likely to persist (p.230). Interestingly, Espinosa found a difference of 4% between the importance of STEM clubs for WOC compared to white women (p.231). I believe that the higher importance of peer to peer relationships through STEM clubs for WOC may have to do with their cultural identities. White American culture is an example of a culture whose values tend to be individualistic. For non-white American cultures, like those of WOC, the values are more communal and cooperative. From personal experience, I believe that it is this cultural background that makes peer to peer relationships more important for WOC's persistence. It is also important to note that white women in STEM may be able to better fit in among majority white male STEM departments because of their overlapping white identities as opposed to WOC. As such, it is likely that WOC have a higher degree of lack of departmental inclusion to counter, so they may seek out external community at higher levels.

For some WOC, peer relationships are formed through necessity by working with other minority students in their departments, like the group of students of color I worked with on my quantum physics group final. We worked together (myself, a Latinx man, an Asian woman, and a Black woman) because it often felt like no one else wanted to work with us, a common phenomenon in the literature. For example, a student in Hodari's (2016) article recounted, "In my computer science class, a lot of the projects were group [work], and so I found two [minority] groupmates, who were heaven-sent. And we stuck by each other and actually...planned all of our schedules in sync with each other...in order to get through...together" (2016, p.62). These students' connections were so critical to their persistence that they lined up their schedules in order to ensure they had each other as supports. To think that they went through the trouble of lining up work, sports, family and other schedules just to take classes together is commentary on how bad their exclusion from the department had to be.

While some WOC are able to find students they shared identities with, others have to change their identities just to try to fit in with the dominant group. This is a topic discussed in detail below, in the resistance section, where I discuss how this is an agentic strategy. But just as an example of what I mean by "changing their identities," consider the women engineers in Neumann's study who "adapted to cultural expectations through dress, speech, and behavior" (2016, p.154). Often this meant that these engineers de-feminized themselves, a part of their gender identity expression, to be able to be "one of the guys" (2016, p.150-151). The STEM culture was so hostile to their existing identities that in order to fit in and improve their chances of persisting, the engineers had to do the extra work of camouflaging as "one of the guys."

Relationship building within their field is a key strategy to the persistence of WOC in STEM because these connections provide students with knowledge and tools to navigate their

coursework and persistence. For some students, like the community college transfers in Reyes, this strategy is more salient than for more traditional students because they have the extra obstacle of having to navigate between institutions. For all students, however, this strategy is still an agentic way of persisting that pushes back on their pushout.

Participating in research programs

Participating in research programs and internships where WOC are able to take on the role of scientist is crucial to their persistence. In fact, WOC who participated in research programs were 12% more likely to persist and finish their undergraduate degrees (Espinosa, 2011, p.230). Being able to perform the role of scientist not only provides technical knowledge and skills, it also legitimizes the STEM identities of WOC. In part, the legitimization of WOC's STEM identities through research is that it often involves working with and being validated by the "people in power" (Hodari, 2016, p.60) of STEM, like professors, research collaborators, and even broader STEM communities and experts (including those at large STEM conferences where student research is often presented). Given that the current STEM environment is not supportive and nurturing to the development of the STEM identities of WOC, participating in research programs is particularly powerful at countering that pushout factor.

In addition to the validation WOC receive from participating in research programs and internships, these experiences also give them capital that can propel their STEM careers after their undergraduate degrees. Research experiences often result in return offers or offers from mentors and advisors to write future letters of recommendation. I experienced this at both of the labs in which I conducted research. Both of those advisors, David and Cacey (mentioned in the acknowledgements) offered to have me come back to their labs and have since written me

several letters of recommendation. Conducting research provides WOC the ability to start owning the role of scientist, fighting the pushout they experience, and persisting in their fields.

