

Where Women of Color thrive in STEM: Institutional factors and how departmental practices
indicate shared values

by

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B.S., Midland Lutheran College, 2005
M.S., Creighton University, 2008

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Department of Physics
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

This research is a part of an international collaboration titled *Centering Women of Color in STEM*. Women of color have been historically excluded from STEM fields. The goal of this larger project is to investigate where women of color are thriving in STEM. To do this, we analyzed 12 years of IPEDS data encompassing 77,975 physics graduates at 742 institutions, 275,941 math graduates at 1279 institutions, and 655,082 computer science graduates at 1426 institutions. From this data, we calculated effectiveness scores to facilitate comparison between institutions.

We next elicited common narratives about where women of color earn bachelor's degrees in physics and compared those narratives to the physics women of color effectiveness score. We looked for shared characteristics among institutions where women of color tend to earn physics degrees, such as geographic location, institutional size, and mission. Physics departments in minority serving institutions and women's colleges tend to graduate proportionally more women of color, even after controlling for institutional racial and gender demographics, than primarily white co-educational institutions. Other common narratives related to institution size, location, and Carnegie Classification are not supported by the data, suggesting that departmental factors should be investigated.

As a first step in investigating departmental factors, we used a communities of practice framework to explore how departments value different constituent groups, focusing on faculty, undergraduate, and graduate students. Through a collaborative, autoethnographic, contrastive case study of two physics departments, we analyzed the inter- and intra-constituency interactions and shared practice of each community demonstrating how each department centers or peripheralizes constituent groups. We argue that how each department enacts their community of

practice demonstrates a foundational shared value: faculty autonomy for one and pastoral care of undergraduates for the other.

Finally, we performed exploratory case studies of physics departments using data from their websites. We examined two cases: physics departments with high women of color effectiveness scores and physics, math, and computer science departments at the same institution with contrasting women of color effectiveness scores. Using conjecture mapping, we used our earlier results and literature to create a rubric for analyzing these websites. We see commonalities in the websites of departments that scored high including a focus on undergraduate research and career preparation. This exploratory work will help inform future case studies of high scoring departments.

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Approved by:

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Chapter 1 - Introduction

This work is part of the Centering Women of Color in STEM (CWCS) project. Motivated by the fact that women of color are underrepresented in STEM, this project asks, “Where are women of color thriving in STEM?” We analyzed quantitative data to determine where women of color (WoC) are graduating with bachelor’s degrees in physics and then used that analysis to inform several preliminary qualitative studies of physics departments. An important aspect of this project is that it focuses on success. As one of the leaders of this project points out in her article “Enacting Agency: The Strategies of Women of color in Computing,” focusing on WoC who persist and succeed helps us focus on the ways they enact their own agency rather than painting them as passive victims [1].

Chapter 2 is a review of the literature related to WoC in STEM, specifically focusing on undergraduate women of color in physics.

Chapter 3 describes the data used for the quantitative part of this work. A major portion of the CWCS project that is not covered in this dissertation has involved making this data available to the public on a portal so that prospective students as well as current faculty and administrators can interact with it. This chapter outlines how we obtained this data and used it to calculate effectiveness scores for departments. These effectiveness scores are used in the following chapters and were used to characterize institutions on the CWCS portal.

Chapter 4 describes common narratives related to where WoC earn bachelor’s degrees in physics, connects these narratives to easily measured institutional characteristics, and uses those characteristics to compare the narratives to our quantitative data. A major conclusion of this chapter is that most of these narratives are not supported by the data, suggesting that

departmental level factors rather than institutional level factors play a role in where WoC earn physics bachelor's degrees.

Chapter 5 is a collaborative, autoethnographic study of two physics departments. We used communities of practice (CoP) as a framework to examine departmental values as implied by a department's shared practice. This study is a first step in analyzing physics departments to figure out what departmental characteristics and practices support undergraduate students, particularly ones from historically excluded groups.

Chapter 6 describes another step towards studying individual physics departments. We chose physics departments with high effectiveness scores and completed exploratory case studies of the departments' websites. As a data source, websites are extremely incomplete. However, by examining what departments choose to include on their websites, we can infer information about what physics departments think is important for prospective physics majors to know. These exploratory case studies will help inform future case studies on high scoring departments.

Chapter 7 contains concluding remarks and some discussion of future directions for this work.

Chapter 2 - Literature Review

2.1 Motivation

Women of Color (WoC) are underrepresented in STEM. At the bachelor's level, which is what this project focuses on, WoC make up 13% of science and engineering students while they make up 22% of the U.S. population age 18-24 [2]. Women from underrepresented groups have among the lowest rates of STEM persistence compared to other STEM students [3,4].

Many studies highlight three reasons to care about the status of historically excluded people in STEM [5–7]. There has been increased demand to fill the STEM workforce and people who have been historically excluded from STEM represent a way to fill that demand. Another argument is that the field itself will benefit from the diverse perspectives that historically excluded people can bring. Finally, but perhaps most importantly, there is a social justice reason for increasing historically excluded people's representation in STEM.

Historically, many studies investigating underrepresentation in STEM have focused on gender or race. As Johnson points out in a 2007 chapter examining the experiences of WoC in STEM, a partial explanation for this is small numbers [8]. The numbers of WoC in STEM is smaller than the number of all women and the number of all people of color. Despite this, it is important to understand the experiences of WoC as being unique from all women and all people of color. In Ong's 2011 synthesis of 38 years of studies on WoC in STEM, the author points out that programs that are designed for women disproportionately benefit white women and programs that focus on underrepresented minorities disproportionately benefit men [7].

These two points highlight the importance of using an intersectional lens, which takes into account the multiple identities a person has while also paying attention to the ways those identities intersect, when examining the experiences of WoC in STEM. The two identities,

women and person of color, interact in a way to create overlapping systems of oppression and discrimination that are distinct from the experience of white women or men of color. Many studies have pointed out the importance of considering intersectionality in this situation [5].

A historically common yet incorrect way to interpret the lack of WoC in STEM is to conclude that WoC have a lack of interest in STEM compared to white women and men. In a synthesis of 38 years of research related to women of color in STEM, Ong et. al. found this assumption to not be supported by research [7].

2.2 STEM Culture

As Johnson points out, “Science is portrayed as being neutral regarding issues of racial, ethnic, cultural, and gender differences. The culture of science is a meritocracy that is seen as competitive, difficult, and intellectually superior to other academic and professional fields because of the required technical and scientific expertise” [8]. This culture can contribute to assumptions that students from historically excluded groups are inferior [9].

Ong states that efforts that focus on fixing underrepresented students rather than addressing cultural issues within STEM disciplines contributes to a message that these students do not belong in STEM [10].

2.3 Factors that hurt persistence

There are many factors that can negatively influence WoC’s persistence in STEM. One factor is a sense of isolation and microaggressions. Ong et al. interviewed 39 women of color from various STEM disciplines and found that they experienced isolation and microaggressions which contributed to a sense of not belonging and negatively affected persistence [10]. In another study, Ong et al. found that WoC in postsecondary STEM regularly face gender and racial bias [7].

Students of color find it hard to position themselves and be seen by others as scientists [9]. Studies have also pointed out that WoC are often regarded as representatives of their race and gender rather than future scientists [11].

Another factor that can affect persistence is a lack of peers and mentors. Many studies have pointed out that black students in STEM face a lack of role models or mentors and, since many of their peers drop out of STEM fields, they can become more isolated [12,13].

There are also classroom practices that can affect persistence. Gatekeeper or weed out courses with a competitive culture can have a negative effect of all students but particularly those from historically excluded backgrounds [6]. Conversely, STEM learning environments that have a cooperative peer culture can help lessen the effects of systematic barriers [14].

2.4 Factors that increase persistence

2.4.1 Counterspaces

Ong et al. define counterspace 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 by sharing stories of isolation, microaggressions, and/or overt discrimination; and challenge deficit notions of people of color (and other marginalized groups) and establish and maintain a positive collegiate racial climate for themselves” [10]. One important aspect of these spaces is that they do not have to be physical spaces. In fact, Ong et al.’s study found that peer-to-peer relationships, campus groups, and mentoring relationships can also serve as counterspaces.

Other researchers have found that persistence among African-American and Latino students could be improved if the students had experiences like strong peer support [15,16].

Because WoC can often experience STEM spaces as unwelcoming, due to feelings of isolation [7] and microaggressions [9], finding both physical space and supportive relationships can help WoC persist in STEM.

2.4.2 STEM Enrichment Programs and Mentoring

Many studies highlighted the beneficial effects of STEM enrichment programs, mentoring, and participation in research [3,7,17–21].

In one case study on the experiences of three high-achieving black undergraduate and graduate women in STEM, a theme emerged related to the need for such students to have mentors who have had similar experiences of gender and race bias [22]. Other studies have agreed but also point out that faculty from different backgrounds than the student can still have a beneficial effect when they serve as mentors [19]. Students can also benefit from mentor relationships with alumni and upper level students [17,23] and from having their achievements recognized by faculty [7,19,24]. In a 2019 study, Johnson et. al. found that having black women, black men, and allies as role models for black women in STEM increased the student's sense of belonging at the institution [25]. The importance of having allies as mentors is also highlighted in a study by McCoy et al., which found that white faculty who participated as “colorblind” mentors often found ways to describe their mentees of color as less prepared [21].

Studies have also shown the benefits of participating in research. Espinosa found that WoC who participate in research programs are more likely to persist in STEM [6]. Participating in undergraduate research can result in academic performance gains among undergraduates and can increase retention [26]. In a study of an undergraduate research program at a minority serving institution (MSI), researchers found that participants were more likely to attend graduate school than non-participants.

2.4.3 Campus and Academic Resources

Campus resources can provide important support for undergraduate students and ones that are geared toward underrepresented students are particularly helpful for WoC.

In 2015, researchers at the University of California, Los Angeles, reported improved persistence for underrepresented students enrolled in an academic support program for STEM majors from underrepresented backgrounds [27]. Additionally, several studies have reported that resources such as support groups, learning communities, and student organizations were helpful for persistence of WoC in STEM [17,18,23,28].

2.5 Institution Characteristics

Many studies find that Historically Black Colleges/Universities (HBCUs) provide supportive environments for WoC in STEM. In Ong's review of empirical studies, they found HBCUs provided a supportive climate for women in STEM [7]. In a qualitative comparison between experiences as a predominantly white institution (PWI) and an HBCU, Winkle-Wagner and McCoy found that students of color at the PWI felt excluded in their major whereas the students at the HBCU perceived their discipline as diverse and the institution as supportive [29]. A 2015 study found that black women at HBCUs were more likely to major in STEM than black and white women at PWIs [30]

How selective an institution is can also play a role. Espinosa found that WoC attending highly selective institutions were more likely to switch out of STEM by their fourth year. She proposes this could be due to these institutions engaging in practices that discourage students from staying in STEM, like having a culture that values research over teaching and engaging in

competitive grading practices [6]. Attending a private school and having a more STEM majors in the student body were also positive predictors for WoC to persist in STEM majors [6].

Chapter 3 - Data

3.1 Data Source

Data used in this project came from several publicly available databases. The Integrated Post Secondary Education Data System (IPEDS) consists of data gathered by the U.S. Department of Education's National Center for Educational Statistics. Every institution that participates in federal student financial aid programs reports information to IPEDS including data related to institutional characteristics and graduates [31]. The Carnegie Classifications of Institutions of Higher Education uses data from IPEDS, the National Science Foundation Higher Education Research and Development (HERD) Survey, and the NSF Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS) to classify institutions based on criteria related to the amount of research they do [32]. The R-script used to download and clean the data from these sources is in appendix A.

3.2 Variables Selected

For this project, we selected a subset of the data reported to IPEDS. This subset contains characteristics of institutions like location and size, the numbers of degrees awarded by each institution in different disciplines, and demographic information about degree earners at each institution.

3.2.1 Institutional Characteristics

To characterize the institutions, we selected location, size, control, and several variables related to the institutional mission including the institution's Carnegie Classification, whether it is co-educational or men or women only, and whether it is a Minority Serving Institution (MSI) or a Predominantly White Institution (PWI). These variables and their possible values are summarized in Table 3-1.

Table 3-1 Institutional characteristics used from IPEDS

Variable	Possible Values
Location	U.S. Service schools New England (CT, ME, MA, NH, RI, VT) Mid East (DE, DC, MD, NJ, NY, PA) Great Lakes (IL, IN, MI, OH, WI) Plains (IA, KS, MN, MO, NE, ND, SD), Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV) Southwest (AZ, NM, OK, TX) Rocky Mountains (CO, ID, MT, UT, WY) Far West (AK, CA, HI, NV, OR, WA) Other U.S. jurisdictions (AS, FM, GU, MH, MP, PR, PW, VI)
Carnegie Classification	Under 1,000 (very small)
Size (Four-year institutions)	1,000 - 2,999 (small) 3,000 - 9,999 (medium) Above 10,000 (large)
Control	Public Private not-for-profit Private for-profit
2021 Basic Carnegie Classifications	Doctoral Universities - Very High Research Activity Doctoral Universities - High Research Activity Doctoral/Professional Universities Master's Colleges and Universities - Larger Programs Master's Colleges and Universities - Medium Programs Master's Colleges and Universities - Smaller Programs Baccalaureate Colleges - Arts & Sciences Focus Baccalaureate Colleges - Diverse Fields Baccalaureate/Associate's Colleges: Mixed Baccalaureate/Associate's Baccalaureate College's: Associate's Dominant Special Focus Four-Year: Engineering and Other Technology-Related Schools Special Focus Four-Year: Other Health Professions Schools Special Focus Four-Year: Business & Management Schools Special Focus Four-Year: Arts, Music & Design Schools Special Focus Four-Year: Other Special Focus Institutions Special Focus Two-Year: Other Fields Tribal Colleges and Universities
Minority Serving Institutions	MSI Not MSI
Men's Only Institutions	Men's Only Not Men's Only
Women's Only Institutions	Women's Only Not Women's Only

3.2.2 Awards Variables

IPEDS contains information related to the number of bachelor's degrees awarded by each institution broken down by discipline, gender, and race/ethnicity. To specify the discipline, IPEDS uses the Classification of Instructional Program (CIP) code. For each institution and CIP code, the number of degrees earned by men and by women and the number of degrees awarded by race/ethnicity of the degree earner are listed. The race/ethnicity categories used were developed in 1997 by the Office of Management and Budget and are American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, White, Two or more races, Race/ethnicity unknown, and Nonresident alien [31]. Both the gender categories and the race/ethnicity categories are imperfect representations of an individual student's identity. For example, the way gender is reported does not account for non-binary people and may not accurately reflect the gender of a trans person. The Asian category is broad and includes groups that have been historically excluded in STEM and groups that are overrepresented in STEM. Indigeneity in the US is fraught with complicated and contradictory colonial artifacts which tend to both exclude and undercount indigenous students of any gender. Additionally, a student who belongs to more than one category might not be placed in the category they most identify with depending on how their institution gathers and reports this data. It's important to keep these limitations in mind, especially when talking about individual students. In this work, however, we have a large amount of data and are focusing on trends.

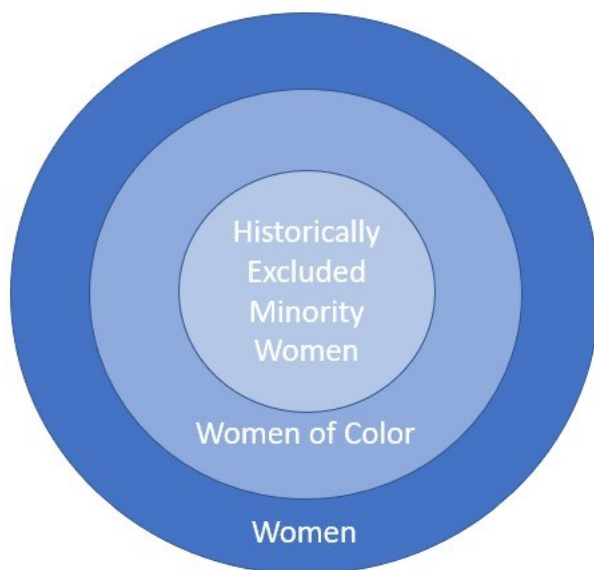
3.2.3 Population Definitions

The central goal of this project is to investigate where women who belong to racial groups that have been historically excluded from STEM earn bachelor's degrees. One limitation of the data is that the numbers of STEM bachelor's degree earners who belong to the

race/ethnicity categories that we are interested in are small. To account for this, we combined race/ethnicity categories rather than looking at each one individually. Since there are several different ways to do this, we defined one group that represents the most inclusive definition of women of color (WoC) and one that represents a more exclusive group.

In the U.S., the term WoC generally refers to women who are not white. Using this definition and the race/ethnicity categories from IPEDS, we defined WoC as women whose schools identified them as American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, or two or more races. We also defined historically excluded minority women (HEMW) as women whose schools identified them as American Indian or Alaska Native, Black or African American, or Hispanic or Latino. The relationship between these three categories is shown in Figure 3-1. In all three cases, we do not include international students.

Figure 3-1 Venn diagram of demographic categories



3.2.4 Inclusion Criteria

This section discusses the choices that we made about what data to include in the larger dataset. We discuss how we determined which bachelor's degrees represent the fields we are interested in, how we address for-profit institutions, and other reasons some institutions were excluded.

STEM Discipline

We selected physics, math, and computer science as the STEM fields of interest because they have among the lowest representation of women and of WoC [33] and because they are degrees that are available at a variety of institutions. From 2006 — 2016, women earned 19% of the bachelor's degrees awarded in physics, 18% of the bachelor's degrees awarded in computer science, and 43% of the bachelor's degrees awarded in math and statistics while making up 49% of the US population and 58% of the total degrees awarded in biological sciences, chemistry, math and statistics, astronomy, computer science engineering, and physics. WoC make up 20.6% of the US population and earned 20.7% of the overall STEM degrees but only earned 5% of physics degrees, 9% of computer science degrees and 13% of computer science degrees.

To analyze data related to degrees awarded in these three fields, we had to decide what CIP codes to use for each field. Within a CIP code, a program is classified at three different levels that correspond to increasingly narrow fields of study. For example, CIP code 40 corresponds to physical science. Within that code, physics is 40.08. Specific areas of physics are classified as 40.08xx. These codes are occasionally updated but since most of our data came from the 2010s, we used the 2010 CIP codes.

For physics, we used all nine of the codes classified under 40.08 "Physics." 89% of the programs and 96% of the degrees in our physics data came from CIP code 40.0801 "Physics,

General.” The total number of programs and degrees for each CIP code used for physics are summarized in Table 3-2. The table also shows the number and percentage of degrees for each CIP code that were earned by women, WoC, and HEMW.

Table 3-2 CIP codes used for Physics

CIP Code	Description	Programs	Degrees	Degrees Earned by Women	Degrees Earned by WoC	Degrees Earned by HEMW
40.08	Physics	915	78946	16153	3821	1887
		100.00%	100.00%	20.46%	4.84%	2.39%
40.0801	Physics, General	812	75524	15472	3639	1793
		88.74%	95.67%	20.49%	4.82%	3.11%
40.0802	Atomic/Molecular Physics	5	61	17	8	2
		0.62%	0.08%	27.87%	13.11%	3.28%
40.0804	Elementary Particle Physics	0	0			
		0.00%	0.00%			
40.0805	Plasma and High-Temperature Physics	0	0			
		0.00%	0.00%			
40.0806	Nuclear Physics	1	2	1	0	0
		0.12%	0.00%	50.00%	0.00%	0.00%
40.0807	Optics/Optical Sciences	8	447	95	34	14
		0.99%	0.57%	21.25%	7.61%	4.70%
40.0809	Acoustics	3	195	28	10	4
		0.37%	0.25%	14.36%	5.13%	3.08%
40.0810	Theoretical and Mathematical Physics	14	168	36	3	2
		1.72%	0.21%	21.43%	1.79%	1.19%
40.0899	Physics, Other	72	2549	504	127	72
		8.87%	3.23%	19.77%	4.98%	3.65%

For math, we used all codes programs under code 27, “Mathematics and Statistics.” which included 27.01 “Mathematics,” 27.03 “Applied Mathematics,” 27.05 “Statistics,” and 27.99 “Mathematics and Statistics, Other.” The CIP codes used, number of programs, and number of degrees are summarized in Table 3-3. Most of the math data (66% of programs and 77% of degrees) came from code 27.0101 “Mathematics, General.”

