International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

"I Don't Know Why They Make It So Hard Here": Institutional Factors and Undergraduate Women's STEM Participation

Danielle Lindemann[1], Dana Britton[2], Elaine Zundl[2]

Lehigh University[1], Rutgers University[2], USA

ABSTRACT

Large-scale, aggregate analyses have produced important insights about the relationship between gender and STEM (Science, Technology, Engineering, and Mathematics) participation at the undergraduate level, but they potentially eclipse the impact of institution-specific elements on women's STEM participation. Through unique access to multi-year data from a highly diverse single-institution sample (n=374), follow-up surveys (n=90), and focus groups, we examine the patterning of STEM major selection and persistence among first-year students at a women's residential college ("WRC") within a larger co-educational university in the United States. Results support the findings of previous research regarding women in STEM but also extend them. Drawing on prior literature about "imposter syndrome" and "stereotype threat", we find that these phenomena are reinforced through processes and interactions occurring at the institutional level. Moreover, gender inequalities related to STEM at the institutional level function intersectionally, potentially exacerbating inequalities related to other student characteristics, such as socioeconomic status and race. Finally, we find that gender stereotyping related to women and communal values may encourage some women to choose and remain in STEM, though it deters others from joining these fields. We discuss the importance of these results for future research and intervention efforts in this area

KEYWORDS

STEM, postsecondary education, "imposter syndrome", "stereotype threat

"I Don't Know Why They Make It So Hard Here": Institutional Factors and Undergraduate Women's STEM Participation

Previous research has identified a variety of factors relating to women's underrepresentation in STEM fields. These include issues such as gender differences in STEM exposure and academic preparation (Blickenstaff, 2005; Huang & Brainard, 2001), as well as the roles of affective traits, such as self-confidence and personal goals (Hill, Corbett, & St. Rose, 2010; Margolis & Fisher, 2002; Sax, 2008; Starobin & Laanan, 2008; Yasuhara, 2005). Additional work has focused on identity (Hughes & Molyneaux, 2015), finding that students whose identities are incongruous with "white," "male", and "middle-class" find it difficult to fit in within these fields (Ong, 2005). Finally, researchers have highlighted the importance of parental and teacher support (Farmer, 1997; Rayman & Brett, 1995; Williams & Ceci, 2007) as well as peer influence (Hazari et al., 2010; Robnett, 2013), on women students' experience with STEM disciplines.

In the United States, it is often the case that students decide on their main degree subject (declare their majors) partway through their time in college (typically, in their first or second years). One predominant theoretical thread within scholarship on women in STEM has been the impact of cultural stereotypes in shaping men's and women's attitudes toward these fields (Nosek et al., 2009; OECD, 2012). Some scholars have argued that these stereotypes intersect with performance in STEM majors to produce two kinds of threats to women's STEM identities; "stereotype threat" (Steele, 1997; Steele & Aronson) and "imposter syndrome" (Clance & Imes, 1978; Stout et. al., 2011). "Stereotype threat" acts on women when they become aware of negative stereotypes regarding their abilities in STEM, and the resulting pressure to avoid confirming these stereotypes causes anxiety, which in turn negatively affects performance. Conversely, when women are successful, they may fail to attribute this success to their own abilities, viewing themselves as imposters who will soon be discovered. Some research has shown that both of these processes can result in a disengagement from a STEM major or field, and a rejection of an identity as a STEM student (Murphy et. al., 2007; Steele, 1997).

While little scholarship has examined the connection between intra-institutional factors and risk of "stereotype threat" and "imposter syndrome", some research suggests that these larger cultural stereotypes can be mediated by institutional culture. For example, results from several social experiments have shown positive results on women's performance on tests when classroom environments encourage equality and female leadership (Van Loo & Rydell, 2014). However, this scholarship has not focused explicitly on the role that school-level factors may play in warding off "imposter syndrome" and/or perpetuating feelings of "unworthiness" among undergraduate women in STEM majors. Here, we assess the connection between institution-level factors and this socio-psychological process. We evaluate the ways in which gender stereotypes interact with elements of institutional culture to play a role in women's STEM-major selection and persistence.

Empirical Frame: Women's STEM Persistence in Institutional Context

Much previous research looking at gender imbalances in STEM at the postsecondary level has relied on large-scale quantitative data aggregated across multiple institutions. As Mullen (2014) points out, literature surrounding gender and college-major choice "has been dominated by quantitative studies that track aggregate levels of gender segregation over time and across countries, or use statistical analyses to predict students' selection of particular fields" (p. 290). Fewer studies have examined the potential importance of institution-specific factors—such as class size and structure, university culture, and the existence of programs supporting women in STEM—and how they might interact with macro-level elements to contribute to, or moderate, the impact of identity threats. Even some studies evaluating the impact of program level interventions have used multi-institutional data. Szelényi and Inkelas (2011), for example, use a national study of the impact of Living Learning (L/L) Communities[1] on female STEM persistence by analyzing over 22,000 survey responses across thirty-four institutions. Some of these previous projects have compared different types of colleges and universities (Solnick, 1995), but in these studies institution type becomes a proxy for all the variation that exists between schools.

There have been some exceptions. Mullen (2014), for instance, specifically draws attention to the importance of institutional context. Drawing on fifty in-depth, semi-structured interviews with junior and senior college students at an elite liberal arts university, she finds that there are a "plurality of gendered meanings" (p. 289) around choosing a major. However, while she touches on the topic of women in STEM, it is not her specific focus. Other studies have looked at particular interventions at the institutional level. Hughes (2011), for example, draws an in-depth picture of seven undergraduate women at one school, finding that women's experiences vary widely and problematizing the assumption of previous research about women in STEM that there are universal predictors for women's STEM persistence and attrition. In another study, Hughes (2014) uses narrative life history methodology to look at the impact of one university's single-sex L/L program on twenty-six undergraduate women's STEM career choices. She highlights the importance of STEM department culture at this institution, finding that department culture is related to female students' identity and support networks, which in turn are associated with their STEM persistence.