Institution type

Though institution type was only mentioned in two of my sources as a persistence factor, it seems that the impact of institution type on persistence is potentially larger than currently thought and should be explored further. The racial and ethnic makeup and the affluence level of the institution are the two characteristics found to affect the persistence of WOC in STEM. In the *current STEM culture and climate* subsection of the status quo section above I write about how HBCUs and MSIs have higher rates of WOC STEM bachelors degree recipients as compared to other institutions. This is because STEM departments at these institutions are more nurturing, accommodating, inviting, and supportive of WOC than most other STEM departments which typically subscribe to the more widespread toxic STEM culture. With regard to affluence level, Espinosa (2011) found that attending private, often expensive, colleges with a strong STEM community was a predictor of persistence, citing a 10% increase in persistence (p.231). However, attending a selective institution was not a predictor of persistence. In fact Espinosa found that WOC who attend highly selective colleges were 14% more likely to switch into non-STEM majors (p.231) Espinosa suggests that private institutions likely have more money to invest in student resources and support, explaining students' higher persistence levels (p.231). What these statistics reveal is that the broader culture at institutions, not just within STEM departments, affect student persistence.

Sometimes students do not have a lot of flexibility in what institutions they can afford (monetarily and otherwise) to attend. However, as explained in the choosing safe and nurturing environments section above, these students do look for specific requirements of their institutions

that they feel would lead to their success, illustrating once again how WOC are agentic in their goal to persist. Regardless, there are always extraneous forces, like school type, that shape student pushout or support persistence.

Culturally relevant pedagogy and curricula

For any college student, it is important to enjoy one's coursework if there is any chance of succeeding at completing any major/course of study. For WOC specifically, Alfred (2011, p.230) found that WOC who were satisfied with their coursework were 14% more likely to persist than those who were not. What exactly makes curricula satisfying to WOC in STEM? Of course, some WOC just simply discover that they enjoy other subjects more than STEM, like Kacey in my 2019 study who found she loved her Peace and Conflict classes more than her Chemistry courses. I also personally enjoy my Education course assignments (papers and readings) more than my Physics coursework (problem sets). Though some of this is just due to individual intellectual interests and preferences, the literature picked up on the trend that WOC are more satisfied with their STEM coursework when it allows for them to bring other aspects of themselves into the classroom. This kind of coursework is known as culturally relevant and sustaining curricula in the education field (Ong, 2018, p.234; Vasquez-Grinnell, 2019, p.45).

An example of this kind of curriculum is the experience of Valencia, mentioned in *choosing safe and nurturing environments*, when she was allowed and encouraged to weave in her Indigenous knowledge into her engineering thesis. In Hodari's (2016) study on WOC in computing, the WOC incorporated other parts of themselves into their dissertation and research projects including their upbringings and hobbies outside of STEM. For example, Kathy, a Latina student, combined her interest in psychology with her research in computing to investigate why people launch cyberattacks and how that influences how the attacks are coded (p.64). Another

student, Jade, a Black postdoc student in computing, wrote her thesis on how using technology could improve reading achievement for Black girls. The project was inspired by her family life where she watched her young cousin struggle to read (p.64). She was motivated to do this work because she knew she could come up with better solutions than a white man could because of her lived experience. When given the opportunity to weave other parts of themselves into their STEM work, these WOC jumped at the opportunity. This made their coursework more satisfying and fulfilling which increased their chances of persistence. The increased chances of persistence are due to the fact that culturally relevant and sustaining curriculum gave the WOC an academic space where they could bring their whole selves and have all of their knowledge, academic and lived, valued.

Gender and racial passing

Gender and racial passing as a persistence strategy was only really identified, named, and theorized in one of my sources (Ong, 2005), but examples of it appeared throughout all the literature. Gender and racial passing is a form of identity fragmentation where students suppress certain parts of their identity in order "to minimize cultural differences between oneself and other members of a community" (p.601). In this study, Ong investigated how WOC of color persisted through their physics degrees, which included fragmentation of WOC's gender and racial identities in order to pass as the stereotype of a physics student by approximating whiteness and/or maleness. One student, Elena, for example, decided to buy pants to change into before her lab because she was wearing a skirt previously. She bought a sign of maleness, pants, in order to avoid attracting negative attention and standing out. The women engineers in Neumann's 2016 study recount similar experiences of de-feminizing themselves just to fit in. Some WOC perform masculinity in order to "pass as legitimate scientific community members" (p.605). For others,

"Performing whiteness...afforded them the benefit of the doubt in establishing their neutrality, objectivity, and authority" (p.604). STEM culture perpetuates the myth that STEM and scientists by extension are neutral, objective, and authoritative (characteristics associated with males in our society).