Table 3-3 CIP Codes used for Math

CIP Code	Description	Programs	Degrees	Degrees Earned by Women	Degrees Earned by WoC	Degrees Earned by HEMW
27	Mathematics and Statistics	1911	275481	114931	29712	14983
27.01	Mathematics	1307 68.39%	215982 78.40%	91411 43.32%	22856 10.58%	13015 6.03%
27.03	Applied Mathematics	320 16.75%	28794 10.45%	10324 35.85%	3210 11.15%	1063 3.69%
27.05	Statistics	220 11.51%	27703 10.06%	11891 42.92%	3281 11.84%	762 2.75%
27.99	Mathematics and Statistics, Other	64 3.35%	3002 1.09%	1305 43.47%	365 12.16%	143 4.76%

Computer Science is classified in CIP code 11 “Computer and Information Sciences and Support Services.” Within code 11, there are 30 different subdisciplines. To decide which ones to use in our data set, we looked at the how many programs there are and how many degrees were awarded in each code to ensure that the data set does not have large contributions from codes that correspond to topics that are not computer science, like data entry and word processing. We also wanted to see if certain codes had higher or lower percentages of degrees awarded to WoC. The number of programs and degrees awarded for each CIP code within code 11 are summarize in Table 3-4. The largest contribution to the dataset comes from codes located with 11.01 “Computer and Information Sciences, General.” These codes contributed 35% of the programs and 41% of the degrees. The second highest contribution came from codes located within 11.07 “Computer Science.” Codes within 11.03 “Data Processing” and 11.06 “Data Entry/Microcomputer Applications” contributed minimally to the overall data. For each code, we also looked at the percentage of degrees that were awarded to women, WoC, and HEMW. While these percentages vary a bit by CIP code the codes that show the most variation from the total computer science category contain small number of programs and degrees. Because of this,

we argue that programs that some may not consider to be computer science have a minimal contribution to the overall data set and decided to use all the CIP Codes located in 11 “Computer and Information Services and Support.”

Table 3-4 CIP Codes used for Computer Science

CIP Code	Description	Programs	Degrees	Degrees Earned by Women	Degrees Earned by WoC	Degrees Earned by HEMW
11	Computer and Information Sciences and Support Services	3753	687689	132874 19.32%	54237 7.89%	28224 4.10%
11.01	Computer and Information Sciences, General	1313 34.99%	279093 40.58%	53216 19.07%	20987 7.52%	11654 4.18%
11.02	Computer Programming	145 3.86%	26086 3.79%	3332 12.77%	616 2.36%	398 1.53%
11.03	Data Processing	24 0.64%	2496 0.36%	468 18.75%	88 3.53%	61 2.44%
11.04	Information Science/Studies	351 9.35%	67622 9.83%	16412 24.27%	7844 11.60%	4887 7.23%
11.05	Computer Systems Analysis	98 2.61%	11222 1.63%	2430 21.65%	1029 9.17%	716 6.38%
11.06	Data Entry/Microcomputer Applications	1 0.03%	3 0.00%	3 100.00%	0 0.00%	0 0.00%
11.07	Computer Science	794 21.16%	206750 30.06%	35876 17.35%	15769 7.63%	4998 2.42%
11.08	Computer Software and Media Applications	329 8.77%	28296 4.11%	10291 36.37%	3448 12.19%	2204 7.79%
11.09	Computer Systems Networking and Telecommunications	124 3.30%	14507 2.11%	1692 11.66%	825 5.69%	691 4.76%
11.10	Computer/Information Technology Administration and Management	485 12.92%	47649 6.93%	8351 17.53%	3338 7.01%	2396 5.03%
11.99	Computer and Information Sciences and Support Services, Other	90 2.40%	3968 0.58%	806 20.31%	293 7.38%	219 5.52%

Institution Control

The institution control variable corresponds to whether a school is public or private and whether it is for-profit or not-for-profit. Private for-profit schools are often predatory, not accredited, and thus a degree from such schools may not be considered as legitimate as one from a public or private non-profit school. However, these institutions also appeal to some students, particularly students who value convenience in scheduling and an emphasis on career preparation [34]. Even though many for-profit institutions have worse outcomes for students in terms of degree completion, student loan default rate, and job placement rates, many students, because of schedules, location, and cultural capital chose to attend for-profit institutions [35]. Giving these competing values, we decided to include accredited private for-profit institutions but exclude unaccredited ones. The number of private for-profit institutions included in the data set is summarized in Table 3-5. The physics data set contains no private for-profit schools, and the math data set has one, which was later excluded because it averaged fewer than one graduate per year. Computer science has 127 private for-profit institutions and 14 of them do not have an accreditor listed in IPEDS.

Table 3-5 Number of Private For-Profit Institutions

	Institutions	private for-profit	Accredited Private for-profit
Physics	800	0	0
Math	1290	1	1
Computer Science	1502	127	113

Excluded Programs

In addition to excluding unaccredited private for-profit schools, we excluded any institution that did not have an accreditor listed with IPEDS. This included four physics programs, six math programs, and 30 computer science programs. Since this project is concerned

with women in STEM, we excluded four physics and math programs and three computer science programs that are located at men's only institutions. Finally, we excluded any institution that averaged fewer than one major/year from 2008-2019. The number of schools excluded for each discipline is summarized in Table 3-6.

Table 3-6 Number of institutions excluded and included

	Total Number	Excluded: Unaccredited	Excluded: Men's Only	Excluded: <1 grad/year	Included
Physics	800	4	4	50	742
Math	1290	6	4	1	1279
Computer Science	1502	30	3	43	1426

3.3 Summary of data

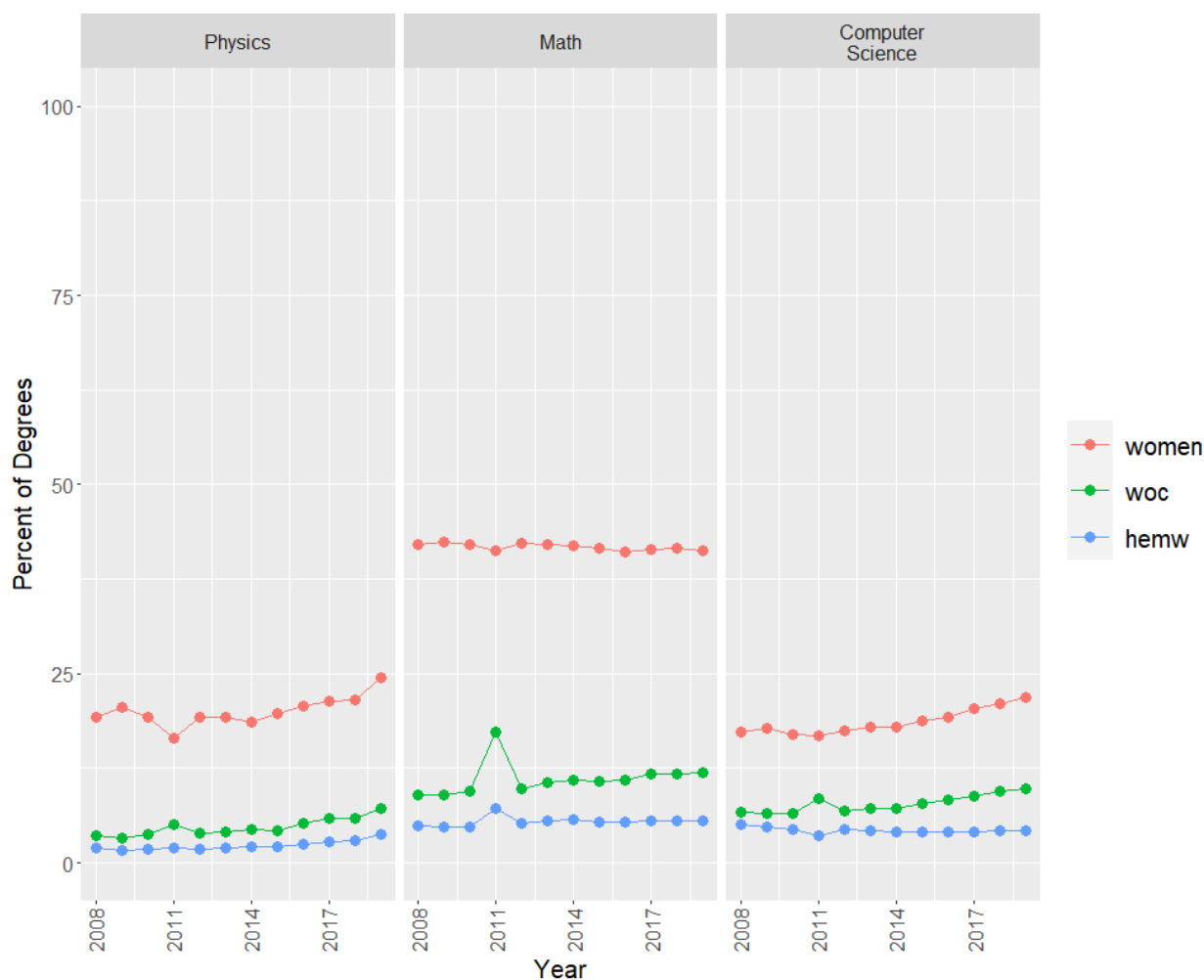
Table 3-7 summarizes the 12 years of data (2008 – 2019) in our data set after removing excluded programs. The dataset is comprised of 77,975 bachelor's degrees in physics, 275,941 bachelor's degrees in math, and 655,082 bachelor's degrees in computer science. Women and WoC are most represented in math, with 41.82% of math degrees awarded to women and 10.82% awarded to WoC. Women are represented about equally in physics and computer science, but WoC are more represented in computer science than in physics.

Table 3-7 Summary of bachelor's degrees in the dataset

	Total	Women		WoC		HEMW	
Physics	77975	16045	20.58%	3796	4.87%	1872	2.40%
Math	275941	115389	41.82%	29861	10.82%	14991	5.43%
Computer Science	655082	126677	19.34%	53858	8.22%	27982	4.27%

Figure 3-2 shows the percentage bachelor's degrees in the three disciplines earned by women, WoC, and HEMW as a function of time. There is a slight decrease in the numbers of women physics graduates in 2011 and a slight increase in 2018. Math and computer science both show a bump in numbers of degrees awarded to WoC in 2011 but these numbers went back down in 2012. Women and WoC in computer science show a slight increase over the time considered. However, in general, these numbers are somewhat steady for the 12 years considered in this project.

Figure 3-2 Bachelor's degrees awarded by year



3.4.1 Physics

The physics dataset consists of 12 years of data from 742 institutions. As can be seen from Table 3-7 Summary of bachelor's degrees in the dataset, these institutions awarded 77,975 bachelor's degrees in physics during that time. 21% of those degrees were earned by women, 5% were earned by WoC, and 2% were earned by HEMW. For comparison, women make a little more than 50% of the U.S. population and women who are not white make up about 17% of the U.S. population and 27% college students overall [33].

Figure 3-3 summarizes physics programs and the number of bachelor's degrees earned by institutional characteristics. Women, WoC, and HEMW earn physics degrees in the 10 different regions of the country in proportion to the number of institutions and the total number of physics degrees awarded in each region. Similarly, all three groups earn physics degrees at institutions in all categories of size, classification, and control. The proportion of the groups on each category is proportional to the distribution of total physics degrees in those categories.

Figure 3-3 Physics programs and degrees by region, size, Carnegie classification, and control

For all four charts, the total number of institutions is 742, the total number of degrees awarded is 77,975, the total number of degrees awarded to WoC is 3,796, and the total number of degrees awarded to HEMW is 1,872.

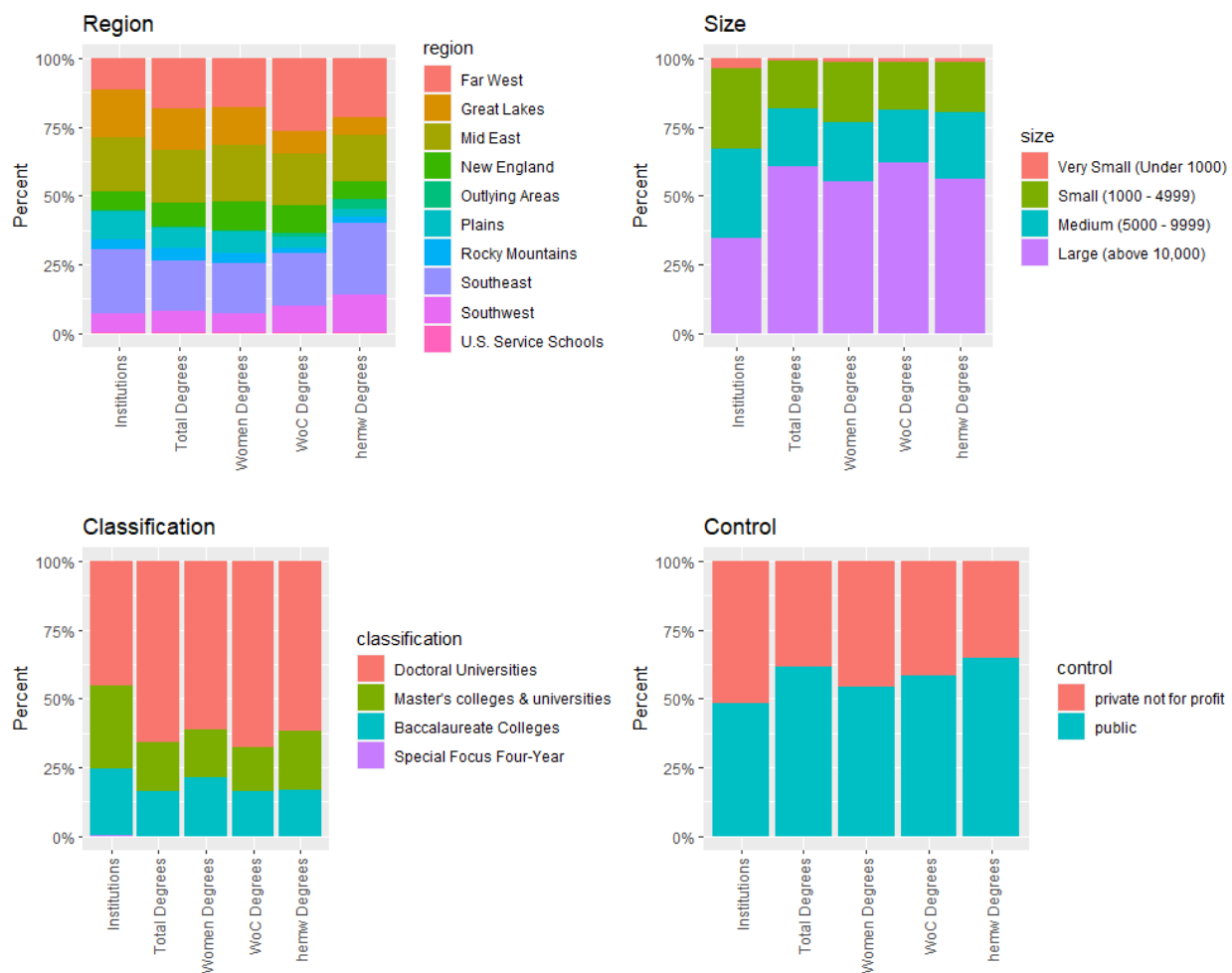
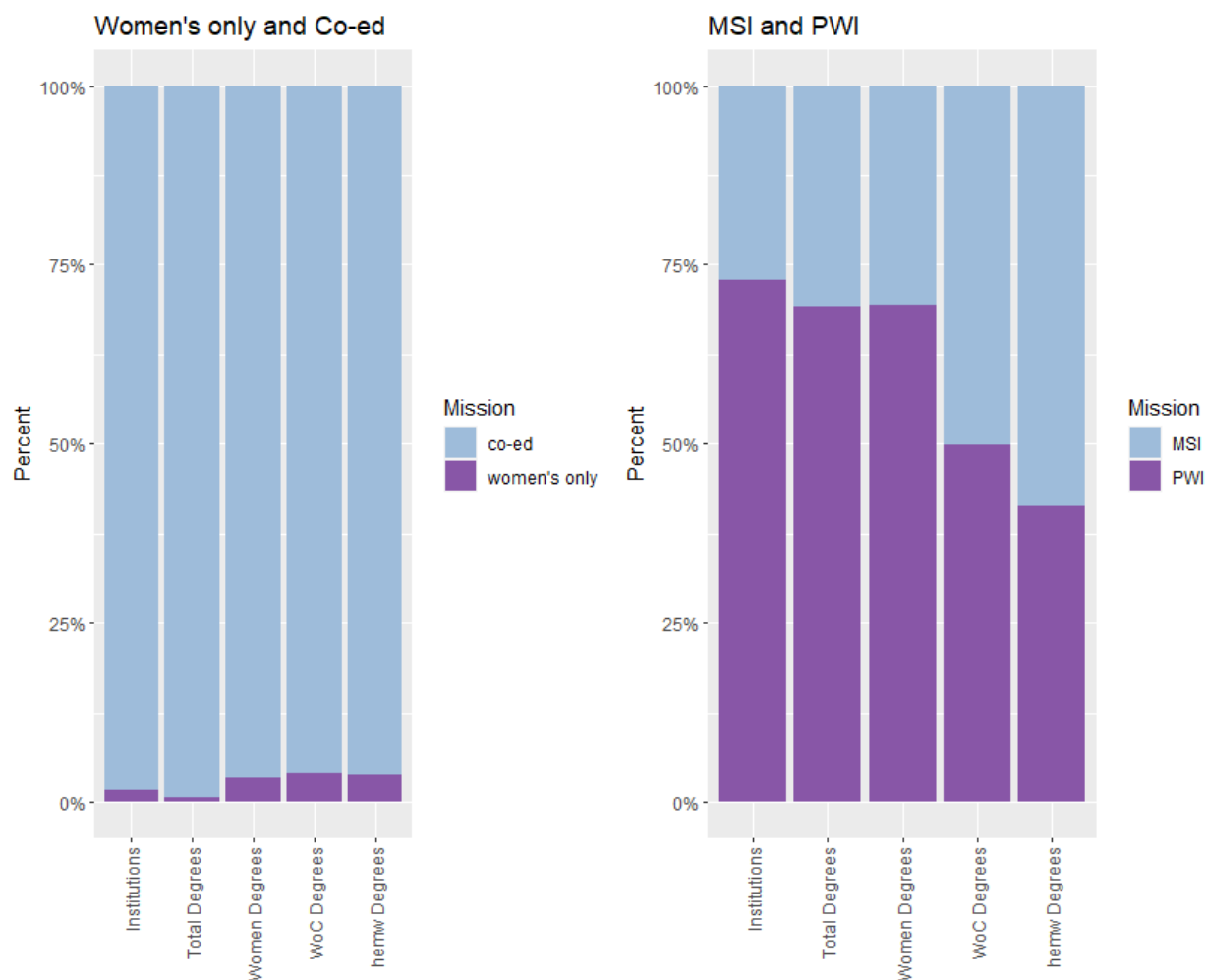


Figure 3-4 summarizes physics programs and degrees awarded by two characteristics related to the mission of the institution. Most women who earn physics degrees do so at co-educational PWIs. However, about half of the women of color who earn physics degrees do so at MSIs.