The two latter studies provide valuable information about some of the institution-specific nuances of women's undergraduate STEM participation. However, they are each based on a small number of cases. What happens "on the ground" in postsecondary classrooms—and the potential relationship between these environmental factors, gender stereotyping, and gender disparities in STEM— is a topic that has yet to be fully unpacked but is potentially crucial to understand. In fact, one study of engineering students found that teaching practices had greater effects on students' perceptions of themselves as engineers than did their background characteristics (Colbeck, Cabrera, & Terenzini, 2001). As other researchers have pointed out (Farmer, 1997; Seymour & Hewitt, 1997), additional qualitative work in this area is necessary to probe the importance of intra-institutional factors. While additional work has relied on single-institution samples

(Creamer, 2015 highlights some of these), to our knowledge, ours is the first study on this topic to use multi-year, multi-method research with a relatively large institution-specific sample.

The Research Site

Women's Residential College ("WRC") represents a strategic research site for the study of intra-institutional patterns. WRC is a program for women at a large, top-tier, State University ("SU"). Originally a college for women, WRC has morphed into a co-curricular program for transfer, commuter, residential, and non-traditional aged women who choose to enroll. It provides living-learning communities that focus on the role of gender and women in major global issues as well as a required course on women's and gender studies for students in their first year. A designated office at WRC specializes in supporting women in every STEM field through advising, mentoring, programming, and undergraduate research opportunities. WRC emphasizes women's leadership programs and encourages students to pursue high-profile executive board positions at WRC and elsewhere at SU. In comparison to the general population of the large university, WRC's population is more ethnically and racially diverse with about 40% underrepresented minority students versus 18.8% at SU. In terms of majors, WRC women can opt to major in any of the university's academic majors, including pharmacy and engineering located in their respective schools.

Though WRC offers a single-sex residential environment, because it is located within the larger co-educational context of SU, all of the students' STEM courses are coeducational. This configuration allows us to observe, as in the case of Hughes's (2014) study, the impact of single-sex programs designed to develop and sustain women's interest in STEM within a broader coeducational environment.

In addition to examining intra-institutional patterns, both qualitatively and quantitatively, this site allows us to make several unique contributions to existing literature on women in STEM. For example, previous work has emphasized the importance of looking at the "double bind" (Malcom, Hall, & Brown, 1976; Ong et al., 2011) women of color face as they experience both sexism and racism in pursuing STEM majors and careers. WRC's student body is highly racially and socioeconomically diverse, allowing us to explore different subgroups' experiences with institution-specific factors. Secondly, prior work has drawn attention to the importance of looking at single-gender environments such as women's colleges (Mullen, 2014), since they are settings in which female STEM recruitment is more successful; women in these settings are about twice as likely to major in STEM fields as their female counterparts at co-educational institutions (Steinberg, 2010). In fact, a large proportion of incoming freshmen at WRC—more than half—intend to major in STEM, and WRC offers programming specifically designed to sustain women's interests in these disciplines. Finally, with few exceptions (Tomlinson, 2014), little research has analyzed the pathways chosen by women who exit the STEM pipeline. The present study's longitudinal design yields information about the majors selected by women who opt out of these disciplines.

METHODS

We define "STEM" to include chemistry, computer and information technology science, engineering, geosciences, life sciences, mathematical sciences, and physics. We exclude the social sciences and nursing because women are overrepresented in these fields at WRC and nationally. We also pay close attention to fields, like the biological sciences, where minority undergraduate women tend to cluster (NSF, 2015).

We collected data in four main ways: through institutional records, an intake survey, a follow-up survey, and focus groups.

Institutional Data and Surveys

At the beginning of year one, we obtained institutional data for the cohort of incoming first-year students—freshmen and transfer students—at WRC. "Transfer students" refers to students who had come to WRC from other postsecondary institutions and who were in their first year at WRC. This dataset included information about intended majors as well as other demographic information such as students' racial/ethnic status. We supplemented these data with intake surveys (n=316), which were administered in paper form in a required course for WRC students and were also available online. Intake surveys collected demographic data as well as information that was unavailable from institutional records; for instance, we asked about students' high school experiences, academic interests, intended majors, and interests in WRC and SU programs. In sum, we had access to data for 374 students, representing 73.8% of the total population of 507 students in the cohort.

At the end of the cohort's second year at WRC, we obtained data for students who had previously indicated the intent to major in STEM through institutional records and a follow-up survey with a subset of respondents (n=90). The follow-up survey asked students about their current majors; it also contained items about their experiences in their STEM courses and questions about their awareness and usage of WRC and university resources. We administered all follow-up surveys online, and to incentivize participation, students were entered into a lottery to win a $250 gift card. In sum, we collected data from 146 students, representing 75.6% of the 193 students who had indicated the intent to major in STEM in year one.

We used the statistical software SPSS to run frequencies and conduct chi-square analyses probing significant differences between subgroups. We use "statistically significant" to refer to results that are significant at the $p<.05$ level.

Focus Groups

We also conducted seven focus groups, composed of three to seven students each. Each focus group lasted approximately one hour. In year one, we conducted three groups, comprised of first-year WRC students who planned to major in engineering, the physical sciences, and the biological sciences, respectively. Discussion topics related to the students' experiences in their STEM courses in high school and their college experiences. At the end of year two, we conducted four focus groups with second-year students from the initial cohort. Two groups were comprised of STEM

"leavers": students who no longer indicated the intent to major in STEM. The other two groups were composed of STEM "stayers" in the biological sciences and engineering, respectively. These groups concentrated on several key themes, including experiences in STEM classes and college life in general, usage of WRC and State University resources, peer networks, and barriers and catalysts to success in STEM.