By hiding their gender or racial identities, something that some WOC agentically choose to do, WOC in STEM manage to persist because they blend in better with the dominant archetype of their field. At the same time, their gender and racial passing also gives them, in the eyes of the broader community, more credibility and authority in STEM. This can then increase the chances that these WOC can persist through undergraduate STEM degrees and beyond. I do not think WOC should have to fragment themselves just to be accepted, but those who do often know the implications and can persist through this strategy.

Support of family and community

For any student, their families and communities back home are often sources of strength and motivation to complete their degrees. WOC in STEM are no different, though there are some unique differences in how their families and communities motivate them to persist through STEM. First, many WOC across the literature I read shared other identities such as being first-generation, immigration status, and of low SES, that made attaining a college STEM degree, a feat that put them on a pedestal to their communities back home. One student recounted that in difficult times she reminded herself, "Don't disappoint the cousins back home" (Milli, 2019, p.193). For oldest sisters like Dani in my 2019 paper, and me, the motivation comes from setting a good example for our siblings and starting the trend of educational achievement for our families. Second, because of some of these other marginalized identities that WOC hold, STEM degrees are often encouraged by their families for their perceived prestige and promised financial

security. As such, WOC feel the pressure to persist because their degree is not only for them, it's for their families (Olvera, 2019, p.9).

Similarly, a significant reason why relying on family and community support is a persistence factor is that as the WOC develop their own STEM identities they are co-creating the family's STEM identity too. This was a phenomenon that I first encountered in my 2019 paper. It is based on the idea of familism, which characterizes identity building as an intergenerational project. Individuals' identities are shaped "within the family and the varying degrees to which individuality and connectedness play out in different families" (Olvera, 2019, p.9). Research has shown that "ethnic and racial minority and immigrant/immigrant-descendent youth had both a strong cultural sense of respecting the family and doing what was best for the family collectively" (p.9) which shapes these students' identities. For example, for two students in my study, Alex and Kacey, they experienced pressure from their families to pursue the more lucrative STEM fields because their education was a reflection on the whole family. Family and community support are persistence factors for WOC in STEM because they motivate the students to push forward in order to be role models and bring prestige and wealth to their families. The pressure can be overwhelming for some but also functions as a motivator because it counters some of the negative messages WOC receive from the STEM community.

Overall, the message of this section on persistence strategies emphasizes two key points. The first is that these persistence strategies counter the pushout factors WOC experience. The second is that WOC are agentic in how and when they employ these strategies, countering the narrative that poses them as victims who just passively experience STEM. Though they should not have to, WOC are actively doing the work to battle their pushout by STEM.

Persistence strategies as pushout factors

During my review, it became clear that depending on how the people around WOC interact with these students' persistence strategies, these strategies can sometimes be misused and contribute to the pushout of the WOC. I observed this shift of persistence strategies to pushout factors primarily in two areas: mentorship and familial pressures. In both cases, these support systems for WOC end up either harming or aggravating their time in STEM and thus contribute negatively to their persistence.

Above, I wrote extensively about how important having good mentors is for the persistence of WOC but also briefly mentioned how there are also *bad* mentors. Because mentorship is so important to the persistence of WOC, when it goes wrong the fallout can be extensive. In the case of WOC, the issue is that the current low numbers of WOC faculty and STEM professionals means many WOC find themselves in mentoring relationships with people who do not look like them or experience the world as they do, leading to misaligned mentorship. Of course, there are exceptions, such as my mentor David, a white man, who truly was invaluable to my persistence in astrophysics because he always supported my academic choices and was accommodating to me. As the department chair, his power and authority and support shielded me from being questioned or ostracized and made it so that my voice had to be heard because he extended his credibility to me.

However, not all WOC are as fortunate to find allies and accomplices in the mentors accessible to them. Instead, some encounter mentors who replicate the harm of the larger STEM culture. Alfred (2019) found that, "Women of color mentees often struggle with ambivalence, loss of confidence, and disenchantment in mentoring relationships...report[ing] mentoring was aligned with annual evaluation, apprenticeship, and theft of intellectual property" (p.125).