Figure 3-4 Physics programs and degrees by institutional mission

For both charts, the total number of institutions is 742, the total number of degrees awarded is 77,975, the total number of degrees awarded to WoC is 3,796, and the total number of degrees awarded to HEMW is 1,872.



3.4.2 Math

The math dataset consists of 12 years of data from 1279 institutions. As can be seen from Table 3-7, these institutions awarded 275,941 bachelor's degrees in physics during that time. 42% of those degrees were earned by women, 11% were earned by WoC, and 5% were earned

by HEMW. Compared to physics, these percentages are almost double, but all three demographics are still underrepresented in math.

Figure 3-5 summarizes math programs and the number of bachelor's degrees earned by institutional characteristics. Women, WoC, and HEMW women earn math degrees in the 10 different regions of the country in proportion to the number of institutions and the total number of math degrees awarded in each region. Similarly, all three groups earn math degrees at institutions in all categories of size, classification, and control. The proportion of the groups on each category is proportional to the distribution of total math degrees in those categories.

Figure 3-5 Math programs and degrees by region, size, Carnegie Classification, and control

For all four charts the total number of institutions is 1,279, the total number of degrees awarded is 275,941, the total number of degrees awarded to women is 115,389, the total number of degrees awarded to WoC is 29,861, and the total number of degrees awarded to HEMW is 14,995.

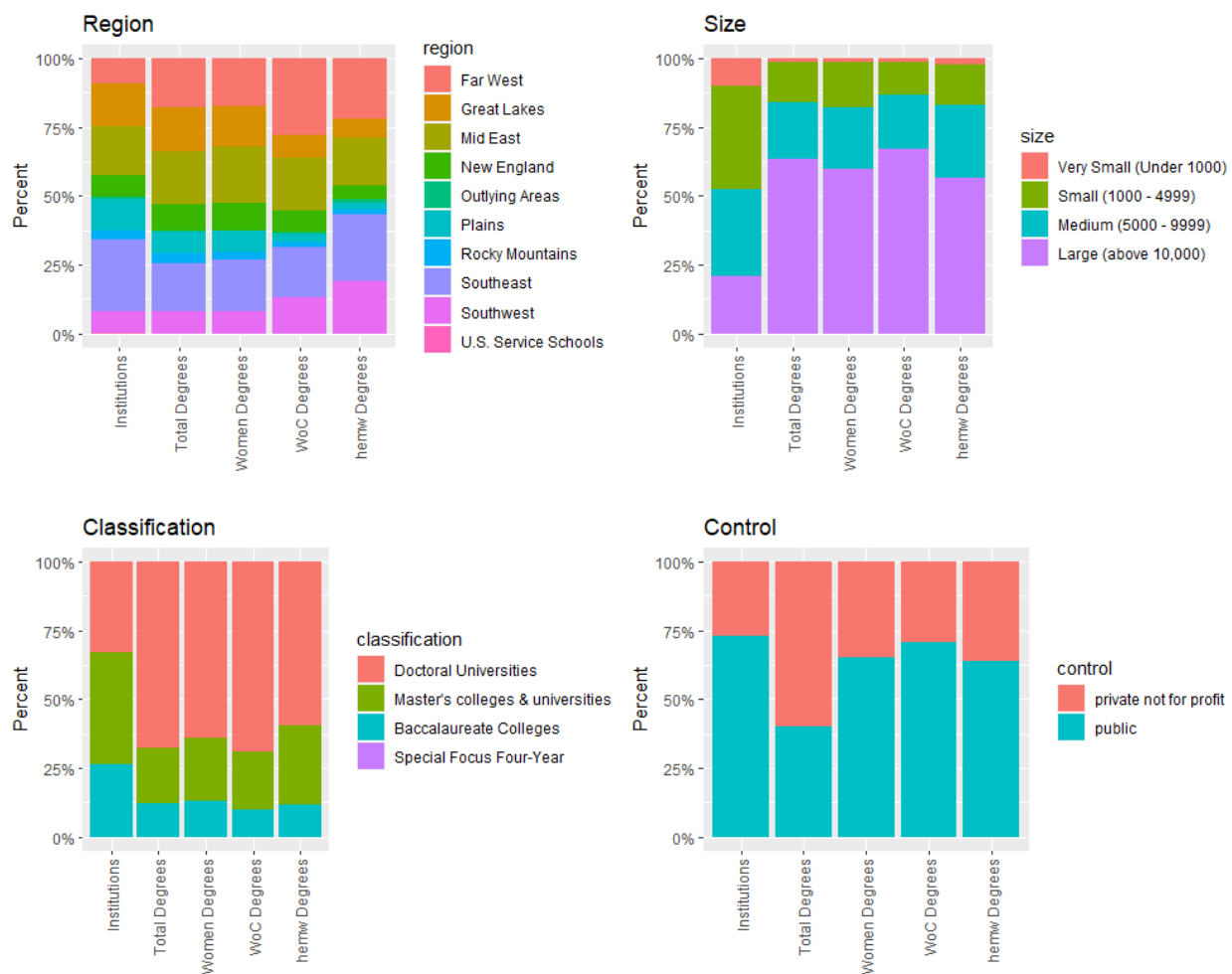
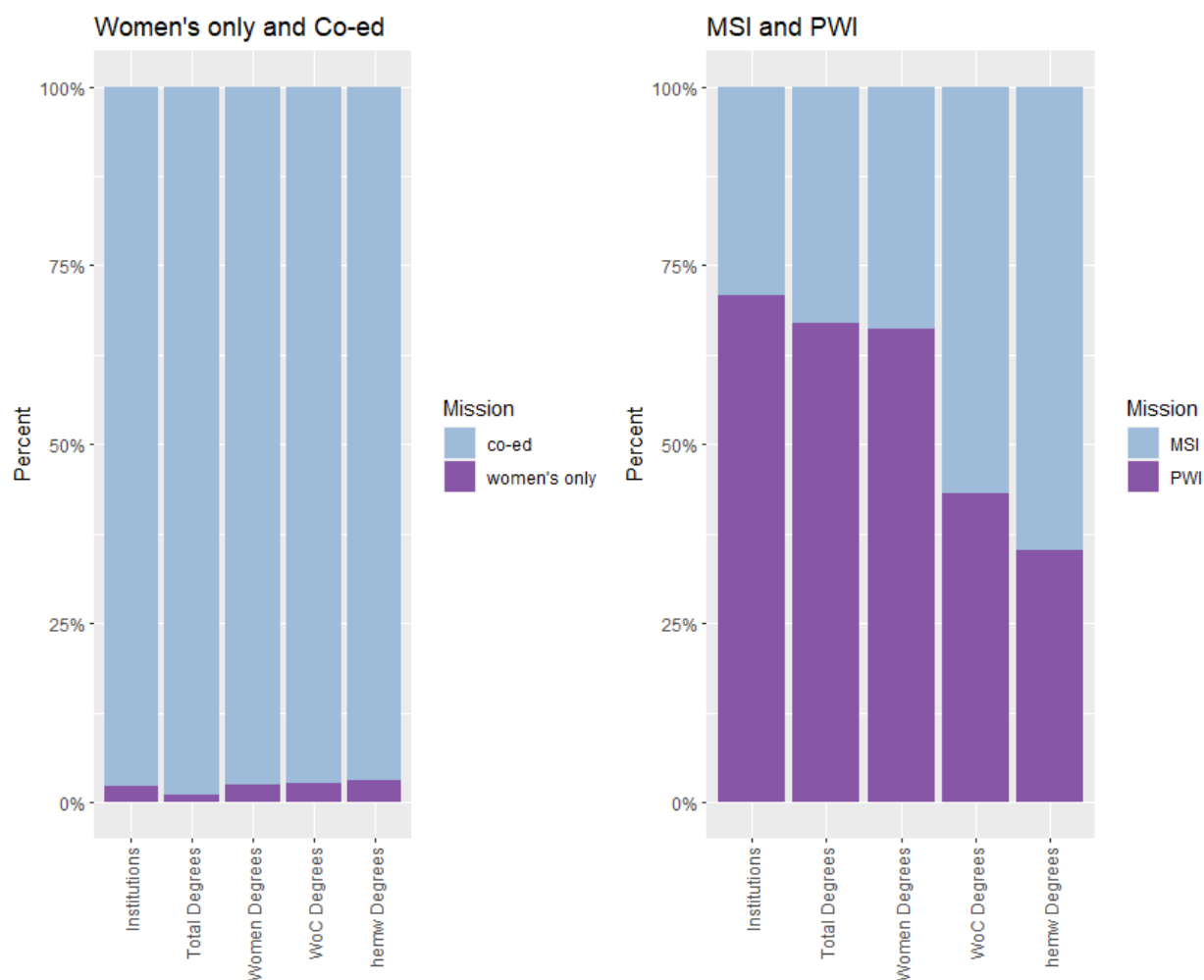


Figure 3-6 summarizes math programs and degrees awarded by two characteristics related to the mission of the institution. Like physics, most women who earn math degrees do so at co-educational PWIs and about half of the WoC who earn math degrees do so at MSIs.

Figure 3-6 Math programs and degrees by institutional mission

For both charts the total number of institutions is 1,279, the total number of degrees awarded is 275,941, the total number of degrees awarded to women is 115,389, the total number of degrees awarded to WoC is 29,861, and the total number of degrees awarded to HEMW is 14,995.



3.4.3 Computer science

The computer science dataset consists of 12 years of data from 1426 institutions. As can be seen from Table 3-7, these institutions awarded 655,082 bachelor's degrees in computer science during that time. 19% of those degrees were earned by women, 8% were earned by WoC, and 4% were earned by HEMW. In both physics and computer science, women make a

similar percentage of the total degrees awarded. However, the percentage of degrees earned by WoC and HEMW are higher in computer science than in physics.

Figure 3-7 summarizes computer science programs and the number of bachelor's degrees earned by institutional characteristics. Women, WoC, and HEMW earn computer science degrees in the 10 different regions of the country in proportion to the number of institutions and the total number of physics degrees awarded in each region. Similarly, all three groups earn computer science degrees at institutions in all categories of size, classification, and control. The proportion of the groups on each category is proportional to the distribution of total science degrees in those categories.

Figure 3-7 Computer science programs and degrees by region, size, Carnegie Classification, and control

For all four charts the total number of institutions is 1,426, the total number of degrees awarded is 655,082, the total number of degrees awarded to women is 126,677, the total number of degrees awarded to WoC is 53,858, and the total number of degrees awarded to HEMW is 27,982.

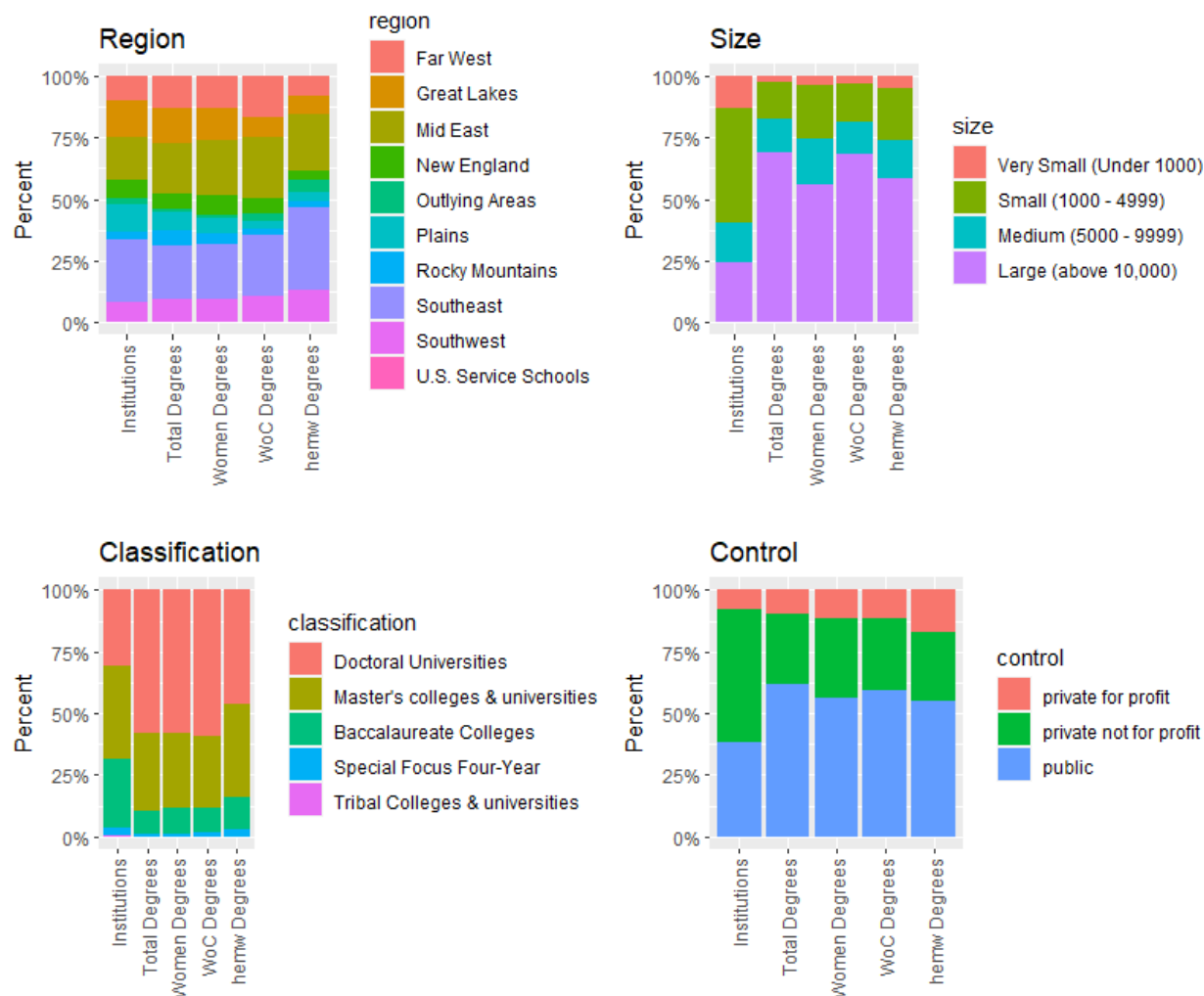
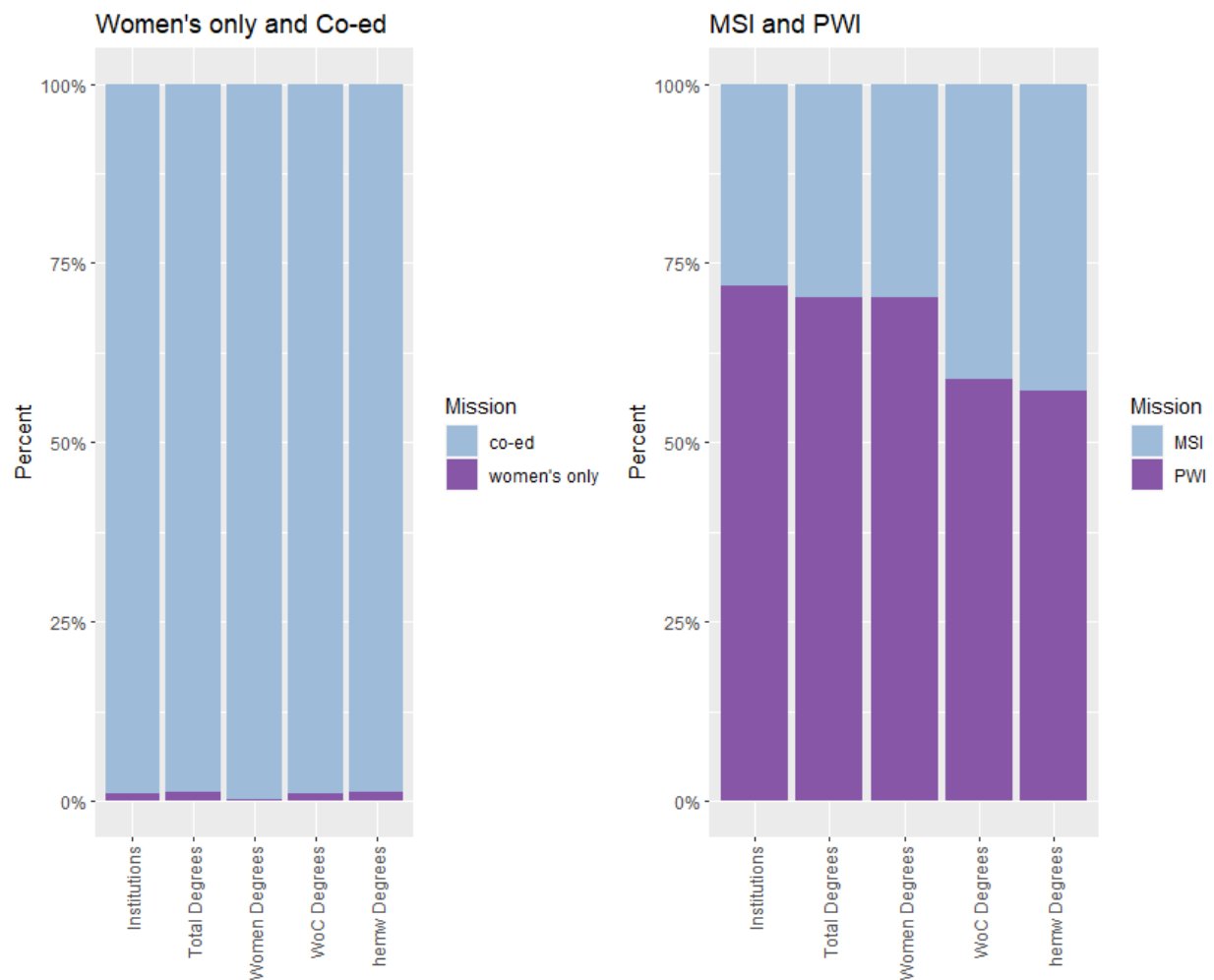


Figure 3-8 summarizes computer science programs and degrees awarded by two characteristics related to the mission of the institution. Like physics and math, most women who earn math degrees do so at co-educational PWIs. However, fewer of the WoC who earn computer science degrees do so at MSIs compared to physics and math.

Figure 3-8 Computer science programs and degrees by institutional mission

For both charts the total number of institutions is 1,426, the total number of degrees awarded is 655,082, the total number of degrees awarded to women is 126,677, the total number of degrees awarded to WoC is 53,858, and the total number of degrees awarded to HEMW is 27,982.



3.4 Effectiveness Score

To facilitate comparison of institutions, we calculated effectiveness scores for each institution. The criteria for the score were that programs with large numbers of graduates belonging to the population considered would score high but we also did not want to favor large institutions and programs over small ones. To calculate this score, we considered several different options.

3.4.1 Diversity Index

Within the literature, there are different ways to calculate a measure that represents diversity [36,37]. For example, the Simpson Index from biology, has been used in other fields to calculate diversity, including in studies related to higher education [36].

$$s = 1 - \sum_{k=1}^n \left(\frac{E_k}{E}\right)^2$$

E_k represents the number of members of a subpopulation while E is the total population. If the population is made up entirely of one group, s will equal 0. Higher values represent more diversity in the population with a maximum value of s occurring when all groups are equally represented.