For all focus groups, we recruited students based on their survey responses. For each group, we created a list of survey respondents who fit the criteria for that group and sampled randomly from the list. We contacted the students via email. There were likely some self-selection issues, with students with strongly negative or positive experiences in their STEM courses being more likely to participate. However, other students indicated that their reasons for participating were unrelated to their feelings about STEM or WRC—for instance, the fit with their schedule or their desire for the incentive (pizza). While incentives are widely used as a recruitment tool in human subjects research, one potential drawback of this approach is that respondents might feel undue pressure to participate. However, per IRB regulations, respondents were assured that they could terminate their participation at any time without loss of the incentives to which they were otherwise entitled.

Focus groups were transcribed, and we coded them for salient themes using the qualitative software NVivo. Using an inductive approach, we first open coded the data and then aggregated it into overarching themes around personal histories, college experiences, barriers/challenges in STEM majors, and reasons for remaining in STEM. In these last two categories, it became apparent to us that institutional context played a major role in shaping students' perceptions of barriers and resources for persisting in STEM majors.

Sample Characteristics and Representativeness

Among students in the sample (those for whom we had information about intended majors), only about one third (33.4%, n=125) were White, non-Hispanic. Over one fifth (23.0%, n=86) were Black non-Hispanic, 16.0% (n=60) were Hispanic, 19.8% (n=74) were Asian, and 3.5% (n=13) were multiracial.[2] More than one in ten (16.8%, n=63) had transferred into SU from a community college within the state. Among those who took the intake survey, about one third—33.0% (n=217)—had grown up in neighborhoods that were mostly or completely non-White, and 42.3% (n=264) indicated that they spoke a language other than English at home. Nearly one in four—23.4% (n=154) were the first ones in their families or households to attend college.

This highly diverse sample was representative of the overall population of first-year students at WRC. The sample did not differ significantly from the unsampled students on any institutionally-coded variables. For instance, the percentage of those in the study who were White, non-Hispanic was not significantly different (p=.140) than the percentage of Whites in the group for whom we did not have access to information. Those in the sample were not significantly more or less likely to be U.S. citizens (p=.140). Their SAT math scores did not differ

significantly (p=.451), nor did their cumulative GPAs at the end of year two (p=.283). Similarly, our follow-up sample of intended STEM majors did not differ significantly from the group of students who were eligible for follow-up but for whom we did not have information about declared majors in year two (n=47).

A large percentage of WRC undergraduates indicated the intent to major in STEM at year one, and the majority of those students had remained in STEM by the time they declared their majors at the end of their sophomore years. More than half of respondents (51.6%, n=193) intended to major in STEM at the beginning of their first year, and 84.9% (n=124) of those students were "stayers" by the end of year two.

RESULTS

Our institutional-level data support the findings of previous research regarding women in STEM analysed by academic major and socioeconomic sub-group. We also not only find evidence for "imposter syndrome" and "stereotype threat", but we find that these phenomena are reinforced through specific school-level factors. Additionally, gender inequalities related to STEM at the institutional level function intersectionally, potentially exacerbating inequalities related to other student characteristics, such as socioeconomic status and race. Finally, we find that gender stereotyping related to women and communal values may encourage some women to choose and remain in STEM, though it deters others from joining these fields.

Institution-Level Data and Women's STEM Majors

Our findings bolster previous research on undergraduate women's STEM persistence while also pointing to the importance of institution-level factors on these women's selection into, and persistence within, STEM disciplines.

The most common intended STEM field for WRC freshmen was the biological sciences.[3] Among STEM majors, 40.9% (n=79) intended to major in this field, compared to, for instance, 17.6% (n=34) in engineering[4] and 8.8% (n=17) in food science or nutrition. Other majors were far less common. For example, only four students (2.1%) intended to major in chemistry, and only one (.5%) indicated that she would major in physics. These disciplinary trends are in line with previous research about gendered subject choice (Sax, Jacobs, & Riggers, 2010).

These data point to several factors associated with WRC women's entry into STEM disciplines. As Table 1 illustrates, STEM majors had significantly higher mean math SAT scores than non-STEM majors (p=.000),[5] were significantly more likely to have college-educated fathers (p=.002), and were significantly less likely (p=0.040) to be transfer students. STEM major selection was also significantly (p=.000) associated with race, with Asian and White students being more likely to select STEM majors than Black and Hispanic students.

Not only was entry into STEM majors related to race/ethnicity, but these data reveal stark disciplinary differences in the types of majors selected by students in different racial/ethnic categories. For instance, Black students were significantly (p=.005) more likely than students of other races/ethnicities to major in the

biological sciences, but they were significantly less likely (p=.012) to major in engineering (Table 2). White students were significantly (p=.009) less likely than others to major in the biological sciences but significantly (p=.006) more likely to be nutrition or food science majors. Asian students were significantly (p=.013) more likely than other racial/ethnic groups to be pharmacy majors.

Table 1: Factors Associated with Selection into STEM Majors (n=374)[a]

Mean SAT Math Score (p=.000)[b]***	
Non-STEM Majors (n=133)	564.06
STEM Majors (n=163)	607.91

Father's Education Level (p=0.002**)	
Father Has Less Than a College Degree	44.8% (n=60) Majoring in STEM
Father Has a College Degree or Higher	62.5% (n=100) Majoring in STEM
Transfer Student Status (p=0.040*)[c]	
Non-Transfer Students	54.9% (n=151) Majoring in STEM
Transfer Students	42.9% (n=42) Majoring in STEM
Racial/Ethnic Category (p=.000)[d]***	
Black	40.7% (n=35) Majoring in STEM
Hispanic	43.3% (n=26) Majoring in STEM
White	54.4% (n=68) Majoring in STEM
Asian	74.3% (n=55) Majoring in STEM

[a]*p<.05; **p<.01; ***p<.001
[b]ANOVA test
[c]Compares undergraduate students with less than twelve college credits entering State University for the first time to undergraduate students with twelve or more college credits entering State University for the first time.
[d]Excludes Native Hawaiian or Pacific Islander (n=1), multiracial students (n=13), and students for whom racial/ethnic data were not available (n=9). Compares Black Non-Hispanic, Hispanic, White Non-Hispanic, and Asian only.