Further, because mentoring is situated within a STEM climate that currently makes WOC out to be responsible for their own pushout, "Mentoring for underrepresented women is a systemic inequality in that the current mentoring practice both privileges and marginalizes, supports and undermines, assumes equal distribution, yet contributes to inequitable outcomes for women of color mentees" (p.125). So although mentoring can be a really positive persistence factor, the current STEM climate often contributes to it functioning as a pushout factor. For example, Melea, a Black graduate student in physics, part of Ong's study on counterspaces for WOC (2018), recounted how she went to her advisor seeking support after a peer made a racially insensitive comment to her. Her advisor was dismissive while other peers told her she was too sensitive. Because her advisor and peers both felt comfortable in the current STEM climate, a potential mentor, her advisor, and potential supports, peers, actually became perpetrators of harm to Melea. The current way of forging mentors often involves students having to initiate contact with STEM authorities, which can be intimidating for students like WOC as they experience isolation and exclusion in their departments. As such, combined with the low numbers of established WOC in STEM, it starts to make sense that many undergraduate WOC end up with bad or misaligned mentors.

And lastly, maybe surprisingly, family pressures can function as both a persistence and pushout factor. Although families may push their students to get STEM degrees for the perceived prestige and financial security, once the WOC are actually in their coursework, they often find that their families are less understanding and can even be a source of stress. As earlier discussed, when WOC have to spend many hours doing their STEM coursework and can no longer help their families with the house chores or by working to help with finances, families who were previously excited about the student's choice to pursue STEM can actually see it as detrimental

to family's current survival. For WOC with their own families to take care of, simply having children can be a barrier to career advancement given the way things like daycare and parental leave are shaped in the US.

Misaligned mentorship and familial conflict are just two examples of how persistence strategies can evolve into pushout contributors, though they are probably not the only examples. Persisting is already a hard thing to do, and it only gets more complicated as potential tensions between pushout and persistence factors arise.

Resistance

The idea to write a separate section on resistance strategies came about when I was reading the literature and started noticing that many of the WOC's strategies of persistence not only countered their pushout but also pushed back on the current STEM climate and culture. It made me hopeful that their resistance is changing the current environment. Overall, WOC's resistance can be characterized as strategic, deliberate, and successful.

Self-isolation as self-preservation

Though self-isolation does not sound like a good thing, I find it to be a method of self-preservation for marginalized people to protect themselves in spaces hostile to their existence like the case of WOC in STEM. Resistance strategies are not always neutral or positive and that is the case with self-isolation. WOC are sometimes forced into isolation, and the current culture of STEM perpetuates the idea of a lone genius at a lab bench or chalkboard somewhere discovering new things, glorifying "the idea that scientific knowledge is gained through singular natural ability and independent hard work" (Ong, 2018, p.230). Isolation is not the best way to succeed in STEM, as a lot of coursework like labs and problem sets require collaboration with peers and professors alike. Additionally, isolation can stop WOC from seeking help when they

need it out of shame for not being able to do things themselves. This was the case of Valencia, who practically almost dropped out of engineering before she reached out to a Latina postdoctoral student for help (Ong, 2018, p.230).

However, for some students like Amy (Ong, 2005), self-isolation allows them to focus on their work by actively removing themselves from the hostility in the classroom. Amy is a Chicana physics student who self-isolated from her classmates during her first physics class due to comments they made about her appearance and status as a sorority woman. Later, she found out that she was an academic top performer and was sought after to join projects and study groups (Ong, 2005, p.609). What this isolation granted Amy was the ability to focus on her work without being distracted by the hostility she was experiencing. Though she should not have had to do this, it granted her credibility and authority as one of the smartest students which increased her chances of persistence through the major because she "earned" her place in the in-group.

I have also personally self-isolated in order to preserve my energy and brain waves for what mattered in the classroom. Lots of my white male colleagues spend an egregious amount of time in the physics lounge and department doing work because they find it a place where they can focus. I, however, always felt out of place and surveilled while I was there, so I would often do my work on the quiet floor of the library nearby. This allowed me to complete my work because I was not distracted or consumed by what others thought of me. WOC in STEM sometimes resort to this strategy, by force or by choice, but nonetheless it can improve chances of persistence as it did for Amy and me.

Existing as a different kind of scientist

One stereotype of why people do science tends to be to discover new things, earn awards, and maybe have an equation or theory named after them. This would be the prevalent caricature

of a typical research scientist, sitting in a lab alone, working late into the night, suddenly finding a new kind of particle. Across my literature review however, the research showed that many WOC in STEM see themselves as altruistic scientists "who use science to serve humanity" and "are often motivated by applications of technical expertise that help others or connect to a broader societal benefit" (Hodari, 2016, p.59&64). In addition, many WOC rely on using soft skills not generally valued by STEM stereotypes to fit into their broader STEM communities. WOC use both of these strategies to exist as different kinds of scientists which helps them both stand against the current STEM climate and persist through it.