One of the problems with using this measure is that it measures diversity while we are interested in measuring inclusion. This measure cannot distinguish between a PWI that graduates no WoC in physics and thus has a diversity index of zero and a women's Historically Black College/university (HBCU) like Spelman College which graduates only WoC in physics and thus also has a diversity index of zero.

3.4.2 Comparing Ratios

Two of the methods we considered involved comparing the makeup of students who earn bachelor's degrees in a specific discipline to the makeup of all students who earn bachelor's degrees at the institution. In both methods, we normalize the number of degrees earned in the discipline by a population by the total number of degrees earned in that discipline. We then compare that value to the number of degree earners at the institution in the same population normalized by the total number of degrees awarded by the institutions. In one method, we subtracted the two normalized values. In the other method, we divided the two normalized values. Both methods allow institutions with more graduates in the STEM discipline being considered who also belong to the concerned population to score higher while also taking into account the size of the department, the demographic makeup of the institution and the size of the institution.

Using WoC in physics as an example, the subtraction score is calculated using the following equation.

$$score_{subtraction} = \frac{n_{woc,phys}}{n_{tot,phys}} - \frac{n_{woc,inst}}{n_{tot,inst}}$$

In this equation, $n_{woc,phys}$ is the number of bachelor's degrees in physics earned by WoC at the institution and $n_{tot,phys}$ is the total number of bachelor's degrees in physics awarded by the institution. Similarly, $n_{woc,inst}$ is the total number of bachelor's degrees earned by WoC at the institution and $n_{tot,inst}$ is the total number of bachelor's degrees awarded by the institution.

An institution's subtraction score is 0 if the makeup of bachelor's degree graduates in a specific STEM discipline exactly matches the makeup of all bachelor's degree earners at the institution. Most institution's subtraction scores are negative because the populations we consider generally make up a smaller proportion of STEM graduates at an institution than all

graduates at the same institution. One problem with this method is how it handles zeros. For example, two different institutions that awarded zero physics degrees to WoC will likely not have the same score and each one will likely have similar scores as institutions that did award physics degrees to WoC. This makes comparing institutions difficult.

Another possible way to calculate a score by comparing ratios is to divide the two ratios. Using the same notation that we used for the subtraction score, the division score is calculated using the following equation.

$$Score_{division} = \frac{\frac{n_{woc,phys}}{n_{tot,phys}}}{\frac{n_{woc,inst}}{n_{tot,inst}}}$$

By this measure, if an institution scores one, it means the population is equally represented in the discipline and at the institution overall. A score lower than one means the population is not as well represented in the discipline as it is at the institution. All institutions that have zero graduates in the considered population and discipline will have a score equal to zero. This method has been used in higher education research to compare the demographics of students at a university to the surrounding community and to measure equity and is sometimes called the equity index [36,38].

We decided that the division of ratios method best fit the criteria for calculating an effectiveness score for several reasons. This method results in a score with properties that are generally desirable in a score. A larger number means more effectiveness while a smaller number means less effectiveness. This score also has a fixed minimum corresponding to zero degrees awarded to WoC. Having properties of any generally good score is especially important here since we want people from different backgrounds to be able to interact with and interpret these data and scores. For this specific score, it was important to us that institutions that

intuitively felt like they were doing a good job of supporting WoC would score high and normalizing by the institutional context accomplishes this goal. Thus, in the rest of this dissertation, effectiveness scores are calculated using the division of ratios method.

For each institution, we calculated a maximum of nine effectiveness scores: physics women, physics WoC, physics HEMW, math women, math WoC, math HEMW, computer science women, computer science WoC, and computer science HEMW. We classified each score as “none,” “below average,” “average,” and “above average.” A “none” classification means that institution awards degrees in the discipline but did not award any to the population being considered. After excluding the institutions that scored “none” we used the remaining scores to calculate three quantiles and used those quantiles to set cutoffs for “below average,” “average,” and “above average.” Classifying scores in this way, provides a meaningful way to make comparisons across institutions, departments, and demographics by providing a similar context for all scores. It also provides some sense of what are considered meaningful differences in scores.

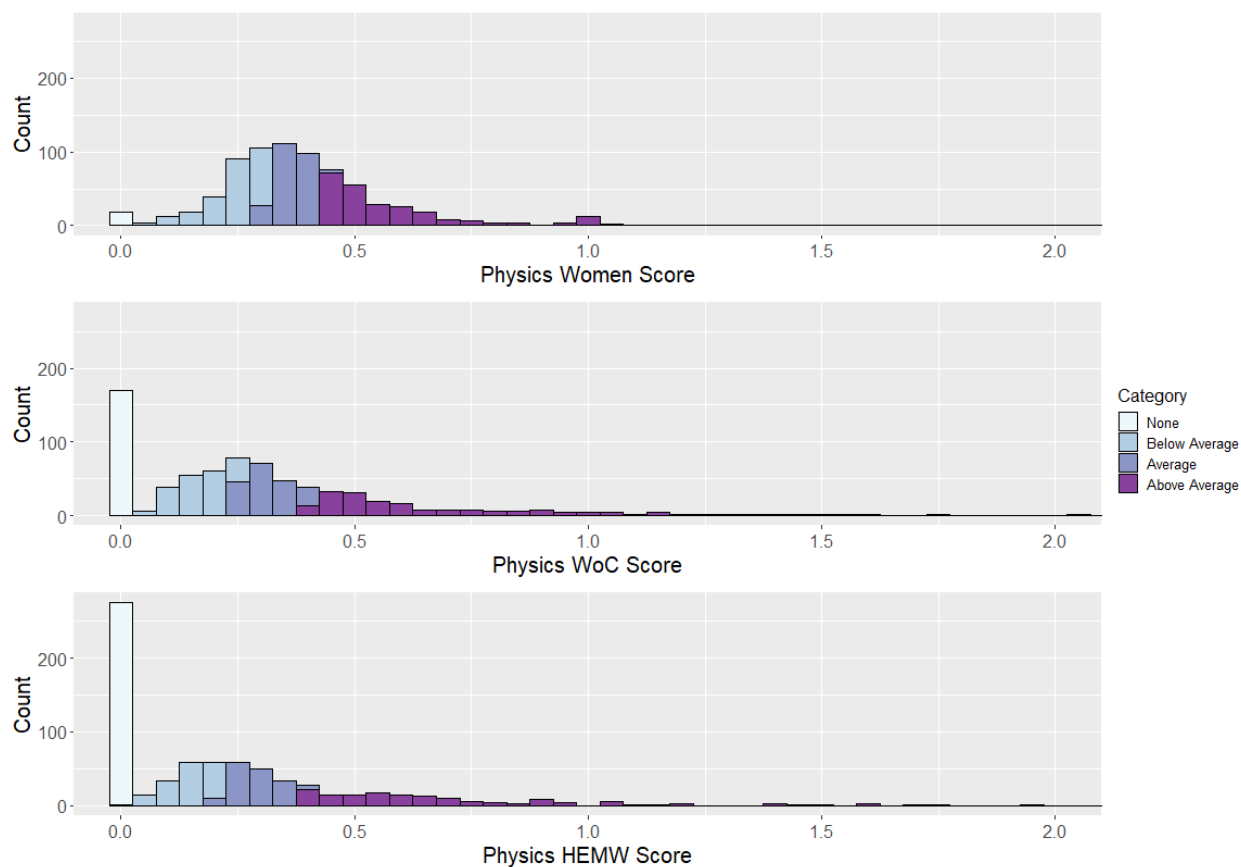
3.4.3 Physics Effectiveness Scores

The distribution of physics effectiveness scores is shown in Figure 3-9. A score of one, means that the group is equally represented at an institution in the discipline and in the institution overall. For women in physics, there is a small peak at one, representing the women’s only institutions in the dataset. In general, for all three populations, most of the scores are quite a bit less than one. The cutoffs for an institution to score “above average” are between 0.3 and 0.4. For WoC and HEMW, institutions that scored “none” make up a significant portion of the dataset. Almost a quarter of the institutions graduated zero WoC and a third graduated zero HEMW in the 12 years that comprise the dataset. There is a longer tail in the physics HEMW

distribution, representing institutions that scored higher because of especially small numbers of HEMW at their institution.

Figure 3-9 Physics effectiveness score distributions

Bin width = 0.05. Institutions that scored above 2.0 (1 women, 6 WoC, 6 HEMW) are not shown.



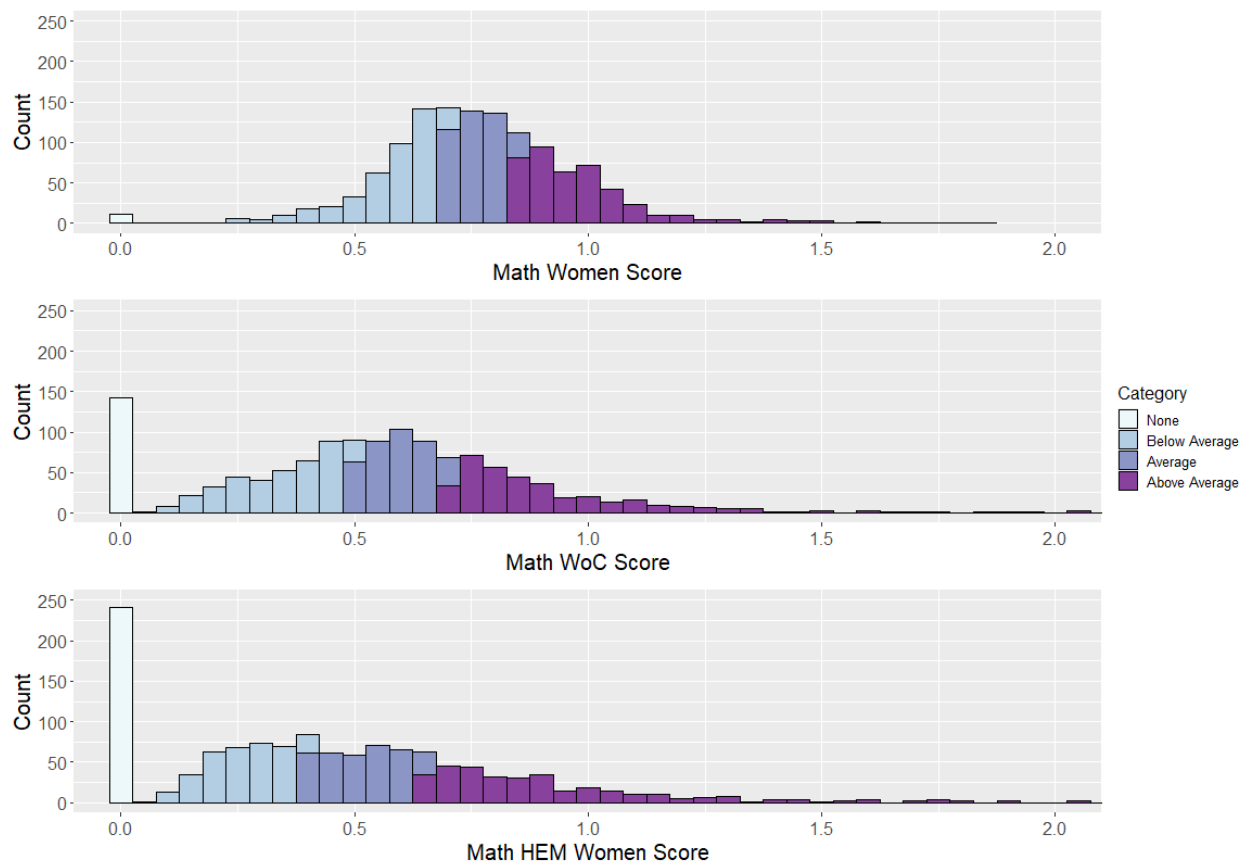
3.4.4 Math Effectiveness Scores

The distribution of math effectiveness scores is shown in Figure 3-10. Math effectiveness scores tend to be higher than physics scores. For all three populations, the cutoff for an institution to score “above average” is above 0.5 which means that average math departments graduate about half as many women, WoC, and HEMW as one would expect compared to their

institutional demographics. While there are still quite a few institutions that earned a score of “none” for WoC in math and HEMW in math, those institutions make up a smaller portion of the overall dataset than in physics.

Figure 3-10 Math effectiveness score distributions

Bin width = 0.05. Institutions that scored above 2.0 are not shown.



3.4.5 Computer science Effectiveness Scores

The distribution of computer science effectiveness scores is shown in Figure 3-11. The cutoffs to score above average in computer science are slightly higher than the physics cutoffs but still lower than the math cutoffs. While there are a significant number of institutions that

awarded no computer science degrees to WoC and HEMW, these institutions make up a smaller portion of the overall dataset compared to physics.

Figure 3-11 Computer Science effectiveness score distribution

Bin width = 0.05. Institutions that scored above 2.0 are not shown.



3.5 Summary

We collected 12 years of IPEDS data related to numbers and demographics of bachelor's degree earners in physics, math, and computer science. From this data, we see the well-known trends of women, WoC, and HEMW being underrepresented in these fields. To make meaningful comparisons and to find institutions that are excelling at graduating WoC in these fields we calculated an effectiveness score which allows us to account for institutional contexts when

making comparisons. For all cases, we see smaller numbers of women, WoC, and HEMW graduates than we would expect based on institutional characteristics. These numbers become worse in all three disciplines as we move from women to WoC to HEMW. All three disciplines have many institutions that awarded no degrees to WoC and HEMW. While math is more representative of women, WoC, and HEMW than physics or computer science, these groups are still underrepresented in their departments.

We also gathered data related to institutional characteristics that can be used to inform comparisons between like institutions. In the next chapter, I discuss some of these comparisons for WoC in physics. Comparisons involving math and computer science and involving the other demographic groups we looked at are areas of future work in the Centering Women of Color in STEM (CWCS) project.

Chapter 4 - Comparing Common Narratives to Data

4.1 Introduction

The goal of the Centering Women of Color in STEM project is to investigate where women of color (WoC) are thriving in STEM by looking at where WoC earn bachelor's degrees in STEM. In this chapter, we contribute to this investigation by comparing the calculated effectiveness scores for WoC in physics to institutional characteristics related to common narratives about where WoC earn physics degrees. We selected institutional characteristics that are related to these narratives and compared physics WoC effectiveness scores across those characteristics. We find that women's colleges and minority serving institutions (MSI) tend to score higher than co-educational, predominantly white institutions (PWI). Other characteristics related to common narratives are not predictive of physics WoC effectiveness scores.

This investigation expands on earlier work on this project that investigated outlier institutions and looked for commonalities among those institutions [39]. The outlier institutions were ones that had high physics effectiveness scores for women, WoC, and historically excluded minority women (HEMW.) Most WoC and HEMW who complete bachelor's degrees in physics do so at co-educational PWI but many of the high scoring outliers tend to be MSIs and women's colleges [39]. In this chapter, we use statistical analysis to expand on this work by looking at whether physics effectiveness scores for WoC vary by institutional characteristics.

We judiciously chose characteristics that were easy to measure and access and that correspond to common narratives invoked when discussing issues related to underrepresented students in physics and STEM. These narratives are often contradictory and are related to intrinsic properties of institutions rather than things that faculty and administrators can control.

By investigating these narratives and whether they are supported by data, we add to the larger CWCS project. These results can also be used by prospective students who are considering what type of institution to attend, by faculty and administrators who want to frame their institution's effectiveness score in a larger context and can help inform future directions for research.

4.2 Theory

To investigate whether the chosen common narratives are supported by data, we employed hypothesis testing, where we use statistical techniques to test an assumption regarding a population parameter. We call these hypotheses common narratives because they are stories that people commonly tell about the types of institutions that WoC and other underrepresented minority students are likely to earn STEM degrees at and why particularly institutions are fated to be bad at serving WoC. We test four common narratives:

- Narrative 1: Institutions in certain regions of the country are better at graduating WoC in physics.
- Narrative 2: Institutions of certain sizes are better at graduating WoC in physics.
- Narrative 3: Institutions with a mission focused on research are better at graduating WoC in physics.
- Narrative 4: Institutions with a mission focused on serving women and people of color are better at graduating WoC in physics.

4.2.1 Narrative 1: Institutions in certain regions of the country are better at graduating WoC in physics

The reasoning that creates this narrative suggests that there will be a difference in physics WoC effectiveness score by region but does not clearly point out which regions we should

expect to have higher scores. Most students attend college close to home. A 2009 study of almost a million students found that the median distance students travel to attend college is 94 miles [42]. From this, we might expect that the differing demographics of regions in the country will result in regional variations in the demographics at institutions. The number of colleges in a geographic region varies. In addition to being correlated with population it is often based on race and class [43], suggesting that students in certain demographics may need to travel farther from home to attend college. Finally, characteristics that vary by region, such as political climate, could affect both college choice and the ability of women, WoC, and HEMW to persist in college.

4.2.2 Narrative 2: Institutions of certain sizes are better at graduating WoC in physics

The size of an institution is often assumed to affect the experience that a student will have at that institution. This assumption often shows up in the way that different institutions explain what they do well. Small colleges argue that they have smaller class sizes and that students benefit from these smaller classes. In fact, a brief search of websites a prospective student might encounter shows that this is very often mentioned as a benefit of attending a small school. Large class sizes can make it difficult for students to form connections [44] and can thus negatively affect persistence. However, given the small numbers of women and WoC in physics, when these students attend co-educational PWIs, they often find community outside of their major [10]. Large co-educational PWIs argue that their larger population make it more likely that underrepresented students will find students like themselves to form community.

4.2.3 Narrative 3: Institutions with a mission focused on research are better at graduating WoC in physics

Different institutions, as evidenced by their mission, focus on and excel at different things. One aspect of an institution's mission is how much the institution focuses on research. This focus is the basis of the Carnegie Classifications which classifies institutions based on the types of degrees they offer, the amount of money they spend on research, and the number of research faculty [32]. Institutions with less research may argue that by not focusing on research they are able to devote more effort to educating and supporting their undergraduate students. On the other hand, institutions that are highly involved in research argue that their undergraduate students benefit from being able to participate in research. This argument is supported by studies that show that undergraduate STEM students benefit from participating in research opportunities [7]. Given this, we might expect institutions with a research focused mission to have higher physics WoC effectiveness scores, corresponding to the narrative that this research mission helps the institution support and graduate WoC in physics.

4.2.4 Narrative 4: Institutions with a mission focused on serving women and people of color are better at graduating WoC in physics

Some institutions have missions related to serving a specific population of student. In particular, women's colleges and MSIs specifically serve the population this investigation is concerned with. Earlier work in the CWCS project cited these institutions, particularly Historically Black Colleges and Universities (HBCU), as among the outlying institutions that had high physics women, WoC and HEMW effectiveness scores [39]. Therefore, we might expect that women's colleges and MSIs tend to have higher physics WoC effectiveness scores, corresponding to these types of institutions being better at graduating WoC in physics.

4.3 Methods

4.3.1 Data Collection

The data used and how they were collected is described in detail in chapter 3. Briefly, we collected 12 years (2008 – 2019) of data from the Integrated Post Secondary Education Data System (IPEDS) including the number, gender, and race/ethnicity of physics bachelor's degrees earners at each US institution. From this information, we calculated a physics WoC effectiveness score for each institution using the following equation.

$$Score_{phys,WoC} = \frac{\frac{n_{woc,phys}}{n_{tot,phys}}}{\frac{n_{woc,inst}}{n_{tot,inst}}}$$

Here, $n_{woc,phys}$ is the total number of physics bachelor's degrees earned by WoC at the institution, $n_{tot,phys}$ is the total number of physics bachelor's degrees awarded by the institution, $n_{woc,inst}$ is the number of bachelor's degrees earned by WoC at the institution, and $n_{tot,inst}$ is the total number of bachelor's degrees awarded by the institution.