These disciplinary differences by race are particularly compelling in light of our findings concerning STEM "leavers" and "stayers" at the end of year two. As Table 3 illustrates, while we did not observe any statistically significant associations between attrition and racial/ethnic category, we did find a significant (p=.008) relationship between attrition and STEM major. In fact, a chi-square test comparing biological sciences students to all other STEM disciplines (not shown on Table 3) indicated that biological sciences students were significantly (p=.036) more likely than other majors to drop out of STEM. The fact that Black students were significantly more likely to major in the biological sciences, and that these majors were less "sticky" than other STEM majors, is important in the context of a

larger conversation about minority retention in STEM—particularly, scholarship about the retention of minority students in the health sciences (National Science Foundation, 2015; St. John et al., 2004).

Table 2: Percentage of Racial/Ethnic Category Intending to Major in STEM Discipline (n=184)[a]

Animal Science	***% in Major***	***p***
Black	11.4% (n=4)	0.263
Hispanic	11.5% (n=3)	0.337
White	4.4% (n=3)	0.282
Asian	5.5% (n=3)	0.578
Biological Sciences	***% in Major***	***p***
Black	62.9% (n=22)	0.005**
Hispanic	42.3% (n=11)	0.959
White	29.4% (n=20)	0.009**
Asian	43.6% (n=24)	0.748
Engineering	***% in Major***	***p***
Black	2.9% (n=1)	0.012*
Hispanic	19.2% (n=5)	0.789
White	22.1% (n=15)	0.201
Asian	20.0% (n=11)	0.542
Nutrition	***% in Major***	***p***
Black	2.9% (n=1)	0.173
Hispanic	3.8% (n=1)	0.344
White	16.2% (n=11)	0.006**
Asian	5.5% (n=3)	0.308
Pharmacy	***% in Major***	***p***
Black	2.9% (n=1)	0.535
Hispanic	0.0% (n=0)	0.212
White	2.9% (n=2)	0.348
Asian	10.9% (n=6)	0.013*

[a]p values from chi-square tests assessing percentage of each racial/ethnic category in each major, compared to all other racial/ethnic categories (includes only Black, Hispanic, White, and Asian) in that major. *p<.05; **p<.01; ***p<.001

In sum, our institutional and survey data reveal patterns in major selection and retention that align with prior work on undergraduate women in STEM, suggesting unevenness in STEM participation and retention based on sociodemographic characteristics such as race and family background. Our follow-up surveys and focus groups with a subset of students, moreover, pinpoint specific institutional factors that likely intersect with "imposter syndrome" and "stereotype threat" to play a role in these disparities.

Table 3: Factors Associated with STEM Major Retention at End of Year Two (n=146)[a]

Mean SAT Math Score (p=.003**)	
Leavers (n=20)	574.00
Stayers (n=102)	635.69

Racial/Ethnic Category (p=.190)[b]	
Black	78.3% (n=18) Stayers
Hispanic	75.0% (n=15) Stayers
White	85.5% (n=47) Stayers
Asian	93.2% (n=41) Stayers
Major in Year One (p=.008**)	
Agriculture	100.0% (n=2) Stayers
Animal Sciences	100.0% (n=13) Stayers
Biological Sciences	76.5% (n=39) Stayers
Computer Science or I.T.	100.0% (n=5) Stayers
Chemistry	25.0% (n=1) Stayers
Engineering	93.3% (n=28) Stayers
Environmental Science	83.3% (n=5) Stayers
Exercise Science	50.0% (n=3) Stayers
Food Science/Nutrition	92.3% (n=12) Stayers
Marine Science	100.0% (n=2) Stayers
Meteorology	100.0% (n=1) Stayers
Pharmacy	100.0% (n=7) Stayers
Physics	100.0% (n=1) Stayers

[a]*p<.05; **p<.01; ***p<.001
[b]Compares Black Non-Hispanic, Hispanic, White Non-Hispanic, and Asian only.

"Imposter Syndrome" at the Institutional Level: "Everyone Else Gets It"
At SU, most STEM prerequisites take the form of lecture courses containing hundreds of students. In every focus group, students brought up the issue of class size as a deterrent to their STEM participation. Many talked about the difficulty of making connections with other students in these large lectures. This lack of connections contributed to "imposter syndrome": participants in our study often talked about how "everyone else" seemed to understand the material easily.

One second-year engineering major explained, for example, "The classes are really freaking hard. And the kids in the classes—everyone seems like they're totally getting it and I'm totally not getting it sometimes. And you just feel out of place. Like everyone else is totally okay, and you're completely confused.". Another focus

group participant, similarly, linked class size to her uncertainty about her own abilities:

> I don't talk to a lot of people in my classes. 'Cause there is such a large group…So it's kind of like, not knowing where they stand relative to where you are. It's kind of daunting 'cause you don't really hear people asking questions or like, seeming worried or anything like that. Or seeming confused. So you kind of start to get an impression like, oh maybe they just get it and that's why they don't look fazed by any of this.

In these types of responses, WRC women repeatedly drew connections between their feelings of inadequacy—feelings at the core of "imposter syndrome" and "stereotype threat"—and the size of the classes at WRC. It is also probable that structuring courses in this way systematically disadvantages other types of students, such as racial minorities, who are at a higher risk for this phenomenon (Ong, 2005).