Examples of altruistic scientists include Jade, mentioned above, and her motivation for using her thesis work to address low reading achievement for Black girls because she could come up with better solutions than a white man could (Hodari, 2016, p.64). Hasina, a Black postdoc in computing, used her computer engineering research to help low income neighborhoods. The women engineers in Neumann's study also used their soft skills such as "time and project management, group work, and communications" (2016, p.145) to become essential members of their group. This countered the initial exclusion they experienced from the men engineers and allowed them to complete their coursework and ultimately persist. I also did this in high school in my robotics team. I quickly saw that the guys would flock to building the robot only to scramble two days before the competition to throw together an engineering notebook, marketing presentation, project booth, and gather people to present the robot to the judges. I pretty quickly took charge of all of those components from the very beginning, and after seeing that those components often won us more points than the robot's performance itself, I became a highly valued member and leader of the team. I should not have had to do all that

work just to be accepted, but it granted me status in the club and built soft skills I now credit as crucial to my persistence in STEM.

I, like the other WOC in the literature, was strategic in how we used our "unconventional" motivations for doing science and soft skills not only to battle the current STEM climate, but also to gain acceptance within our STEM communities. That acceptance into the in-group, which should not be so hard to earn, then increased our chances of persistence. Research shows that when any student feels a sense of belonging, they persist.

Strategic use of stereotypes

Conforming to racial and gender stereotypes may not sound like a productive way of resisting the current STEM culture or increasing one's chances of persistence. However, throughout my literature review I found that some WOC strategically use stereotypes to "manipulat[e] the standard image of the ordinary scientist" in order to gain scientific membership and credibility (Ong, 2005, p.603). I found the way these students employed this resistance strategy absolutely fascinating. According to Ong, this strategy of stereotype manipulation is rooted in the idea of multiplicity where individuals display all of their identities unapologetically (p.601). This is the opposite of fragmentation.

An example of gender stereotype manipulation are the women engineers in Neumann's (2016) study as they used their soft skills to become valued and accepted members of their engineering groups. The women recognized that they took on the role of "mother" or "nagging wife" within their majority men engineer groups. This persona they played "covered" their outsider status to the group and combined with their tangible contributions to the group secured them acceptance into the group (2016, p.152) Of course, the problem here is that by following

these stereotypes the women are possibly perpetuating them though none of them seemed to agree with that statement.

Examples of race stereotype manipulation include the story of Kendra, a Black physics student in Ong's 2005 study. Kendra "intentionally assumed a strategic, situational character - the "loud Black girl" - as an act of resistance" (p.607). It makes sense that Kendra might want to stand out and be loud in an environment that is hostile towards people like her. The manipulation "aligned her loudness and visibility with talking about physics and displaying her knowledge to faculty and peers in the department" (p.608). She was able to obtain some of the authority and credibility often afforded to scientists. She also reaped tangible benefits in the form of professors and people who knew of her sending her applications for programs and recommending her for opportunities.

Both Kendra and the women engineers strategically used stereotypes to establish their credibility and status within their respective STEM communities. Though they ran the risk of confirming gender and racial stereotypes, the payoff of the manipulation increased their persistence chances.

Existing outside of STEM

Another way that WOC in STEM resist and persist through the dominant STEM culture is by finding ways to exist outside of STEM. From personal experience, it seems that being a STEM student assumes that this identity becomes your personality and consumes all aspects of your life: long labs, late nights at the library, too many problem sets, etc. And it gets worse the further up in STEM education with graduate students working without getting vacations or fair pay. Milli (2019) best characterizes this as the myth STEM perpetuates that in order to be a good

and accomplished scientist one must work all the time. To counter this, many WOC in the literature were active in finding ways and spaces to preserve their other non-STEM identities.