The physics WoC effectiveness score is a measure of the proportion of physics degrees awarded by the institution to WoC compared to the proportion of total bachelor's degrees awarded by the institution to WoC. A score of 1 means that a physics department's proportion of bachelor's degrees awarded to WoC exactly matches the proportion of WoC earning bachelor's degrees at the institution. For most institutions, this score is less than one, so the closer the score is the one, the better the department is at representing WoC among its bachelor's degree earners.

To investigate whether differences in the physics WoC effectiveness score correspond to the four chosen common narratives, we selected variables from IPEDS that represent each of these characteristics. The variables used were region, size, Carnegie Classification, women's only institution, and MSI. Table 4-1 shows how the region categories are defined and how many

institutions are in each region. Table 4-2 shows how the size categories are defined and how many institutions are in each category.

Table 4-1 Number of Institutions by Region Category

Region Category	Number of Institutions
Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV)	172
Mid East (DE, DC, MD, NJ, NY, PA)	147
Great Lakes (IL, IN, MI, OH, WI)	126
Far West (AK, CA, HI, NV, OR, WA)	86
Plains (IA, KS, MN, MO, NE, ND, SD)	74
New England (CT, ME, MA, NH, RI, VT)	53
Southwest (AZ, NM, OK, TX)	51
Rocky Mountains (CO, ID, MT, UT, WY)	27
Outlying Areas (AS, FM, GU, MH, MP, PR, PW, VI)	4
U.S. Service Schools	2

Table 4-2 Number of Institutions by Size Category

Size Category	Number of Institutions
Large (Above 10,000)	255
Medium (3,000 - 9,999)	242
Small (1,000 - 2,999)	219
Very Small (Under 1,000)	26

To create research mission categories, we used the Carnegie Classification for each institution. So that we could consider fewer categories, we combined institutions into three categories based on just the level of degree that they offer. The Carnegie Classifications included in each research mission category and the number of institutions in each category are shown in Table 4-3.

Table 4-3 Number of Institutions by Research Mission

Research Mission Category	Carnegie Classification	Number of Institutions
Bachelor's	Special Focus Four-Year: Engineering and Other Technology-Related Schools	183
	Baccalaureate/Associate's Colleges: Mixed Baccalaureate/Associate's	
	Baccalaureate Colleges: Diverse Fields	
Master's	Baccalaureate Colleges: Arts & Sciences Focus	223
	Master's Colleges & Universities: Small Programs	
	Master's Colleges & Universities: Medium Programs	
Doctoral	Master's Colleges & Universities: Larger Programs	336
	Doctoral/Professional Universities	
	Doctoral Universities: High Research Activity	
	Doctoral Universities: Very High Research Activity	

To create population mission categories, we used the classification of institutions as women's only or not and MSI or not. We combined women's only institutions and MSIs into one category and placed the co-educational PWIs in another category. The number of institutions in each of the population mission categories are shown in Table 4-4.

Table 4-4 Number of Institutions by Population Mission

Population	Number of Institutions
Co-ed PWI	598
Women's or MSI	144

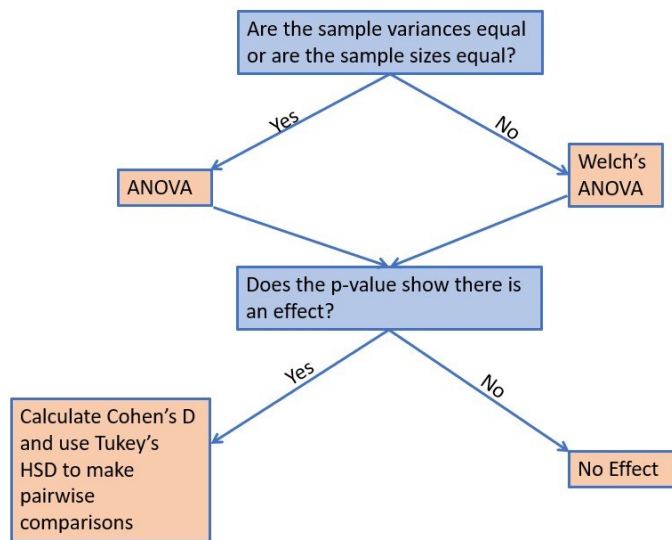
4.3.3 Data Analysis

To test whether the narratives are supported by the data we treated the calculated physics WoC effectiveness score as the dependent variable and each of the four characteristics as separate independent variables. We used either one-way ANOVA or Welch's ANOVA to test

whether the characteristic chosen to represent the narrative affected the physics WoC effectiveness scores.

ANOVA compares sample means by comparing the with-in group variance to the between-group variance [40]. We can treat each characteristic of institutions as a factor with multiple levels and the effectiveness score as the response to that factor. ANOVA assumes that the responses to each factor have a normal distribution, that the distributions have the same variance, and that the data are independent. However, ANOVA is still robust for non-normal data, especially if the sample size is large, and for data with unequal variance if the sample sizes are about the same [40]. Welch's ANOVA is an alternative test that can be used when the assumption of equal variance is violated, even if the sample sizes are not the same [41]. When the appropriate ANOVA test showed that one of the characteristics affected the physics WoC effectiveness score, we calculated Cohen's d , which provides a measure of the effect size. We also used Tukey's Honest Significance Difference Test to make pairwise comparisons and determine which of the levels of the characteristic provided statistically different mean physics WoC effectiveness scores. The procedure followed to test each characteristic is summarized in Figure 4-1.

Figure 4-1 Logic Tree for Statistical Analysis



4.4 Results

4.3.1 Narrative 1: Institutions in certain regions of the country are better at graduating WoC in physics

To test whether institutions in certain regions tend to be better at graduating WoC in physics, we compared the physics WoC score for institutions by region of the country. Physics WoC effectiveness scores by region are shown in Figure 4-2. Table 4-5 shows the median physics WoC score for each region. Although ANOVA compares means, the median better represents our data because of the large number of institutions that scored zero. ANOVA shows that there is not a statistically significant difference in scores by region ($f(9) = 0.348$, $p = 0.958$); therefore, the narrative that institutions in certain regions of the country are better at graduating WoC in physics is not confirmed by the data.

Figure 4-2 Physics WoC Effectiveness Scores by Region

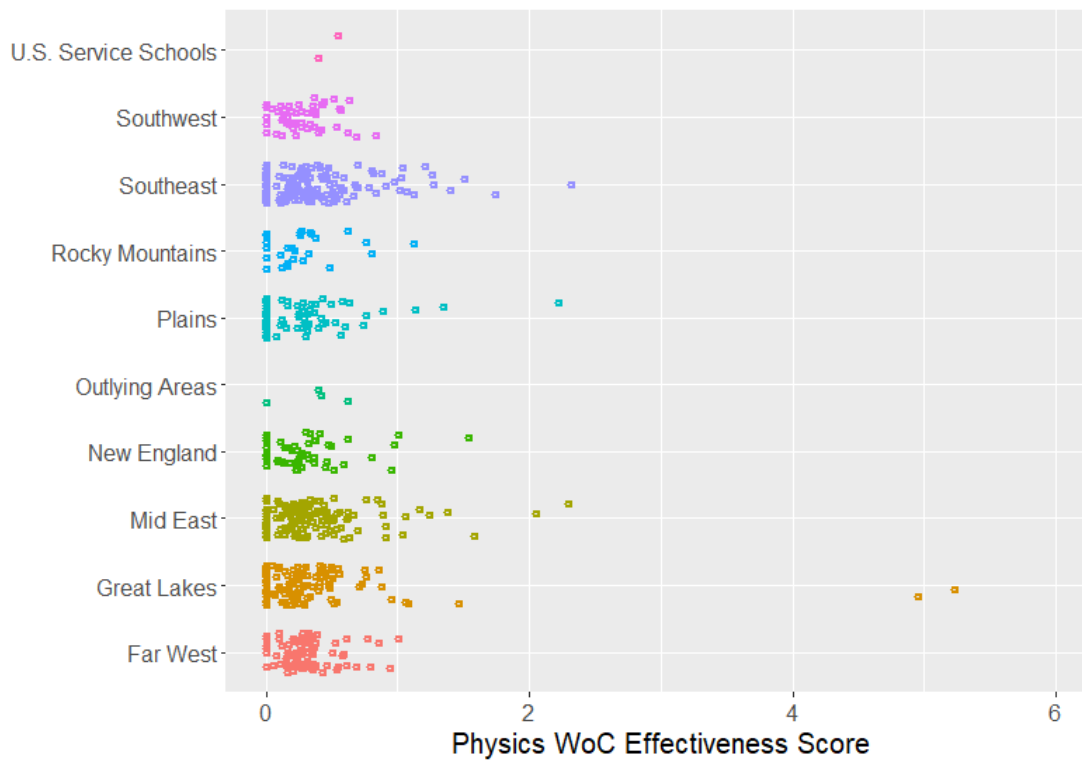
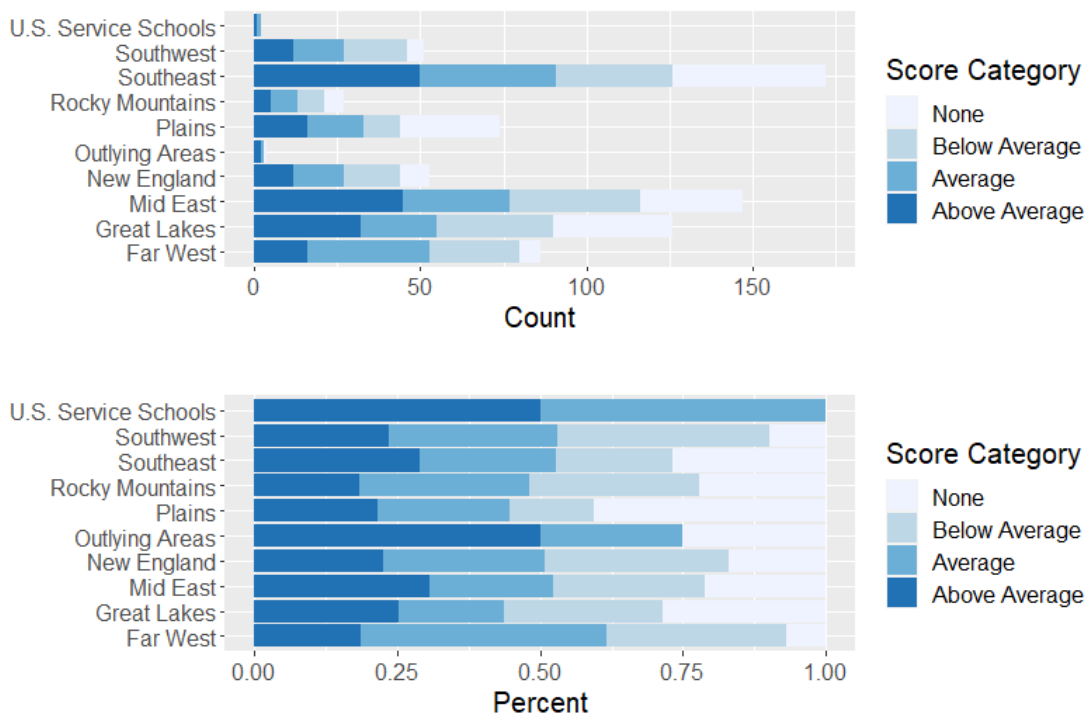


Table 4-5: Number of institutions and average score for each region

Region	Number of Institutions	Median Physics WoC Effectiveness Score
Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV)	172	0.27
Mid East (DE, DC, MD, NJ, NY, PA)	147	0.26
Great Lakes (IL, IN, MI, OH, WI)	126	0.22
Far West (AK, CA, HI, NV, OR, WA)	86	0.28
Plains (IA, KS, MN, MO, NE, ND, SD)	74	0.16
New England (CT, ME, MA, NH, RI, VT)	53	0.25
Southwest (AZ, NM, OK, TX)	51	0.27
Rocky Mountains (CO, ID, MT, UT, WY)	27	0.22
Outlying Areas (AS, FM, GU, MH, MP, PR, PW, VI)	4	0.41
U.S. Service Schools	2	0.48

To further conceptualize the variation in physics WoC effectiveness score, we categorized each score as none (if the institutions awarded no physics degrees to WoC), below average, average, and above average. Figure 4-3 shows both the count and percent of each score category by region. From this chart, we can see that there are institutions in each region of the country that score above average as well as institutions that graduated no WoC in physics from 2008 – 2019. The fact that there are institutions in each region at which WoC are thriving (i.e., institutions that have above average physics WoC effectiveness scores) is in agreement with our statistical analysis which showed no variation in mean physics WoC effectiveness score by region.

Figure 4-3: Physics WoC effectiveness score categories by region



4.4.2 Narrative 2: Institutions of certain sizes are better at graduating WoC in physics

To test whether institutions of certain size institutions tend to be better at graduating WoC in physics, we compared the physics WoC score for institutions by institution size. Physics WoC effectiveness scores by institution size are shown in Figure 4-4. From this plot, we can see that the physics WoC effectiveness scores are less spread out for small schools. The other size categories show more variation in physics WoC effectiveness score and that variation increases as the size category gets smaller.

Figure 4-4 Physics WoC Effectiveness Scores by Institution Size

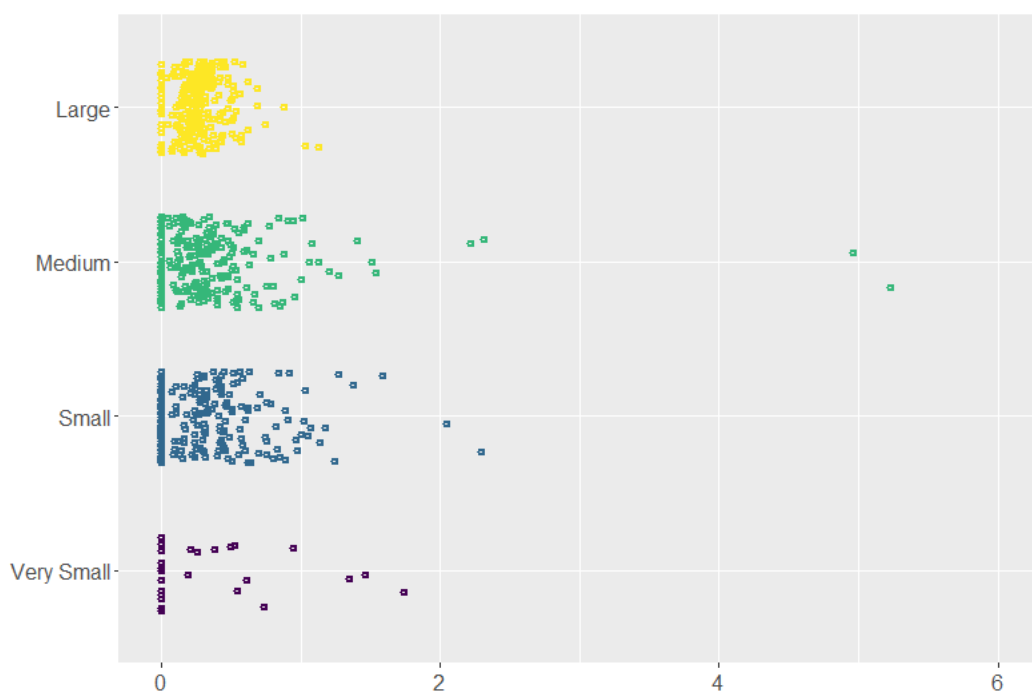


Table 4-6 shows the median physics WoC score for each region. ANOVA showed that there is a statistically significant difference in effectiveness score by size for WoC ($f(3) = 2.994$, $p = 0.03$.) The results of the post-hoc Tukey test are shown in Table 4-7. The only comparison

that showed a statistically significant difference was large-medium ($p = 0.02$) with medium schools scoring higher than large schools. However, since neither large nor medium schools have physics WoC effectiveness scores that are statistically different from small or very small schools, we cannot conclude that the size of an institution affects the physics WoC effectiveness score and the narrative related to this characteristic is not confirmed by the data.

Table 4-6: Number of institutions and median score by institution size

Size	Number of Institutions	Median Physics WoC Effectiveness Score
Large (Above 10,000)	255	0.25
Medium (3,000 - 9,999)	242	0.27
Small (1,000 - 2,999)	219	0.27
Very Small (Under 1,000)	26	0.1

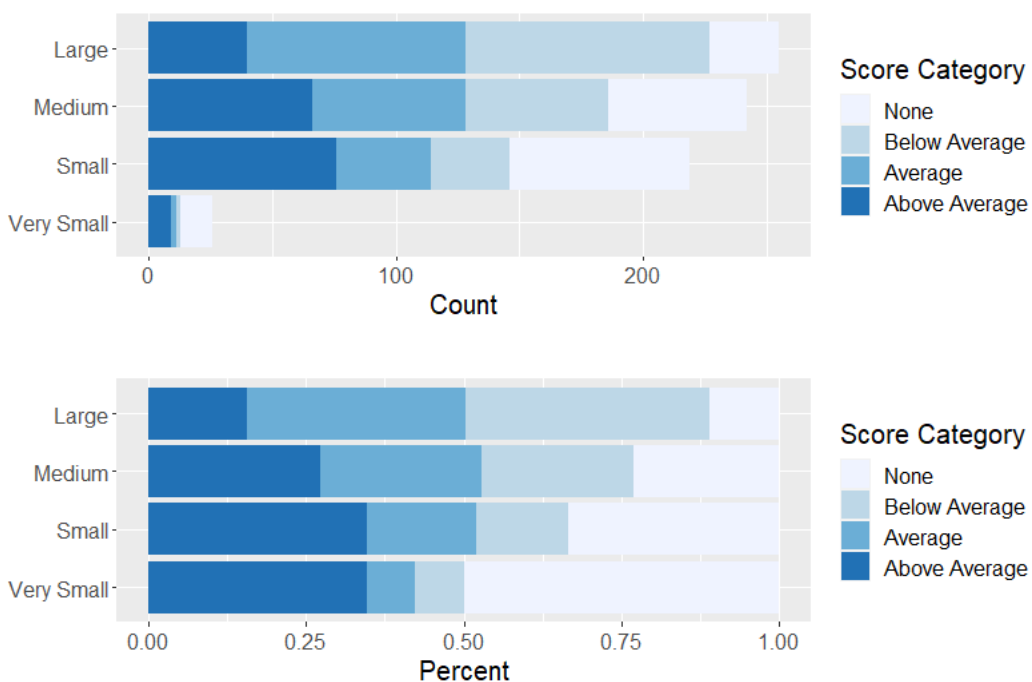
Table 4-7 Results of Tukey test for Physics WoC Effectiveness Score by institution size

Size 1	Size 2	p
Small	Very Small	0.98
Medium	Very Small	0.99
Large	Very Small	0.59
Medium	Small	0.81
Large	Small	0.23
Large	Medium	0.02

Figure 4-3 shows both the count and percent of each score category by institution size. As with region, we can see that there are institutions of each size that score above average as well as institutions that graduated no WoC in physics from 2008 – 2019. The fact that there are institutions in each region at which WoC are thriving (i.e., institutions that have above average

physics WoC effectiveness scores) is in agreement with our statistical analysis which showed that an institution's size category is not predictive of its physics WoC effectiveness score.