"Imposter Syndrome" at the Institutional Level: "Weed Out" Culture

Another institution-level factor linked to female students' feelings of inadequacy was the fact that STEM exams at State University, as one engineering student put it, "are made to dishearten you". Other scholarship (e.g. Seymour & Hewitt, 1997) has discussed the existence of a "weed out" culture in postsecondary STEM education; we found evidence of this as well. One theme we heard repeatedly, both from STEM "leavers" and "stayers", was that some STEM courses at SU were designed to "weed people out" and to "make you fail". As one physical sciences student said, "I don't know why they make it so hard here". Some women talked about low exam averages and professors who actively encouraged students to drop their courses. Other focus group participants described specific classes that they felt were geared toward failure. For example:

> Orgo [organic chemistry] is known as a 'weed out' course…I do think it's a little unfair, too, that they sort of ramp up the difficulty of Orgo on purpose, sort of to determine who's willing to stick it out. Because there are probably a lot of people who drop out of Orgo and who drop out of science fields who would be very good scientists or doctors or other things in those professions.

Still other students felt that this culture of attrition was not confined to specific classes but rather pervaded STEM courses in general at this institution. As one "leaver" told us:

> I feel like at [State University] it's set so that most of the students don't do well, because there's so many students that are in the sciences. The way they set up the sciences—it could be biology or chemistry—it's set so that only the brightest or the greats in science can do well and pass.

It is not difficult to imagine how "weed out" culture might deepen feelings of inadequacy, for women and other underrepresented STEM students who are already at greater risk for "imposter syndrome". For example, one theme in previous

research has been the impact of parents and peers on women's STEM selection and retention (Rayman & Brett, 1995; Robnett, 2013; Williams & Ceci, 2007). Our focus group data specifically illuminate how, at the institutional level, family characteristics work to facilitate STEM persistence in the face of this "weed out" system. Our findings suggest that students with family members who were involved in STEM—and, specifically, students with parents or other family members who had attended State University—had a clear advantage when it came to persisting within the culture of attrition at this institution. As a second-year engineering major explained:

> Both of my parents are engineers. Sometimes I would go to them kind of frustrated about my classes, like, 'I don't know if I wanna keep doing this.' But they're—because they kind of went through the same thing, and my mom actually did go to [State University]—they're both always like, 'Don't worry, we all know it's hard. That's why the averages are always terrible. But long-term, this is going to be worth it.' I guess seeing them where they're at also inspires me. Like, if they can get through all that, I can probably do it too.

Furthermore, on a practical level, specific institutional information from parents and older siblings was helpful for these students, who talked about knowing which professors were "easier," which University resources to use, and how to get credit for courses taken outside of State University.

"Imposter Syndrome" at the Institutional Level: The Impact of Programmatic Interventions

In line with other studies documenting the effectiveness of L/L communities (Szelényi & Inkelas, 2011), qualitative evidence from our focus groups supported a connection between STEM persistence and participation in programs for women in STEM. Furthermore, we found that, for some students at WRC, these communities served as a guard against "imposter syndrome." When asked what had kept her in her engineering major, one second-year student replied:

> For me it was the [L/L] program. 'Cause I kind of was surrounded by other people who were also struggling with their classes and were auditory about it, whereas everyone else in my classes would suppress their feeling of being really stupid all the time. So I had a group of people that were like, 'Oh, we're really bad at Calc. One, too. Let's all help each other'. …It was nice to have a group of girls around me that were open about not doing awesome all the time.

This response contrasts markedly with the experience of a former engineering student who had not formed attachments with peers in her major:

> I am friends with some people [who are STEM majors] but they're into the medical field, mostly, not really in engineering. When I was in [a prerequisite course] it was—the majority of men, also, but I wasn't the only girl, there were a few girls in that class—but everybody was very into

> themselves…It doesn't feel healthy because everybody is so competitive. You have to be better than the other person. Sometimes I would ask for help, and they would be very dry. Like, 'You couldn't get that?'…There weren't a lot of people in STEM that surrounded me that I interacted with.

WRC programs' mediating influence on "imposter syndrome" may be one reason why preliminary findings from the follow-up surveys suggested that there was a relationship between participation in STEM-related programming at the institutional level and STEM-major retention. For example, based on our intake survey data, 87.0% (n=20) of STEM students who had participated in WRC programs or clubs for women in science, engineering, and/or math intended to remain in their STEM majors at the end of their second year, compared to only 77.6% (n=52) of STEM students who had not taken part in these programs. However, due to the small sample size, this difference is not statistically significant (p=.33).

The potentially positive impact of WRC intervention programs is particularly important to consider in light of evidence that awareness and access to such resources is socially patterned. For example, when asked if they were aware of a graduate mentoring program that was offered at WRC, 58.3% (n=7) of commuting students said no, compared to 29.5% (n=18) of students who lived on campus.[6] While, perhaps due to the low sample size of the follow-up survey, this result is not statistically significant (p=.054), this finding suggests that lack of awareness of resources may deepen pre-existing social inequalities—for example, between resident and commuter students. In fact, qualitative evidence from the surveys and focus groups supports this point, as respondents who were transfers or other types of non-traditional students mentioned the challenges of feeling disconnected.

"What Did You Expect?": "Stereotype Threat" at the Institutional Level

Although we did not ask focus group participants about the relationship between gender stereotyping and STEM participation, some participants spontaneously discussed this topic. "I'm on the pre-med track, and I also want to be a surgeon possibly, so my parents are like, 'Why don't you do something that requires less time? Because you're a girl. You gotta have kids'". explained one second-year student. Another sophomore—a biochemistry major—told us, "Growing up, I was half encouraged and half discouraged from doing this type of stuff…Basically it comes down to, I had one parent who was very encouraging and one parent who was more discouraging about my abilities to do something like this…Because, specifically, I'm a female".