For example, some students exist outside of STEM by participating in non-STEM clubs, maintaining separate social and academic groups (Tate, 2005, p.488), and even double majoring or minoring in a non STEM field (Milli, 2019, p.191), which is something I did myself. I specifically recall my sophomore fall when I first started taking education classes. I was tired of just doing problem sets all day every day, sitting in the science center until 1, sometimes 2 am, deriving formulas, feeling like a human calculator. I did not want to be the stereotype of that STEM obsessed student with no other skills. I needed to do something else academically that meant more to me than numbers on a paper that meant nothing to my human experience. And I am not alone in this feeling, as the WOC engineers in Tate (2005) also found that "although students desire careers in engineering and successfully persist through the academic study of the field, they seem separate from it" (p.490). Perhaps, existing outside of STEM and not letting it control their lives, meant that WOC were able to seek peace and security away from the hostile STEM climate, contributing to their persisting and fighting stereotypes.

Finding motivation in challenges

Like many other students, WOC find motivation in challenges. For WOC there were two common challenges that motivated and influenced them to persist: persisting to change the environment for the WOC coming after them and persisting to prove those who question their abilities wrong. Hodari's study on WOC in computing found that some WOC like Miranda and Christy (2016, p.62) enjoyed being the "only one" and proving their abilities. The women engineers in Neumann were cognizant that their major choice was non-stereotypical for people like them but were deliberate and intentional in their choice (2016, p.147). Others, like Georgette

and Francesca (Hodari, 2016, p.62), are motivated by the previous persistence of WOC, with goals of becoming teachers and professors themselves to better the climate for the next generation of STEM WOC. I consider this sort of motivation to be an act of resistance because the persistence of these students is actively pushing back on the status quo.

Being activists

Related to the last persistence strategy of staying motivated to make things better for the next generation, are WOC who persist and find strength in being activists. Being activists "aided women of color persisting in STEM, changing departmental culture, and giving back to their communities" (Milli, 2019, p.191). The activism for these WOC takes many forms including motivational talks, teaching, mentoring, serving on committees, professional organizations, and volunteering. Though it should be noted that being activists can further disadvantage WOC in STEM by taking up time that could be spent doing science. This is particularly a problem for WOC professors trying to obtain faculty positions or tenure. In the current hiring and tenure process, candidates must have a certain amount of research and published papers to be competitive. Standards vary across institutions, but the problem is that most do not consider service, i.e. activism, in place of research or writing papers. And thus, these kinds of meritocratic reviews continue to prioritize already privileged STEM students that do not have to rely on activism or perform service to persist. Regardless, the service WOC in STEM perform is an act of resistance as they actively work to change conditions for those behind them.

It is extremely important to acknowledge that there are emotional, physical, and mental costs of persisting and resisting in STEM as a WOC, and it should not be romanticized. WOC should not have to endure things like feeling that their reason for persistence is to change an entire system for the next generation while at the same time having to do their homework. How

many white men in STEM do you think feel this kind of pressure? None. So at no point should this struggle be romanticized. It should however, be recognized that because of WOC and other marginalized groups, STEM will one day be better for everyone.

The Conclusion: What now?

The path of STEM persistence is unnecessarily complicated for WOC. The current STEM climate and culture perpetuate the myths that the retention of WOC in STEM is so limited because WOC do not work hard enough or are just not interested in these fields. For those that do persist, the current STEM culture makes martyrs out of them and romanticizes their struggle to overcome the emotional, mental, and physical toll of STEM persistence. Westernized science, the science taught in the dominant US schools curriculum, came about as the pastime of rich, white European men with "extra"[8] time and money to think. As such the institution of science, how it is taught, how it is done, was never designed to accommodate or include gender and racial minorities. The culture of STEM is not welcoming or inclusive of WOC, so it is no surprise that only about 12% of WOC in college earn a STEM degree (*Women of Color in STEM: The Past, Present, and Future* 2021).

WOC of color are systematically pushed out of STEM even before they get to college through practices like academic tracking and disproportionate rates of school punishment which leads to their criminalization. Those that do make it to college are confronted with a STEM climate that is racist, sexist, cutthroat, full of gatekeeping practices like weeder classes, and unsupportive of WOC in the form of unapproachable professors and peers who exclude them from study groups and departments. WOC also receive constant messages of exclusion and not belonging as they often find themselves being the only ones in their classes that look like them. This environment inevitably leads to WOC experiencing stereotype threat, imposter syndrome, and feeling demoralized. If not pushed out of STEM, some WOC also decide to remove

[8] This extra time and money was a result of these white men colonizing other peoples and exploiting them for profits.

themselves from these departments. For some it is to protect themselves, while others just discover other academic interests and passions.