Figure 4-5 Physics WoC effectiveness score categories by institution size



4.4.3 Narrative 3: Institutions with a mission focused on research are better at graduating WoC in physics

To test whether institutions with a research focused mission tend to be better at graduating WoC in physics, we compared the physics WoC score by institution Carnegie Classification category. Physics WoC effectiveness scores by institution Carnegie Classification category are shown in Figure 4-6 . Table 4-8 shows the median physics WoC score for each Carnegie Classification category. ANOVA shows that there is not a statistically significant difference in scores by region ($f(3) = 0.995$, $p = 0.4.$); therefore, the narrative that institutions

with a mission that focuses on research are not better at graduating WoC in physics is not confirmed by the data.

Figure 4-6 Physics WoC effectiveness scores by institution Carnegie Classification category

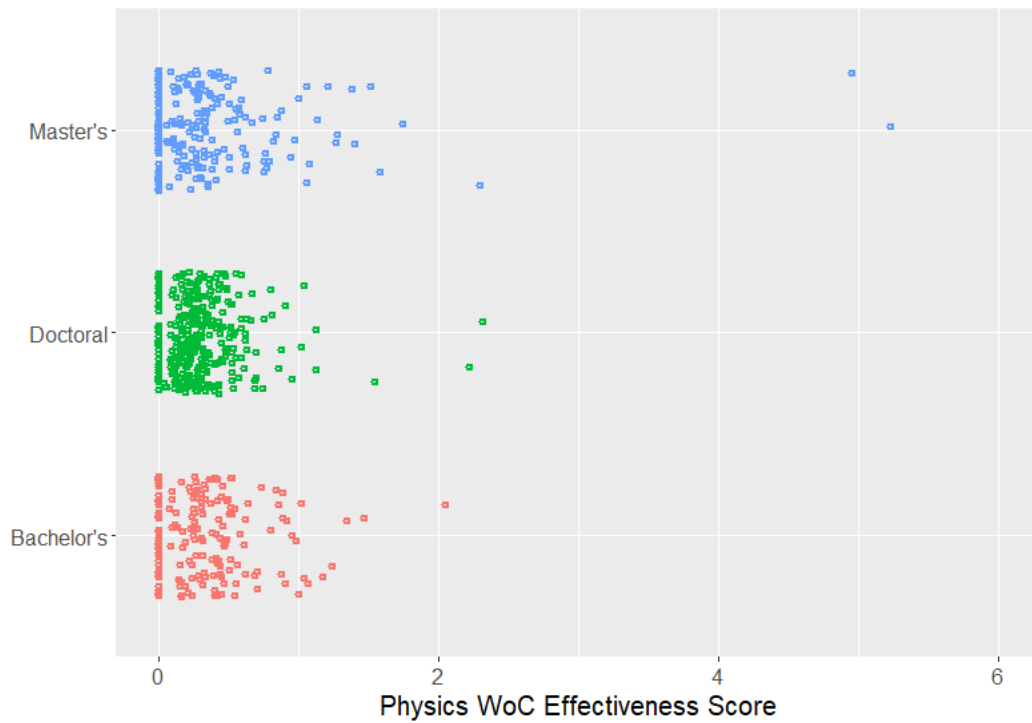
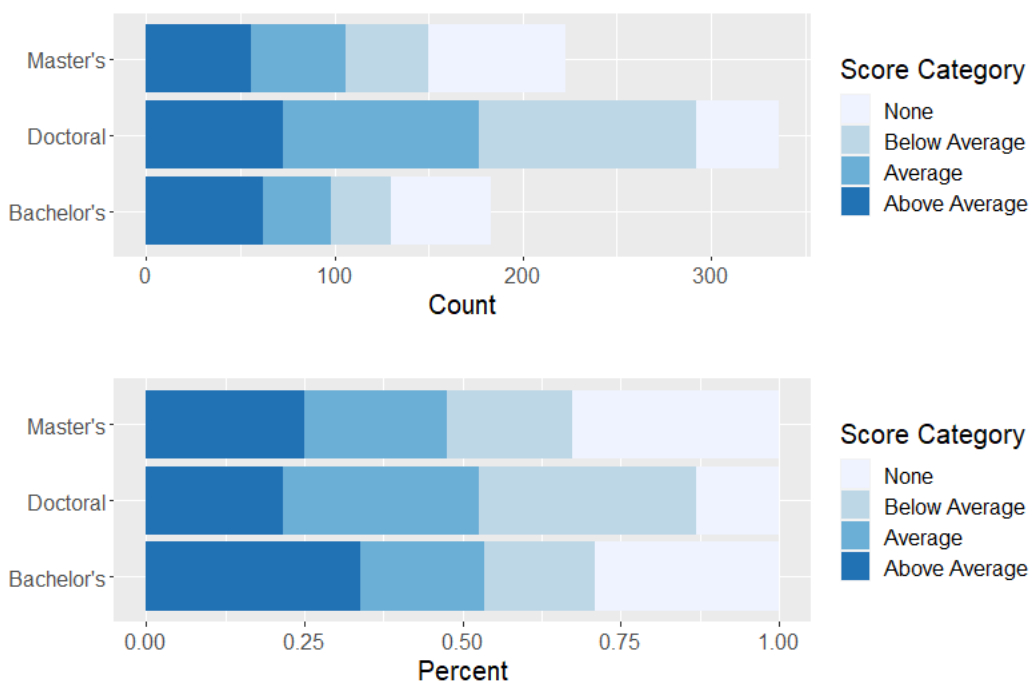


Table 4-8 Number of institutions and average score for each Carnegie Classification Category

Category	Carnegie Classification	Number of Institutions	Median Physics WoC Effectiveness Score
Bachelor's	Special Focus Four-Year: Engineering and Other Technology-Related Schools	183	0.27
	Baccalaureate/Associate's Colleges: Mixed		
	Baccalaureate/Associate's		
	Baccalaureate Colleges: Diverse Fields		
	Baccalaureate Colleges: Arts & Sciences Focus		
Master's	Master's Colleges & Universities: Small Programs	223	0.23
	Master's Colleges & Universities: Medium Programs		
	Master's Colleges & Universities: Larger Programs		
Doctoral	Doctoral/Professional Universities	336	0.26
	Doctoral Universities: High Research Activity		
	Doctoral Universities: Very High Research Activity		

Figure 4-7 shows both the count and percent of each score category by research mission. As with region and size, we can see that there are institutions of each size that score above average as well as institutions that graduated no WoC in physics from 2008 – 2019. The fact that there are institutions in each region at which WoC are thriving (i.e., institutions that have above average physics WoC effectiveness scores) is in agreement with our statistical analysis which showed that an institution's Carnegie Classification category is not predictive of its physics WoC effectiveness score.

Figure 4-7 Physics WoC effectiveness score category by Carnegie Classification category



4.4.4 Narrative 4: Institutions with a mission focused on serving women and people of color are better at graduating WoC in physics

To test whether institutions with missions focused on serving women and people of color are better at graduating WoC in physics, we compared the physics WoC score for institutions in different population mission categories. Physics WoC effectiveness scores for women's colleges and MSIs and co-educational PWIs are shown in Figure 4-8. Table 4-9 shows the median physics WoC score for both population mission categories. Welch's ANOVA showed that there is a statistically significant difference in physics WoC effectiveness score by population mission category ($p = 0.04$, $D = 0.18$ small.) Physics WoC effectiveness scores tend to be higher at women's only colleges and MSIs compared to co-educational PWIs. Because the effect size is small, the difference in population mission does not completely explain the variation in physics WoC effectiveness scores.

Figure 4-8 Physics WoC effectiveness scores by institution population mission

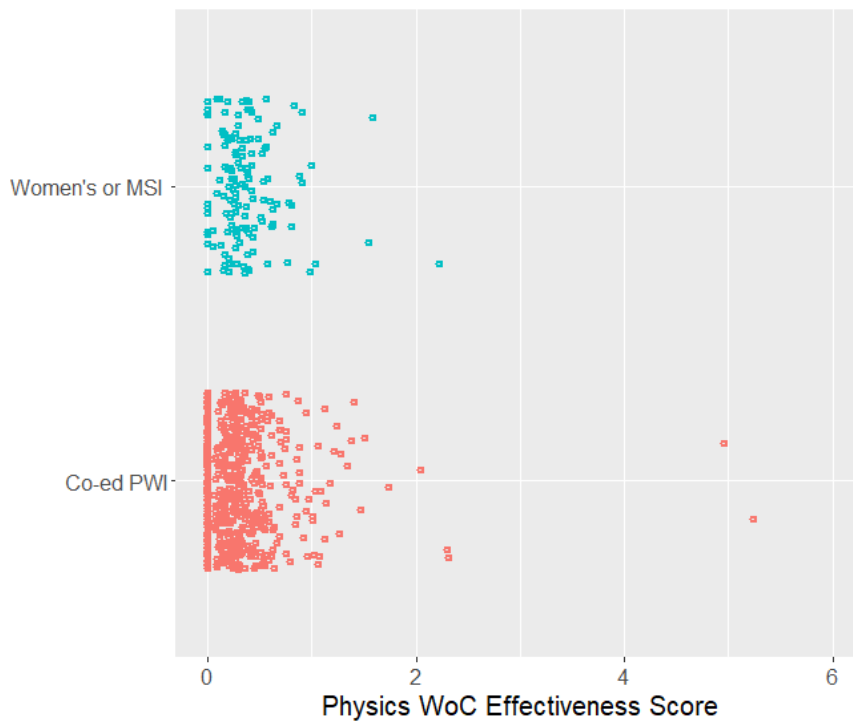


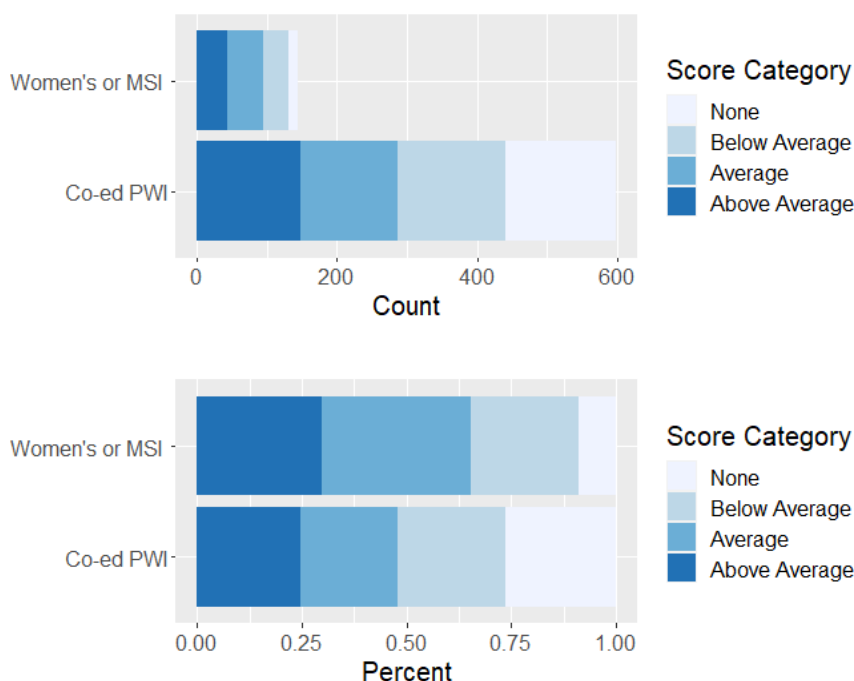
Table 4-9 Number of institutions and average score for population mission

Population	Number of Institutions	Average Physics WoC Effectiveness Score
Co-ed PWI	598	0.24
Women's or MSI	144	0.32

Figure 4-9 shows both the count and percent of each score category by population mission. While there are co-educational PWIs where WoC are thriving (i.e., with an above average score) we can also see that about a quarter of the co-educational PWIs awarded no physics degrees to WoC from 2008 – 2019. About 60% of the institutions that are either women's colleges or MSIs scored either average or above average compared to slightly less than

50% of the co-educational PWIs. These results agree with the results of our statistical analysis, which showed that women's colleges and MSIs tend to score higher than co-educational PWIs. They are also in agreement with previous work that showed many of the institutions that scored high in all three demographic categories were women's colleges and MSIs.

Figure 4-9 Physics WoC effectiveness score category by population mission



4.8 Discussion

Of the four narratives we examined, only one was supported by our data. After accounting for department size and institutional demographics, region, size, and research mission (Carnegie classification) did not predict physics WoC effectiveness scores. From this, we conclude that these institutional level characteristics are not indicative of whether WoC thrive in physics departments. One important limitation of using these characteristics is that they are

institutional level characteristics rather than departmental level characteristics. For example, an institution's Carnegie Classification does not give us information about what degrees the physics department at that institution offers. It is possible for a physics department to offer only a bachelor's degree but be a part of an institution that is classified as doctoral granting. It is likely that whether a physics department has a graduate program is more indicative of department culture and practices than whether other departments at that institution offer graduate degrees.

Of the four narratives that we examined, only one was supported by our data. After accounting for department size and institutional demographics, population mission did affect the physics WoC score with women's colleges and MSIs scoring higher than co-educational PWIs. It might be expected that women's colleges and MSIs graduate more WoC in physics given they have missions that involve specifically serving those populations. Our results confirm this intuition but also show that they score high even after accounting for the increased presence of WoC at the institution. Further study of departments at those institutions may help elucidate practices that departments at other types of institutions can adopt to support physics students from historically excluded populations.

4.9 Conclusion

Our results show that women's colleges and MSIs tend to have higher WoC effectiveness scores, confirming the narrative that institutions with missions related to serving women and people of color are better at graduating WoC in physics. Other narratives related to institutional characteristics are not confirmed by the data. This is a useful result in that it tells us that for most physics departments, which are located at co-educational PWIs, a department's outcomes are not predetermined by the institutional context in which they exist. These results also confirm earlier

work on this project in pointing to physics departments at women's colleges and MSIs as potential models for what departments can do to support undergraduate students who are WoC.

The CWCS project frames its central question as, “Where are WoC thriving in STEM?” Our results add to the answer to this question by showing that WoC do thrive in physics departments at many different types of institutions. These results also inform a future direction for research. The lack of correlation between most institutional characteristics and physics WoC effectiveness scores point to departmental characteristics as factors that may be more important in determining outcomes.

Chapter 5 - Using Communities of Practice to Explore

Departmental Values

In the previous chapter, I discussed how common narratives relating to institutional characteristics compare to data about where women of color (WoC) earn bachelor's degrees in physics. That work showed that minority serving institutions (MSIs) and women's colleges tend to have higher WoC effectiveness scores than co-educational, predominantly white institutions (PWIs). However, the other institutional characteristics that we investigated do not correlate with effectiveness score. One possible reason is that individual practices within a department have a larger effect on where WoC thrive. In this chapter, I discuss a collaborative, autoethnographic comparison of two physics departments, Prairie State University (PSU) and Large Catholic University (LCU). This work is a preliminary step in investigating departmental practices and culture.

5.1 Introduction

There is a growing body of literature centered around questions of equity and inclusion within post-secondary education.¹ One area that can contribute to this conversation is an exploration of our own cultures, activities, and practice, with particular attention to how we conceptualize working together within a community and how we value members of the community. The communities of practice framework [42] provides a human-centered perspective on this question by focusing on how interactions and practice center or peripheralize members of a community. In this chapter, we present a collaborative, autoethnographic, contrastive case study of two US physics departments using the communities of practice (CoP) framework to

¹ A version of this analysis was accepted for publication in the 2022 PERC Proceedings.

explore how different constituent groups within the department (faculty, staff, undergraduate students, and graduate students) engage with the departmental community. We see how different constituent groups are centered and from this analysis, we infer a foundational value that informs how each department enacts their community of practice.

We chose to focus on physics departments for multiple reasons. First, we are each a member of a physics department at a US institution and thus bring an insider perspective to the culture we are exploring. Second, there have been calls within physics to address issues of diversity, equity, and inclusion (e.g. [43,44]), and better ways of describing and understanding physics department cultures can productively contribute to research on these issues. Third, there is not an accrediting body for physics degrees, unlike some disciplines (e.g. ABET for engineering [45], ACS for chemistry [46], or state credentialing for education). Thus, one might expect physics departments to have more variation than programs that are more explicitly pre-professional; physics departments are therefore more suited to a contrastive study. Finally, it is typically expected within physics that most graduate students will be full-time students; work as graduate teaching assistants in undergraduate classes; choose their own faculty mentor; and conduct research that is explicitly related to their mentor's research. Thus, there is an expectation that members of each constituent group will significantly interact with other constituent groups, providing particular affordances for an analysis that explores inter- and intra-constituency interactions.

5.2 Theoretical Framework: Communities of Practice

CoP is a sociocultural learning theory based on several fundamental assumptions: humans are social beings; knowledge is a matter of both competence with respect to and participation in valued enterprises; and making meaning is the goal of learning [42]. Within this

framework, a CoP is a group of people that regularly interact to deepen their knowledge or expertise about a particular domain. A CoP can be effectively described by the domain of interest, the community interactions, and the shared practice that facilitate the group's effectiveness [47]. Framing learning as social participation shifts the study of learning to understanding how individuals participate in the practices of their communities and how communities refine those practices and acculturate new members [42]. This framework has been used in physics education research to study students' physics identity development [48–50] and sense of community [51].

The CoP in this paper share a domain: academic physics in the United States. All members of the community, including faculty, staff, graduate students, and undergraduate students share an overall goal of enabling members of this community to contribute to our understanding of the universe. Thus, we will focus on articulating the community interactions and the shared practice that characterize these communities. In doing so, we highlight the ways in which a CoP can center or peripheralize constituent groups within the community and what this tells us about their shared values.

5.3 Methods

5.3.1 Collaborative Autoethnography

Collaborative autoethnography is a qualitative methodology in which researchers work together to analyze and interpret autobiographical data [52]. A similar approach has been used in other areas of physics education research, for example to explore the space between theory and application in curriculum development [53]. This methodology embraces the inherent subjectivity of autoethnography while also leveraging collaboration to gain multiple perspectives

on the data and analysis [52]. Key features of collaborative autoethnography are that the researcher is visible in the work and it is self-focused, context conscious, critically dialogic [52].

Our approach consisted of full and concurrent collaboration between three physicists. These three physicists involved in this work are a current graduate student and former staff member at Prairie State University, a tenured faculty member at Large Catholic University, and a tenured faculty member at Prairie State University.

Our data were individual and collaborative reflections on our own experiences within these departments as well as departmental data that are generally available to all faculty within the department (e.g., website descriptions, program review documents, enrollment statistics, etc.). To collect our reflections on our own experiences, we asked each member of the collaboration to reflect on the following questions:

- How does our department support students?
- How do the different constituencies of our department interact?
- What practices do members of the department share?

Our collection method was iterative; we each reflected on the questions then met to discuss our reflections. These discussions inspired further reflection after which we again met to discuss and compare. After about three cycles of reflection and comparison, we used our reflections to define common areas where constituent groups interacted in both departments. We then compared these interactions and looked for shared values for each department.

We also shared a draft of our paper with other members of each department, including staff and faculty in both departments, graduate students at PSU, and a graduate student who has been a member of both departments. We elicited feedback from these colleagues to verify that we are presenting an accurate description of both departments.

5.3.2 Institutional Contexts

Prairie State University (PSU) is a large (~20,000 students), predominantly white, public, land-grant university. The Department of Physics offers bachelor's degrees in physics, a minor in physics, and a MS and Ph.D. degrees in physics. The department currently has about 50 undergraduate majors and minors, and 56 graduate students. There are 26 tenure-line faculty, 7 instructional staff, 15 postdocs, and 18 support staff.