Our findings suggest that not only were students aware of these stereotypes but that institutional factors could play a role in "stereotype threat." These experiences, furthermore, were intersectional. For example, focus group responses suggested that large class size may exacerbate issues associated with minority and marginalized identities in STEM. A former chemistry major, for instance, recalled:

> My lecture, which was like 200-300 plus [people]…I was one of three black girls in that class. And it was more of a pride thing and not going up to the professor because it's kind of like, oh well, you're that black girl from the

> inner city school, of course you're going to need help. You know what I mean?...It's kind of like, oh, she's a black girl, what did you expect?...[I]t's still that whole fear of being in a science class and having it be filled with predominantly white males, and then there are a few white women there, and then it's kind of like being the minority in that class and being afraid to raise your hand because you might be 'the dumb one.' It was that whole fear.

This student's response encapsulates how the large lecture format may contribute to "stereotype threat" and the "double bind" of intersectional marginalized identity experienced by women of color in STEM. This finding reinforces prior work indicating that it is crucial to examine women's participation in science and technology fields through an intersectional lens (Malcom, Hall, & Brown, 1976; Ong *et al.*, 2011).

Gender-Role Stereotyping: Women and Communal Values

Though we found a connection between institution-level factors and "stereotype threat", we also found that gender-stereotypical role ideals actually *propelled* some women into STEM fields. One factor that was important in WRC students' decisions to remain in, or leave, STEM majors was the connection between class material and "communal values" (Diekman & Steinberg, 2013). Both "leavers" and "stayers" spoke about their desire to understand and see the impact of their work and to make a difference in the world around them.

However, these same gender-role stereotypes were also related to women's STEM attrition. One sentiment that students repeatedly expressed in focus groups was frustration at not understanding how some prerequisite courses connected to these goals. For example, one STEM "leaver" who had switched into a public health major told us:

> When I came to [State University]…[the pre-med culture] was overly-competitive and very—cutthroat is really the word for it—and I felt like most of the people weren't in it for the same reasons that I was: to help people...I felt like microbiology was sort of alienated from the real world…What I wish I had known before going to college was that there were other fields that I could go in where I would also be able to help people in a way but still be connected with the human side of things…People are slightly more interesting than proteins.

This student's assertion that she wanted to "help people" and understand the "human side" of her work echoes previous research about gender and scientific career aspirations. Sax (1994), for instance, has found that the prospect of monetary or status rewards tended to drive male college students' career aspirations, while females were more likely to be motivated by the perceived "social good" of these careers. Similarly, Diekman & Steinberg (2013) have found that engineering and computing occupations are not associated with societal and community concerns that are traditionally connected with female careers.

Furthermore, the fact that this student left the pre-med program to go into the STEM-adjacent field of public health also resonates with prior work on women in STEM. While little scholarship has followed the trajectories of former STEM majors, some research suggests that women who leave the pipeline are much more likely than men to switch into health or medical careers (Etzkowitz, Kemelgor, & Uzzi, 2000; Tomlinson, 2014). Our own survey data also suggest evidence of this trend. Among the 22 "leavers" for whom we had information about their declared majors at the end of their second year, the most common major was public health (n=5; 22.7%). While this finding comes from a relatively small sample of students, our other survey data support this connection between WRC students and the desire to do societal good. For example, when asked as part of the first-year survey about WRC programs relating to advocacy and/or health, substantial portions of first-year students—both STEM and non-STEM students—indicated an interest in these programs. For example, more than half—54.4% (n=364)—said that they were interested in human rights advocacy, 36.8% (n=246) indicated an interested in global health programs, and 32.9% (n=220) were interested in exploring the health and dignity of girls and women.[7]

In sum, though the desire to make a difference was a gender-related element that drew women to STEM interests and majors, institution-level factors such as "cutthroat" environments and a lack of emphasis on practical implications, ultimately, played a role in women's attrition from these fields.

LIMITATIONS

One limitation of these data is that they do not include comparative information about male students. It is probable that some of the institution-level factors we have identified—such as the worry that "everyone else" in a large lecture course understands the subject matter,, or frustration at the disjuncture between class material and exam material—impact men's STEM attrition at State University as well as women's. Yet female STEM students are more likely than males to underestimate their own abilities in STEM (Drew, 1996; Felder et al., 1995), to have lower self-confidence (Colbeck, Cabrera, & Terenzini, 2001), to have difficulty identifying with the label of "scientist" (Ong, 2005), and to be motivated to see the societal good in their work (Sax, 1994 ; Diekman & Steinberg, 2013). "Stereotype threat", due to prevailing cultural norms associating STEM careers with men, can be worsened in these settings where women are marginalized and isolated (Murphy et. al. 2007). Furthermore, a wealth of prior research (e.g. Clance & O'Toole 1988; Pell 1996; Yentsch & Sindermann 2013) has pinpointed "imposter syndrome" as an issue of specific concern for women. In addition, as other scholars have pointed out, female students are more likely to prefer teaching practices such as cooperative learning and class discussions, versus some of the specific practices we identify—like large lecture formats (Sax 2001; Colbeck, Cabrera, & Terenzini, 2001). While future work, then, should turn attention to the impact of intra-institutional factors on both men's and women's undergraduate STEM attrition, it is also probable that these issues disproportionately impact female students.

We also only follow these students over two years of their college trajectories. Based on previous research (Leggon, 2006; Seymour & Hewitt, 1997), it is likely

that some students whom we coded as "stayers" will drop out of STEM later in their college trajectories. However, a strength of these data are that they provide a look at which students are most at risk for dropping out of STEM early in their undergraduate tenures.

Finally, our findings cannot fully capture the diversity of factors related to STEM retention and attrition at WRC. As in the case of Mullen's (2014) and Hughes's (2011) work, our results suggest a plurality of experiences and meanings around choosing a major. But at the same time that these data reveal variation in experiences, they also highlight shared and systematic institutional practices that contribute to STEM selection, retention, and attrition among women—and particular subgroups of women—at this residential college.