However, WOC use a variety of resistance and persistence strategies to pushback against their active pushout from STEM. When choosing their institutions, WOC seek places that are nurturing and safe or that allow them to create their own couterspaces. They seek out positive and supportive relationships with mentors and peers both within their own STEM departments and institutions and in broader STEM communities like national diversity conferences. WOC are able to come into their STEM identities by participating in research programs, seeking out support from mentors, gaining strength from their families and communities back home, and combining their intellectual and cultural identities in their academic work through culturally relevant and motivated work. Some students also manage to persist by employing the technique of racial and/or gender passing as a way to fit into the dominant STEM group. However, some of these positive persistence factors can trigger a pushout if manipulated incorrectly.

Beyond persisting, WOC in STEM also actively resist the dominant STEM culture. They do so by creating alternative STEM identities such as altruistic ones, who use their science to better the world and their communities and to improve conditions for the next generation of STEM WOC. Others use stereotypes strategically to their advantage, to become crucial members of their groups or stand out in their departments, making them indispensable to the STEM group around them and securing their membership. Others are able to persist by existing outside of STEM through hobbies and pursuing other academic interests, finding motivation in challenges, and participating in activism to benefit their communities. WOC are agentic in how they use these strategies to resist and persist, countering the myth that they simply experience STEM. Rather, they are active, agentic participants.

Investing in the persistence of WOC in STEM is critical to improving the persistence of other marginalized groups. Particularly, I would like to see more research on minority non-women, gender minorities in STEM. Throughout my review for this paper, I could not help but notice that the literature was almost entirely written through the lens of the gender binary. The only paper that mentioned femme or nonbinary people was my 2019 paper. I would also like to see more studies on how the experiences of WOC from different SES differ. Considering the intersecting identities of all students is crucial to improving their persistence and changing the STEM culture and climate, so that it is welcoming and accommodating for non-white male figures.

Throughout this review and my four years at Swarthmore, I have picked up on a few changes I think would make a huge difference in the persistence of WOC in STEM. First, to those in power and with privilege like professors, committee chairs, administration, etc. can no longer just be allies to WOC students, they must be accomplices. When students come to you worried about not finding summer opportunities, make space for them in your labs, call your colleagues, and find the money to make sure they are paid. But also be on the lookout for students that do not come to you and reach out. When students come to you about struggling in a class, do something by changing the way curriculum is covered, the kinds of assignments given, etc. Second, wherever possible there must be opportunities for students with academic deficits to catch up without penalty. This can take the form of precollege summer programs, winter and summer break classes, specifically targeted for WOC in STEM. Departments should also be flexible with major class requirements by allowing flexible substitutions, accepting outside credit, or concurrent taking of prerequisites with classes. And finally, the biggest problem WOC in STEM face is their exclusion and isolation so keep an eye out for possible hostile peer to peer

climates and noninclusive language used in the classroom and in communications. Bring in diverse speakers for lectures and colloquium, so that WOC can see themselves represented. Support students by sending them to diversity conferences or funding them to host their own events. The list goes on, but the fact of the matter is that the persistence of WOC requires everyone to pitch in.

Overall, what I have learned from the WOC I have read about in these articles and from my own experience is that we survive and thrive and persist, in community with each other and our supporters. We have to in order to battle against our isolation and exclusion from STEM and navigate the unnecessarily complicated path of persistence. And to end on a hopeful note that there one day will be more of us, I tell you the story of my friend Erin. I met her the summer before we matriculated at Swarthmore. She is one of the few WOC in my department, and one of two Black students. She was part of the group of students of color I studied with during our first two years. We both majored in astrophysics and have interests in exoplanets, so it was fitting that she gave me a solar system bracelet at the end of our senior year and said "a solar system for your wrist." It made me emotional because it was a sign of our sisterhood, a sign of recognition of what we had just accomplished as WOC in our department. Erin will join the exclusive club of about only 100 African American women in the US with physics PhDs in a few years (*Women of Color in STEM: The Past, Present, and Future* 2021). I am putting up my physicist hat to start a career in computer systems engineering. We chose different paths of persistence, but nevertheless we did.

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