Large Catholic University (LCU) is a large (~21,000 students), diverse, urban, private, Catholic university. The Department of Physics and Astronomy offers bachelor's degrees in physics and astrophysics, a minor in physics, and MS degrees in physics. The department typically has about 8 graduate students, 50 undergraduate majors, and 10 undergraduate minors. There are nine full-time faculty (8 tenure-line and 1 term) and an administrative assistant who is the sole full-time staff member.

The Centering Women of Color in STEM (CWCS) data for both institutions as well as their physics women, women of color (WoC), and historically excluded minority women (HEMW) effectiveness scores are shown in Table 5-1. During the 12 years (2009-2018) considered in the CWCS data, PSU awarded 123 total bachelor's degrees in physics. 23 of those degrees were earned by women and 1 was earned by a woman of color. LCU awarded 95 total bachelor's degrees in physics. 22 of those degrees were earned by women, 4 were earned by WoC, and 3 were earned by historically excluded minority women (HEMW).

Table 5-1: CWCS data for LCU and PSU

Institution	Physics Bachelor's degrees (Total)	Physics Women Bachelor's degrees (effectiveness score)	Physics WoC Bachelor's degrees (effectiveness score)	Physics HEMW Bachelor's degrees (effectiveness score)
LCU	95	22 (0.42, Average)	4 (0.21, Below Average)	3 (0.23, Average)
PSU	123	23 (0.37, Average)	1 (0.13, Below Average)	1 (0.19, Below Average)

While both departments are made of the same constituent groups (faculty, staff, graduate students and undergraduate students) and have similar numbers of undergraduates, they are also different in ways that likely affect how they enact their CoP. PSU's physics department is larger overall, with more faculty, staff, and graduate students. PSU offers both M.S. and Ph.D. graduate degrees while LCU offers only an M.S. degree.

5.4 Results

5.4.1 Community Interactions

We compared the community interactions for these two departments, focusing on how the constituencies interact with each other. These interactions are summarized in Table 5-2. Both departments include many of the same types of interactions: teaching; undergraduate advising; faculty and committee meetings; research mentoring; departmental events; and student clubs. Across all interactions in both departments, all constituencies regularly interact with one another. Yet, there are variations in the nature and frequency of those interactions that differentially center the constituent groups.

As one might expect for a university department, faculty are central to the community for both departments. Most of the community interactions involve faculty. However, even with intra-faculty interactions, we see a difference. At PSU, faculty meetings are focused on reports from the department head, whereas at LCU, there is more focus on issues of shared governance.

We see another significant difference in how the two departments position graduate students compared to undergraduate students. This difference is particularly evident in research mentoring, departmental events, and student clubs. At LCU, undergraduates are encouraged to participate in research, all faculty serve as research mentors for undergraduate students, and there is a departmental event specifically aimed at sharing and celebrating undergraduate research. At PSU, undergraduates are encouraged to participate in research, but faculty are not required to mentor undergraduates. Both consider departmental events to be open to the whole department. However, LCU has events specifically targeted at the whole department, undergraduates, or graduate students, while PSU undergraduates are welcome at events, most draw only faculty and graduate students. From these interactions, we see that at LCU undergraduates are central, with graduate students slightly more peripheral to the community. In contrast, graduate students at PSU are significantly more central than undergraduates.

Table 5-2: Comparison of the community interactions at LCU and PSU.

For each type of interaction, we include the constituencies (or groups) that are involved in the interaction (grad = graduate students, u-grad = undergraduate students). Constituencies in parentheses are occasional, but not expected participants in the given interaction.

Interaction	Groups (LCU)	Description (LCU)	Groups (PSU)	Description (PSU)
Teaching	Faculty, grad, u-grad	Load is 1-2 courses per term, more u-grad than grad courses	Faculty, grad, u-grad	Load is 1 course per term, more grad than u-grad courses
	Grad, u-grad	Grads TA throughout degree	Grad, u-grad	Grads TA 1st yr, & if not RAs
	faculty, grad, u-grad	All teaching faculty and grad TAs hold office hours for students in their courses		
U-grad advising	faculty, u-grad	All tenure-line faculty serve as u-grad academic advisors	staff, u-grad	U-grads are advised by a staff advisor
Faculty & Committee Meetings	Faculty, staff	Ad hoc and ~3-6x/year. Discuss administrative activity (e.g. budget items, committee reports); teaching assignments; and emergent topics.	Faculty	Ad-hoc and ~8x/year. Discuss administrative activity (e.g. promotion & tenure, review of graduate students); and receive reports from the department head.
	Faculty	Standing and ad hoc committees meet as needed and typically consist of 3-4 faculty members.	Faculty, staff, grad	Standing and ad hoc committees meet as needed and are made up of mostly faculty and possibly a staff member or grad.
Research mentoring	faculty, grad, u-grad	Faculty are expected to mentor u-grads and grads in research	faculty, grad, (u-grad)	Faculty mentor grads and occasional u-grads in research
Dept. events	Whole dept.	Welcome events and colloquia	Whole dept.	Welcome events
	faculty, grad, (u-grad)	Thesis proposals and defenses		
	faculty, (grad), u-grad	Research Day and year-end celebrations	faculty, grad, (u-grad)	Colloquia, research seminars, thesis proposals and defenses
Student clubs	u-grad, (grad), faculty	Each club (of several) meets on a regular or semi-regular basis and has a physics faculty member advisor.	u-grad, faculty or staff	U-grad club (singular) meets rarely, has faculty or staff advisor, and hosts dept open house.
			grad	Physics grad student club meets regularly.

5.4.2 Shared Practice

Community interactions affect and inform shared practice, and vice versa, in a mutually reinforcing way. Much of the shared practice in both departments focuses on educating students and preparing them for life after graduation. The shared practice that we documented in each department fall into three main categories: pedagogy, research, and other mentoring. From this shared practice, we find a focus on pastoral care for undergraduates at LCU and an emphasis on faculty autonomy and at PSU.

Pedagogy

In both departments, specific pedagogical practices vary significantly between courses. However, the LCU physics department explicitly chose to employ classroom practices that are student-centered (i.e. practices that center the needs of students). All departmental classrooms are designed in a studio or SCALE-UP style [54] and all classes, both graduate and undergraduate, involve collaborative activities during class (collaborative problem solving, group experiments, peer review, etc.). Conversely, outside of service courses, the PSU physics department does not have a standard curriculum or teaching practice, but generally uses faculty-centered modalities (i.e. modalities that center the needs of faculty.) Both departments train graduate and undergraduate teaching assistants through a required course (LCU) or summer orientation (PSU) and weekly prep meetings (LCU and PSU.) In addition, at LCU, all faculty maintain an open-door policy for student interactions beyond scheduled office hours. At PSU, this is at faculty discretion.

Research

Both departments place a strong emphasis on student research and their graduate programs require a thesis project supervised by a faculty member. At PSU, most graduate

students are supported by faculty after their first year and faculty set their own pay rates. A yearly faculty meeting is devoted to discussing graduate students' progress. At LCU, most faculty cannot support graduate students, but do help them apply for internal or external funding,

While PSU encourages undergraduates to participate in research, faculty are not required to have undergraduates working with them. In contrast, all faculty at LCU are expected to support undergraduates in research. Both institutions have internal programs that fund undergraduate research. The LCU physics department holds a departmental event (Research Day) designed to introduce undergraduates to research opportunities for the following summer and academic year. This event is scheduled to occur before the deadline for internal funding programs. The PSU physics department discusses undergraduate research during a required course that all first-year students take. Students are then encouraged to find a research project to join, and individual faculty members help students who work for them apply for funding. Both departments also encourage students to apply for external research opportunities (e.g., NSF's REU program). Announcements about such opportunities are circulated to the undergraduate majors via staff and faculty will provide letters of recommendation and application support.

Other Mentoring

The LCU physics department provides opportunities for students to present their research and create connections with the broader scientific community. The departmental administrative assistant is largely responsible for organizing LCU's Annual Undergraduate Research Showcase, as well as organizing departmental events and serving as a departmental photographer. Many of the physics faculty serve as reviewers for LCU's undergraduate research journal, with one serving on the editorial board. The LCU physics department also pays student membership fees for any STEM organization and funds both graduate and undergraduate students to attend

professional society conferences to present their research. In addition, undergraduates are supported to attend professional development conferences even when not presenting research. At PSU, individual faculty, rather than the department, provide support for students to attend conferences and determine the amount of support and there is large variation in policies between faculty. The graduate staff assistant organizes formal and informal events for the department as well as performs general non-research advising for grad students, and unofficially takes on a role that the graduate students call “grad mom.”

At LCU, individual faculty members have also taken up activities to help undergraduate students prepare for life after graduation. One offers an optional course for students preparing for the physics GRE and another has helped create makerspaces at LCU to provide opportunities for students to develop creative and technical skills. Two faculty work with student clubs, helping them to host events such as a Women in Physics Career Day. At PSU, individual faculty informally mentor individual undergraduates and it is often left up to the students to seek these relationships out. All undergraduates are advised by a primary role advisor who meets with students once a semester to discuss course plans and career goals. The academic advisor also works with the physics club and helps them host the department’s contribution to the annual university open house.

Physical Space

The physical space that a department occupies affects how the community housed within it develops and sustains community and shared practices. PSU and LCU each share their respective buildings with one other department, and each department houses research labs, instructional spaces, faculty offices, graduate student offices, administrative offices, and undergraduate study space in that building. However, PSU's physical space is distributed

throughout the building (interweaved with the other department in the building) and LCU's departments are primarily concentrated by floor.

Both departments segregate their space by constituency: undergraduate students study in the undergraduate study space and graduate students and faculty rarely enter the space. At LCU, the graduate students also have a separate space that is rarely entered by undergraduates or faculty. Almost all faculty offices are in the same suite, with the departmental administrative staff at the main desk. In contrast, at PSU, graduate students and faculty segregate by research group: students in the same research group share office space, and research lab rooms belong to specific research groups.

LCU's tight grouping of faculty and administrative space increases intra-faculty interactions. Candy provided at the main desk often encourages students to come to the office and interact; and keeping all the faculty together increases the chances for undergraduates to interact with all faculty, rather than just a specific person they're visiting. Recently, the department has recognized the way their space allows the different constituencies to interact and has begun to think about how to reconfigure their space to better facilitate more interactions between faculty, undergraduates, and graduate students.

PSU's segregation by research group decreases intra-faculty interactions around pastoral care of graduate students outside of their research groups and of undergraduate students overall. Housing graduate students by group—and tying them to research labs by group—also decreases their availability to undergraduate students. Some efforts in the department to increase inter-group interactions have been stymied by this geographic separation. The department recently created a graduate student common space to facilitate interaction between graduate students from different research groups.

5.5 Discussion and Conclusion

From the community interactions, we see differences in how constituent groups are centered in each department. While faculty are central for both, PSU strongly centers graduate students whereas LCU primarily centers undergraduates with graduate students slightly more peripheral to the community. The shared practice of each department is influenced by these interactions, but also serves to reinforce the centering of the different groups. Both departments are explicitly interested in the acculturation of new members (i.e., students) into both the local CoP and the broader community of physics outside of their institutions. At PSU, efforts in this regard are led by individual faculty and predominantly focused on graduate students. In contrast, LCU explicitly engages both undergraduates and graduate students and many of these efforts are departmental in nature (e.g., the use of studio classrooms and departmental funding for conferences). From the shared practice, we see evidence of fundamental shared values: faculty autonomy for PSU and pastoral care for LCU.

The importance of faculty autonomy at PSU is demonstrated by practices that center research preparation for graduate students, place decisions about teaching and mentoring solely in the hands of individual faculty, and by the physical segregation of faculty and graduate students by research area. In contrast, LCU's commitment to pastoral care means a shared practice that is more undergraduate focused, places more emphasis on joint work in faculty interactions, and uses physical space in a way that encourages interaction between different constituencies.

While these departments represent a contrast with each other, there are also other models for departmental CoP. In addition, we are not making claims about how members of each community feel about the culture in these departments. Instead, we have shown how shared

practice within a department affects and is affected by interactions and that these together illuminate foundational values within a CoP.

Chapter 6 - Exploratory Case Studies of Departmental Factors

6.1 Introduction

In this chapter, we discuss exploratory case studies of physics, math, and computer science departments using their websites to elucidate information about how these departments support their undergraduate students. This work is motivated by the assertion that departments with welcoming and supportive climates should have higher effectiveness scores for underrepresented populations. We ask the question, “What evidence can we find of a welcoming and supportive climate in departments with high physics Women of Color (WoC) effectiveness scores?” Ideally to address this question, we would perform large scale interview or observational based studies of departments to learn about the culture and environment in departments with high effectiveness scores; that is an area for future work.

Here, as a preliminary step, we use department websites to investigate department culture. We assume that departments provide information on their websites for prospective students and that the information they provide can hint at departmental practices and values. In general, websites are not a great source of data. If we find something on a department’s website, we can conclude it represents something about the department, but we cannot conclude anything if something is absent from the website. Despite this large limitation, websites are still valuable as a first source of data about departments. For many prospective students a department’s website is the first way they interact with the department and can affect their initial impression of the department. Additionally, what a department chooses to include says something about what they think is important for their students (although we will not conclude that something missing from a website is not valued by the department).

We used our calculated WoC effectiveness scores (Chapter 3) to select institutions for this study. We chose institutions that would allow us to conceptualize excellence (high scoring institutions) and institutions for within institutional comparisons.

6.2 Theory Conjecture Mapping

Conjecture mapping is a method that allows for the mapping of theory to specific, observable outcomes [55]. While conjecture mapping is commonly used in design-based research, here we apply it to operationalize elements of a welcoming and supportive physics departmental environment that we might expect to find on a department's website.

To create the conjecture map, we started with the assertion that departments with welcoming and supportive climates should have higher effectiveness scores. Then we looked for elements of welcoming and supportive departmental climates. These elements generally came from two sources: the shared practices that contributed to Large Catholic University's physics departments shared value of pastoral care (see Chapter 5) and items on the AIP TEAM-Up Report Rubric for high school students and parents to evaluate physics and astronomy programs [44]. We used these two sources to select elements of welcoming and supportive departments that could then be operationalized to information we could look for on department websites. The four elements that we selected are sense of belonging, physics identity, academic support, and personal support. These elements do not represent all the behaviors and characteristics we would expect of welcoming and supportive physics departments. Instead, they represent elements of welcoming and supportive physics departments for which evidence is likely to be found on department websites.

Belonging is how much students feel like they belong in the department. The TEAM-Up Rubric lists items related to how students interact with the department, faculty, and other

students. We also saw belonging as an important part of LCU's pastoral care, specifically in the way they have department events that center undergraduates.

Physics identity is whether students are viewed by themselves and others as future physicists. This element is listed in the TEAM-Up Rubric for this element are characteristics of departments such as whether undergraduates participate in research, are supported to travel to present research, and can work with faculty members from the same race or affinity group. It can also be seen in LCU's departmental practices around engaging undergraduate students in research.

Academic support consists of steps the department takes to ensure their undergraduate students are successful academically. The TEAM-Up Rubric lists multiple pathways to degrees, state-of-the-art teaching methods, and advising systems as being important elements of academic support. We also see a focus on academic support in LCU's student centered teaching modalities.

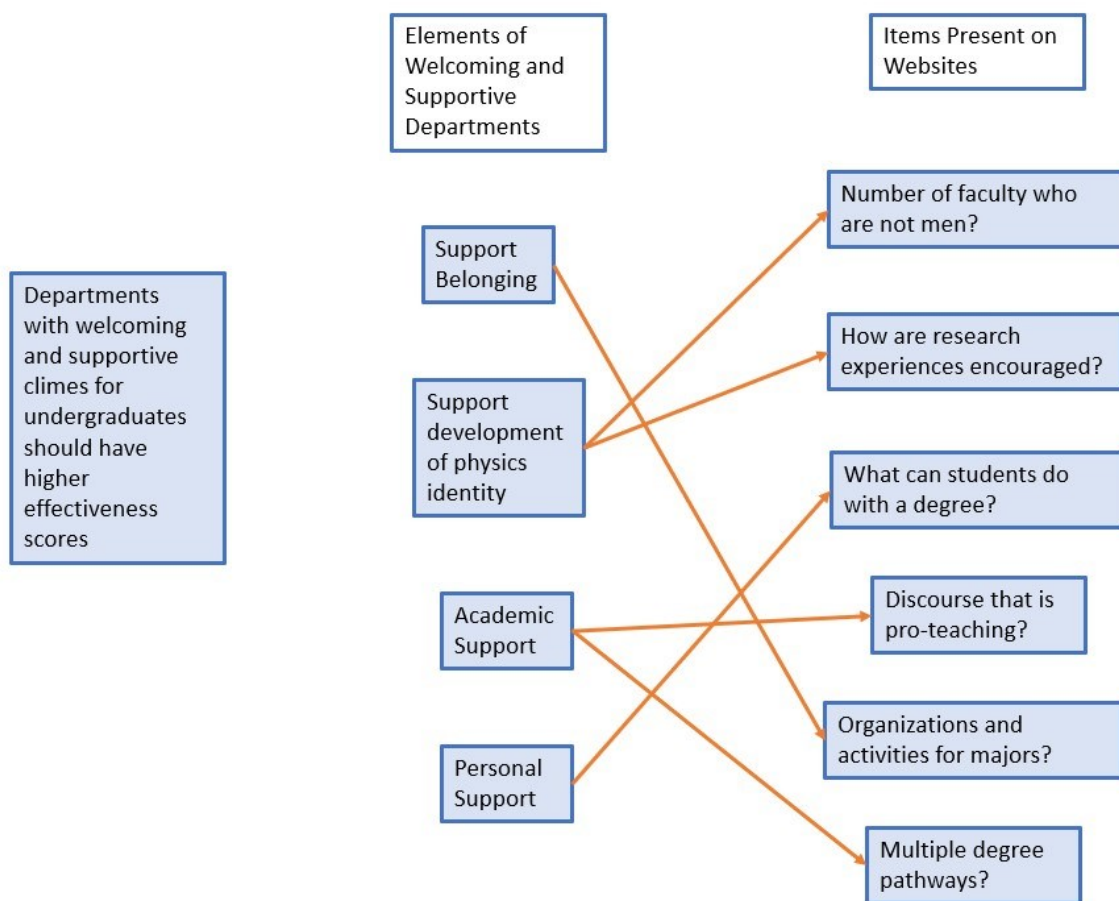
Personal support is defined by the TEAM-Up Rubric as support that offsets financial burdens and stress. These are items like access to financial aid, access to mental health services, and descriptions of career pathways.

After selecting the four elements, we linked them to six observable items:

- The number of physics faculty who aren't men
- How the department encourages and supports undergraduate research
- How does the department help undergraduates plan for life after graduation
- If the department use language the is pro-teaching of undergraduates
- Are there departmental activities and organizations for undergraduates
- If there are multiple degree pathways.

The conjecture map, linking these observable items to the four chosen elements of departments with welcoming and supportive climates is shown in Figure 6-1.

Figure 6-1 Conjecture map linking elements of welcoming and supportive departments to observable items



6.3 Methods

6.3.1 Data Collection

We used an institution's calculated physics, math, and computer science WoC effectiveness score to select institutions for this study. We focused on two comparisons: conceptualization of excellence in physics and multiple departments at the same institution. Once

the institutions were chosen, I spent ~20 minutes interacting with each department's website². I approached this interaction as if I were a prospective undergraduate student looking for information about the department. I specifically looked for information related to the observable items from Figure 6-1. Notes from these observations are included in Appendix B.