DISCUSSION AND CONCLUSIONS

Our findings suggest that both "stereotype threat" and "imposter syndrome" are connected to institutional-level factors that contribute to women's STEM attraction at WRC. These results bolster previous research by pinpointing several factors—including sociodemographic dynamics, family and peer networks, "weed out" culture, and the desire to do societal good—related to the major selection and persistence of undergraduate women in STEM. However, they also extend prior scholarship by specifically highlighting the ways in which these factors might be influenced by, and work uniquely within, particular institutional contexts.

Our findings have implications not only for work on "stereotype threat" and "imposter syndrome" but for scholarship on women and other under-represented groups in STEM more broadly. For instance, women's desire to relate their coursework to practical "helping" applications relates to the broader framing of STEM fields but also to pedagogical practices and specific cultures of teaching at the university and college levels. Additionally, our findings illuminate the ways in which these institution-level factors can work to disadvantage not only women but other groups in STEM, such as under-represented minorities, non-traditional students, and first-generation college students.

These findings suggest that acknowledging inter-institutional diversity and particular contextual challenges for female STEM students should be a crucial part of interventions in this area. It is clear, for instance, that taking an introductory physics course in a seminar at a small liberal arts college is a markedly different experience from taking it in a 500-person lecture. In fact, some of our focus group respondents specifically talked about taking prerequisite courses at other schools in order to avoid large lectures. Our results also highlight the particular importance of L/L communities within larger institutions like SU. Such communities break down students into smaller groups, spurring peer interaction within majors and placing them at less risk for "imposter syndrome". Additionally, our results suggest that comparing institutions based on the programs they offer to support women in STEM could obscure internal unevenness in awareness of and access to these programs—unevenness that may exacerbate pre-existing inequalities within student populations. Outreach efforts at the school level should focus on bringing awareness of STEM-related resources to broader swaths of students.

Contrary to prior work, which tends to analyze either large, multi-institutional datasets or intra-institutional data using small numbers of cases, we have drilled down to the institution level by drawing on data from a multi-year, multi-method project involving a highly diverse undergraduate sample. Our findings have much to contribute to the existing conversation on women's participation in STEM at the postsecondary level. However, we also hope that they will serve as a catalyst for further research in several different areas. First, we highlight the benefit of examining students' pathways into and out of degrees over time during undergraduate education. Many large data sets do not track students' movements into and out of their intended major over time, but begin their analyses when students enroll in a STEM major. Secondly, our study takes into account students' intended major versus their enrolled major, capturing the disparity between women interested in the biological sciences and those who actually went on to declare a biological science major. In light of Mullen's (2014) findings that the choosing of a major can be influenced by specific institutional context, including the range of possible majors offered and the ways that STEM may be positioned in relation to the liberal arts and social sciences, more scholarship is needed to better understand this connection. Finally, our work currently follows our initial cohort of students for only two years. Future scholarship should continue to assess not only the ways in which school-level effects factor into female students' STEM participation but also how these contextual differences play out over the course of these women's full college experiences.

ENDNOTES

[1]L/L Communities are environments in which undergraduates live together in a residence hall, or an area of a residence hall, and engage in mutual academic and extra-curricular programming.
[2]Racial/ethnic categories are exclusive. "Hispanic" includes persons, regardless of race, having origins in any of the Hispanic cultures of the Americas. Racial/ethnic data were not available for 9 students (2.4% of sample). One student (.3% of sample) was coded as Native Hawaiian or Pacific Islander/non-Asian. No students were coded as American Indian or Alaskan Native.
[3]"Biological sciences" majors include animal biotechnology, biochemistry, biology, bio- mathematics, biotechnology, cell biology and neuroscience, genetics, marine biology, microbiology, and molecular biology and biochemistry.
[4]"Engineering" majors include applied science engineering, bioenvironmental engineering, biomedical engineering, chemical engineering, civil engineering, electrical and computer engineering, industrial engineering, materials science and engineering, and mechanical engineering.
[5]Interestingly, intended STEM majors also had slightly higher mean verbal SAT scores than non-STEM majors (580.25, compared to 563.46), though this difference was not statistically significant (p=.133) (not shown on Table 1).
[6]Students who lived on campus during their first year at WRC, versus those who lived off-campus with friends or relatives.

REFERENCES

Blickenstaff, J.C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education,* 17, 369-386.

Clance, P. R., & Imes, S. A. (1978). The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. *Psychotherapy: Theory, Research & Practice*, 15, 241-247.

Clance, P. R., & O'Toole, M. A. (1988). The imposter phenomenon: an internal barrier to empowerment and achievement. *Women and Therapy*, 6, 51–64.

Colbeck, C. L., Cabrera, A. F., & Terenzini, P. T. (2001). Learning professional confidence: Linking teaching practices, students' self-perceptions, and gender. *The Review of Higher Education*, 24, 173–191.

Corbett, C., & Hill, C. (2015). Solving the Equation: The Variables for Women's Success in Engineering and Computing. Washington, D.C.: AAUW. Retrieved from http://www.aauw.org/research/solving-the-equation/

Diekman, A. B., & Steinberg, M. (2013). Navigating Social Roles in Pursuit of Important Goals: A Communal Goal Congruity Account of STEM Pursuits. Social and Personality Psychology Compass, 7(7), 487–501. http://doi.org/10.1111/spc3.12042

Drew, D. W. (1996). *Aptitude revisited: Rethinking math and science education for America's next century.* Baltimore, MD: Johns Hopkins University Press.

Etzkowitz, H., Kemelgor, C. & Uzzi, B. (2000). *Athena unbound: The advancement of women in science and technology*. Cambridge University Press.

Farmer, H. S. (1997). Women's motivation related to mastery, career salience, and career aspiration: A multivariate model focusing on the effects of sex role socialization. *Journal of Career Assessment*, 5, 355-381.

Felder, R. M., Felder, G. N., Mauney, M., Hamrin, C. E., Jr., & Dietz, E. J. (1995). A longitudinal study of engineering student performance and retention: Gender differences in student performances and attitudes. *Journal of Engineering Education*, 84, 151-163.

Hazari, Z., Sonnert, G., Sadler, P.M. & Shanahan, M.C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, 47, 978-1003.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: American Association of University Women.

Huang P.M., & Brainard, S.G. (2001). Identifying determinants of academic self-confidence among science, math, engineering, and technology students. *Journal of Women and Minorities in Science and Engineering*, 7, 315-337.

Hughes, R. (2011). Are the predictors of women's persistence in STEM painting the full picture? A series of comparative case studies. *International Journal of Gender, Science and Technology*, 3, 547-570.

Hughes, R. (2014). The Effects of a Single-Sex STEM Living and Learning Program on Female Undergraduates' Persistence. *International Journal of Gender, Science and Technology*, 6, 25-54.

Hughes, R., & Molyneaux, K. (2015). Unpacking secondary school students' identity negotiations regarding science and engineering: A case study in the United States. *International Journal of Gender, Science and Technology*, 6, 291-309.

Leggon, C. B. (2006). Women in science: Racial and ethnic differences and the differences they make. *Journal of Technology Transfer*, 31, 325-333.

Malcom, S.M., Hall, P.Q., & Brown, J.W. (1976). *The double bind: The price of being a minority woman in science.* Washington, DC: American Association for the Advancement of Science.

Margolis, J. & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing.* Cambridge, MA: MIT Press.

Mullen, A. L. (2014). Gender, social background, and the choice of college major in a liberal arts context. *Gender & Society*, 28, 289-312.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling Threat: How Situational Cues Affect Women in Math, Science, and Engineering Settings. Psychological Science (Wiley-Blackwell), 18(10), 879–885. http://doi.org/10.1111/j.1467-9280.2007.01995.x

National Science Foundation. (2013). *Science and engineering degrees: 1966-2010.* Arlington, VA. Retrieved from http://www.nsf.gov/statistics/nsf13327/content.cfm?pub_id=4266&id=2

National Science Foundation, National Center for Science and Engineering Statistics. (2015). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2015*. Special Report NSF 15-311. Arlington, VA. Retrieved from http://www.nsf.gov/statistics/wmpd/.

Nosek, B.A., Smyth, F.L., Sriram, N., Lindner, N.M., Devos, T., Avala, A., Greenwald, A.G. (2009). National differences in gender-science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences*, 106,

10593-10597.

OECD. (2012). *Better skills, better jobs, better lives: A strategic approach to skills policies.* OECD Publishing. Retrieved from http://www.oecd-ilibrary.org/education/better-skills-better-jobs-better-lives_9789264177338-en

Ong, M. (2005). Body projects of young women of color in physics: Intersections of gender, race, and science. *Social Problems*, 52, 593-617.

Ong, M., Wright, C., Espinosa, L.L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in

science, technology, engineering, and mathematics. *Harvard Educational Review*, 81, 181-196.

Pell, A. N. (1996). Fixing the leaky pipeline: Women scientists in academia. *Journal of Animal Science*, 74, 2843-2848.

Rayman, P., & Brett, B. (1995). Women science majors: What makes a difference in persistence after graduation? *Journal of Higher Education*, 66, 388–414.

Robnett, R. (2013). The role of peer support for girls and women in the STEM pipeline: Implications for identity and anticipated retention. *International Journal of Gender, Science, and Technology*, 5, 233-253.

Sax, L. J. (1994). Retaining tomorrow's scientists: Exploring the factors that keep male and female students interested in science careers. *Journal of Women and Minorities in Science and Engineering*, 1, 45-61.

Sax, L.J. (2008). *The gender gap in college: Maximizing the developmental potential of women and men.* San Francisco: Jossey-Bass.

Sax, L.J., Jacobs, J.A., & Riggers, T. (2010). Women's representation in science and technology (STEM) fields of study, 1976-2006. Annual Meeting of the Association for the Study of Higher Education (ASHE), November 2010, Indianapolis, Indiana.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Solnick, S.J. (1995). Changes in women's majors from entrance to graduation at women's and coeducational colleges. *Industrial and Labor Relations Review*, 48, 505-14.

Starobin, S.S., & Laanan, F.S. (2008). Broadening female participation in science, technology, engineering, and mathematics: Experiences at community colleges. *New Directions for Community Colleges*, 142, 37-46.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. American Psychologist, 52(6), 613–629. http://doi.org/10.1037/0003-066X.52.6.613

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). Journal of Personality and Social Psychology, 100(2), 255–270. http://doi.org/10.1037/a0021385

St. John, E. P. S., Hu, S., Simmons, A., Carter, D. F., & Weber, J. (2004). What Difference Does a Major Make? The Influence of College Major Field on Persistence by African American and White Students. *Research in Higher Education*, 45, 209–232.

Szelényi, K., & Inkelas, K.K. (2008) The role of living–learning programs in women's plans to attend graduate school in STEM fields. *Research in Higher* Education, 52, 349-369.

Tomlinson, C. (2014). Outcomes and options: Gender differences in exiting the STEM educational and career track. Paper presented at the American Sociological Association Annual Meeting. San Francisco, CA.

Van Loo, K. J. V., & Rydell, R. J. (2014). Negative exposure: Watching another woman subjected to dominant male behavior during a math interaction can induce stereotype threat. *Social Psychological and Personality Science*, 5, 601–607. http://doi.org/10.1177/1948550613511501 Williams, W.M. & Ceci, S.J., Eds. (2007). *Why aren't more women in science? Top researchers debate the evidence*, Washington D.C.: American Psychological Association.

Yasuhara, K. (2005). Choosing computer science: Women at the start of the undergraduate pipeline. Paper presented at the 2005 American Society for Engineering Education Annual Conference & Exposition.

Yentsch, C. M., & Sindermann, C. J. (2013). *The woman scientist: Meeting the challenges for a successful career*. New York: Springer.