Conceptualizing Excellence

Departments were selected from the 191 institutions that had above average physics WoC effectiveness scores (> 0.41 .) We excluded high scoring departments that had fewer than 3 WoC earn physics degrees over the 12 years of our data. This left 115 departments to choose from. Mathematically, departments can score high if they graduate large numbers of WoC, if they have a high proportion of WoC graduates, or if they are at an institution that has a low proportion of WoC graduates. We chose 12 departments that represent this range as well as several departments that scored above average for women, WoC, and historically excluded minority women (HEMW) and several departments at institutions that scored above average for WoC in physics, math, and computer science. The departments chosen are summarize in Table 6-1.

² These department websites were accessed June 2022

Table 6-1 Selected physics departments with high WoC effectiveness scores

Institution	Size	Carnegie Classification	Population Mission	Physics WoC score	Physics WoC count	Physics WoC percent	Institution WoC percent
Saint Vincent College	Small	Bachelor's	Co-ed, PWI	2.1	3	7%	3%
Notre Dame of Maryland University	Small	Master's	Women's PWI	1.58	8	53%	34%
Simmons University	Medium	Doctoral	Former Women's PWI	1.54	5	36%	23%
William Jewell College	Very Small	Bachelor's	Co-ed, PWI	1.34	6	10%	7%
Spelman College	Small	Bachelor's	Co-ed, MSI	1.04	20	100%	97%
Jackson State University	Medium	Doctoral	Co-ed, MSI	0.91	22	58%	64%
South Carolina State University	Small	Master's	Co-ed, MSI	0.83	11	42%	53%
Wellesley College	Small	Bachelor's	Women's, PWI	0.81	34	34%	43%
Walla Walla University	Small	Master's	Co-ed, PWI	0.79	3	9%	12%
Seton Hall University	Medium	Doctoral	Co-ed, PWI	0.54	15	12%	23%
Massachusetts Institute of Technology	Large	Doctoral	Co-ed, PWI	0.46	95	10%	22%
The University of Texas at El Paso	Large	Doctoral	Co-ed, MSI	0.44	28	22%	50%

Contrasting departments at the same institution

To compare departments at the same institutions, we selected two contrasting cases:

- institutions with high physics WoC effectiveness scores, low math WoC effectiveness scores, and low computer science WoC effectiveness scores
- institutions with low physics WoC effectiveness scores, high math WoC effectiveness scores, and high computer science WoC effectiveness scores.

I am going to refer to the two contrasting cases as “high physics WoC effectiveness scores” and “low physics WoC effectiveness scores.”

For the high physics WoC effectiveness score contrasting case, we chose institutions that had above average physics WoC effectiveness scores ($> .41$), below average math WoC effectiveness scores ($< .49$), and below average computer science WoC effectiveness scores ($< .32$.) There were 27 institutions that met these criteria. We excluded 16 schools that only had one WoC graduate with a physics degree. Of the remaining 11 institutions, we selected 3. For the low physics WoC effectiveness score contrasting case, we chose institutions that had below average WoC effectiveness scores in physics (< 0.25) and above average WoC effectiveness scores in math (> 0.70) and computer science (> 0.49 .) There were 16 possible institutions that met these criteria and we selected 3. Characteristics of the six selected institutions are summarized in Table 6-2.

Table 6-2 Characteristics of institutions chosen for contrasting departments at the same institution

School	Size	Carnegie Classification	Population Mission	Department	WoC Score
Walla Walla University	Small	Masters	Co-ed, PWI	Physics	0.79
				Math	0.40
				Computer Science	0.15
Seton Hall University	Medium	Doctoral	Co-ed, PWI	Physics	0.54
				Math	0.46
				Computer Science	0.09
Western Kentucky University	Large	Doctoral	Co-ed, PWI	Physics	0.53
				Math	0.25
				Computer Science	0.28
Creighton University	Medium	Doctoral	Co-ed, PWI	Physics	0.23
				Math	1.24
				Computer Science	0.92
New Jersey Institute of Technology	Medium	Doctoral	Co-ed, PWI	Physics	0.11
				Math	1.29
				Computer Science	0.74
University of North Carolina at Asheville	Medium	Bachelor's	Co-ed, PWI	Physics	0.00
				Math	0.83
				Computer Science	0.51

6.3.2 Data Analysis

In order to evaluate how departments conceptualize the four chosen elements of welcoming and supportive departments, we looked for evidence of the observable items articulated in our conjecture map. Each of these items were evaluated on a scale of 0-3. To create the rubric for this evaluation, I briefly examined five of the chosen websites to get a sense of the type of information they provide and how they present it. Generally, scores of 3 represent information that the department explicitly discusses on their website. This explicit discussion

tends to include examples and sometimes links to resources. Websites that scored 2 tended to have statements that implied the presence of the observable item but did not have more in depth explicit discussion or examples. For example, a department that listed multiple degree paths but provided no other information about them would score a 2 in “multiple degree pathways.” A score of 1 for an observable means that the item is referenced in passing somewhere on the website. For example, many websites have a welcome statement from the department head and a few have testimonials from recent graduates. These statements often mention the observable items on the rubric, but if further details related to that item are not provided on the website, the department scores 1 for that element. A score of 0 means the observable item is not present on the website. The rubric and additional descriptions of each score are given in Table 6-3.

Table 6-3 Rubric used to evaluate departmental websites

Observable Items	3	2	1	0
How are research Experiences encouraged?	Explicitly discuss opportunities and how students can access them	Undergraduate research implied by curriculum	Undergraduate research mentioned briefly in department description or welcome statement	Not mentioned
What can students do with degree?	Explicit examples and resources	lists some options	Mentioned briefly in department description or welcome statement	Not mentioned
Discourse that is enthusiastic and pro-teaching?	Gives explicit examples of department teaching practices	vague statements like, "small class size"	implied by alum statements but not mentioned elsewhere	Not mentioned
Other exciting things for majors	Gives explicit examples of multiple things	Mentions physics club or SPS	vague statements like, "our students participate in a range of activities," implied by alum statements but not mentioned elsewhere	Not mentioned
Degree Pathways	multiple pathways/customizable with descriptions of why a student might pick something	Multiple pathways but no descriptions	just basic courses	Not mentioned/only link to university catalog
How many faculty and how many are not men?				

6.4 Results

6.4.1 Conceptualizing Excellence

We selected 12 institutions with above average physics WoC effectiveness scores and investigated the websites of the physics departments at those institutions. Descriptions of each of the 14 institutions are given below.

Institutions Selected

Saint Vincent College

Saint Vincent College is a small, private, Benedictine institution located in Latrobe, Pennsylvania. The Carnegie Classifications classify it as bachelor's degree granting and it is a

co-educational predominantly white institution (PWI.) The physics department has above average effectiveness scores for women, WoC, and HEMW. Mathematically, this is likely because the institution has among the smallest proportion of bachelor's degrees awarded to WoC of the institutions with above average physics WoC effectiveness scores.

Notre Dame of Maryland University

Notre Dame of Maryland University is a small, private, Catholic institution located in Baltimore, Maryland. It's classified as a Master's degree granting institution and is also a PWI women's college. In addition to having an above average physics WoC effectiveness score it's physics department has one of the highest percentages of bachelor's degrees awarded to WoC. The physics department had above average effectiveness scores for women, WoC, and HEMW. The institution also had above average WoC effectiveness scores in physics, math, and computer science.

Simmons University

Simmons University is a medium, private, former women's college located in Boston Massachusetts. It's classified as a master's degree granting institution and is also a PWI. The physics department had above average effectiveness scores for women, WoC, and HEMW. The institution had above average WoC effectiveness scores for physics, math, and computer science.

William Jewel College

William Jewel College is a very small, private, liberal arts institution located in Liberty Missouri. It is a bachelor's degree granting, co-educational PWI. The physics department had an above average WoC effectiveness score while the math and computer science departments had below average WoC effectiveness scores.

Spelman College

Spelman College is a small, private, bachelor's degree granting, liberal arts, Women's Historically Black College/University (HBCU) located in Atlanta, Georgia. It had one of the highest percent of physics degrees awarded to WoC, had above average physics effectiveness scores for women, WoC, and HEMW, and had above average WoC effectiveness scores for physics, math, and computer science.

Jackson State University

Jackson State University is a medium, public, doctoral degree granting, co-educational HBCU located in Jackson Mississippi. It had among the largest percent of physics bachelor's degrees awarded to WoC and had physics effectiveness score that were above average for women, WoC, and HEMW.

South Carolina State University

South Carolina State University is a small, public, master's degree granting, co-educational, HBCU located in Orangeburg, South Carolina. The physics department had an above average WoC effectiveness score.

Wellesley College

Wellesley College is a small, private, liberal arts, bachelor's degree granting, women's PWI located in Wellesley, Massachusetts. It had the second highest number of physics degrees awarded to WoC (34) and had above average effectiveness scores for WoC in physics, math, and computer science.

Walla Walla University

Walla Walla University is a small, private, Adventist, master's degree granting, co-educational, PWI located in College Place, Washington. It had an above average physics WoC effectiveness score but below average math and computer science WoC effectiveness scores.

Seton Hall University

Seton Hall University is a medium, private Catholic, doctoral, co-educational, PWI located in South Orange, New Jersey. It had an above average physics WoC effectiveness score but below average math and computer science WoC effectiveness scores.

Western Kentucky University

Western Kentucky University is a large, public, doctoral degree granting, co-educational, PWI located in Bowling Green Kentucky. It has an above average physics WoC effectiveness score but below average math and computer science WoC effectiveness scores.

Massachusetts Institute of Technology

Massachusetts Institute of Technology is a large, private, doctoral degree granting, co-educational, PWI located in Cambridge, Massachusetts. The physics department had an above average WoC effectiveness score and awarded the largest number of physics degrees to WoC (95) of the institutions in our dataset.

The University of Texas at El Paso

The University of El Paso is a large, public, doctoral degree granting, co-educational, Hispanic serving institution. The physics department had an above average WoC effectiveness score and awarded the third largest number of physics degrees to WoC (28) of the institutions in our dataset.

The rubric scores for the chosen high scoring physics departments are given in Table 6-4. Notes about the individual websites are in Appendix B.

Total Faculty and Faculty Gender

Two of the departments did not include information about their faculty on their website. The two smallest physics departments, Notre Dame of Maryland University and Walla Walla University, had only men among their physics faculty. According to the American Institute of Physics, 19% of physics faculty are women [56]. Compared to this national average, women made up greater than 19% of the physics faculty in six of the departments and less than 19% in two of the departments. The majority (6/10) of the high scoring physics departments that provided information about their faculty, had more women faculty than the average. This can contribute to undergraduate women's physics identity because it helps them see that people like them can be physicists. Because of the limitations of websites as a data source, we do not have access to other demographic information about the physics faculty at these institutions, which would allow for further comparisons between faculty demographics and physics effectiveness scores.

Research Experience

All but two of the departments had language encouraging research experiences for undergraduates. Seven departments explicitly discussed the importance of participating in research. Smaller institutions that do not have large research programs on campus encouraged their students to find opportunities off campus. Some smaller institutions, like Walla Walla University, explicitly encouraged their students to participate in REU programs at other institutions and encouraged research at nearby partner institutions. The two HBCUs in the set had a mention of research on their websites: Spelman College had quotes from a former student that mentioned research and Jackson State University stated that students participate in research in the department head's welcome statement. From this, we can conclude that most of these

departments recognize the importance of research experiences for their students and encourage their students to participate in research.

Planning for Life after graduation

South Carolina State University was the only department that did not have information about careers for physics majors on their website. Four of the departments had a statement somewhere on their site about physics being a degree that is applicable to a large range of careers but did not include any other information about potential careers. Jackson State included something about career preparation only in their learning goals. Four of the departments had more explicit discussion about potential careers. This included links to AIP resources and information about what previous students did after graduating. Like research experiences, potential career options is something that these high scoring physics departments recognize is important. Most of the departments also mentioned that there are multiple paths a student can take after graduation, including but not exclusively graduate school.

Pro-teaching Discourse

Half of the departments did not have language discussing teaching on their websites. Of the six that did, three mentioned small class size as a benefit. Walla Walla University's physics department highlighted that students have many opportunities to interact with faculty (including contacting faculty at home). The physics department at Wellesley College had information about how their required courses tied into the department's learning goals. The University of Texas at El Paso's department head statement encouraged students to take their new physics pedagogy course. In general, pro-teaching discourse is something that is not explicitly present on most of the websites. It is likely that these departments have practices that are pro-teaching of

undergraduates, but details of those practices are not included on their websites from which we can conclude that websites are not a good way to gather this information.

Other opportunities for majors

Seven departments had no mention of other opportunities for majors. William Jewel College's physics department had a statement about students participating in a wide range of collegiate activities. Wellesley College and Seaton Hall University had information about their chapters of Society of Physics Students and Sigma Pi Sigma. Massachusetts Institute of Technology was the only department that discussed other opportunities for undergraduates, including a mentorship program, TA positions, and department town halls. Like pro-teaching discourse, it is likely that these departments have activities and organizations for their undergraduates even though they do not mention them on their websites.

Degree Pathways

Most of the departments offered multiple pathways for students to earn a degree, including options like different tracks, options to customize the degree, and concurrent physics and engineering or data science bachelor's or master's degrees. Five of the departments had some guidance for students about the types of students the different options are designed for. Four of the departments listed multiple pathways but had no other description of them. The University of Texas at El Paso and William Jewel College did not have information on their website about degree requirements. From this, we can conclude that high scoring physics departments tend to offer multiple degree pathways.

Table 6-4 High Physics WoC effectiveness score results

Institution	Department	Physics WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro-teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Saint Vincent College	Physics and Physics Education	2.1	No information	3	3	0	0	2
Notre Dame of Maryland University	Department of Math, Computer Studies, and Physics	1.58	1 (0)	3	3	0	0	2
Simmons University	Chemistry and Physics	1.54	15 (6)	3	2	2	0	2
William Jewell College	Physics	1.34	3 (1)	0	2	2	1	0
Spelman College	Physics Department	1.04	9 (2)	1	1	1	1	3
Jackson State University	Department of Chemistry, Physics, and Atmospheric Science	0.91	14 (2)	1	1	0	0	1
South Carolina State University	Department of biological and physical sciences	0.83	No information	0	0	0	0	2
Wellesley College	Physics Department	0.81	13 (5)	3	3	3	2	3

Walla Walla University	Department of Physics	0.79	2 (0)	3	3	2	0	3
Seton Hall University	Department of Physics	0.54	8 (3)	3	2	0	2	3
Massachusetts Institute of Technology	Physics Department	0.46	120 (16)	3	2	0	3	3
University of Texas at El Paso	Physics Department	0.44	17 (4)	2	1	3	0	0

6.4.2 Contrasting Departments at the same institution

Most institutions have some level of standardization for department websites. Because of this, we are likely to see some commonalities between departments that say more about the institutional expectations and values than they do about departmental practices and environment. To investigate how this possibility affects what we can learn from department websites, we chose six institutions and investigated the physics, math, and computer science departments at all six institutions. Contrastive cases provide the best opportunity to see differences in departments at the same institution and to see if those differences correlate to WoC effectiveness scores. Therefore, we chose institutions with high physics WoC effectiveness scores and low math and computer science WoC scores as well as institutions with low physics WoC effectiveness scores and high math and computer science WoC effectiveness scores.

Walla Walla University

Walla Walla University was chosen because it had an above average physics WoC effectiveness score and below average math and computer science WoC effectiveness scores. The results for Walla Walla University are shown in Table 6-5. All three of the departments had only male faculty. They also all had multiple degree paths with explanations and information about what students can do with their degree. The math department's website did not have any information encouraging research or any pro-teaching discourse. The physics department and computer science departments had similar information on their websites.

Table 6-5 Walla Walla University comparison

Discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro-teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Department of Physics	0.79	2 (0)	3	3	2	0	3
Math	Department of Mathematics	0.40	5 (0)	0	3	0	1	3
Computer Science	Department of Computer Science	0.15	6 (0)	2	3	2	3	2

Seton Hall University

Seton Hall University was chosen because the physics department had an above average WoC effectiveness score and the math and computer science department had below average WoC effectiveness scores. The results for Seton Hall University are shown in Table 6-6. This institution has a combined math and computer science department, although the department kept information for math majors and computer science majors in different sections. Given that they are the same department, it is not surprising that the websites for the two majors only had slight differences. On the math portion of the site, undergraduate research was briefly mentioned and multiple tracks were described. The computer science portion of the site had information about computer science careers. In contrast, the physics department had information related to all categories of the rubric except pro-teaching discourse. For this institution, the department with the higher WoC effectiveness score had more of the rubric information on their website.

Table 6-6 Seton Hall University comparison

Discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro- teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Department of Physics	0.54	8 (3)	3	2	0	2	3
Math	Department of Math and	0.46	18 (5)	1	0	0	0	3
Computer Science	Computer Science	0.09	18 (5)	0	2	0	0	0

Western Kentucky University

Western Kentucky University was chosen because the physics department had an above average WoC effectiveness score and the math and computer science departments had below average WoC effectiveness scores. The results from Western Kentucky University are shown in Table 6-7. In general, the three departments have similar websites. All three had information about other opportunities for majors and multiple paths to degrees. Two of the three departments had explicit career information and two of the three departments had pro-teaching rhetoric on their websites.

Table 6-7 Western Kentucky University comparison

Discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro- teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Physics and Astronomy	0.53	16 (2)	0	3	0	3	3
Math	Mathematics	0.25	36 (19)	0	3	2	3	2
Computer Science	Computer Science	0.28	7 (2)	1	0	2	2	3

Creighton University

Creighton University was chosen because it had a below average WoC effectiveness score and above average math and computer science WoC effectiveness scores. The results for Creighton University are shown in Table 6-8. In general, the three departments had similar websites. None of the departments had in depth information about research for undergraduates, although the physics and computer science departments mentioned it briefly in their description of the department. None of the departments had language that was pro-teaching. All three of the departments' websites discussed other activities that their majors can participate in and had multiple degree tracks with explanations.

Table 6-8 Creighton University comparison

Discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro- teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Department of Physics	0.23	10 (2)	1	2	0	3	3
Math	Department of Mathematics	1.24	7 (2)	0	2	0	2	3
Computer Science	Department of Computer Science	0.15	5 (1)	1	0	0	2	3

New Jersey Institute of Technology

New Jersey Institute of Technology was chosen because it had below average physics WoC effectiveness score and above average math and computer science WoC effectiveness scores. The results for New Jersey Institute of Technology are shown in Table 6-9. The physics and computer science departments have similar websites and have a bit more information than math. All three of the departments discussed multiple tracks and career options on their websites.

Table 6-9 New Jersey Institute of Technology comparison

discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro-teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Department of Physics	0.1	14 (1)	1	3	2	0	2
Math	Department of Mathematical sciences	1.3	37 (5)	0	3	0	0	3
Computer Science	Department of Computer Science	0.74	13 (1)	0	2	2	0	2

University of North Carolina at Ashville

University of North Carolina at Ashville was selected because it had a below average physics WoC effectiveness scores and above average math and computer science effectiveness WoC scores. The results for University of North Carolina at Ashville are shown in

Table 6-10. The results for the three departments are similar. All three websites had information about career options, information about other activities for majors and multiple degree tracks.

Table 6-10 University of North Carolina at Ashville comparison

Discipline	Department	WoC Effectiveness Score	Total Faculty (Total not men)	How are research experiences encouraged?	What can students do with degree?	Is there discourse that is enthusiastic and pro- teaching?	Are there other exciting things for majors?	Are there multiple degree pathways or ways to customize degree?
Physics	Physics and Astronomy	0	9 (3)	0	3	0	2	3
Math	Math and Statistics	0.83	17 (5)	3	2	1	3	3
Computer Science	Computer Science	0.51	7 (3)	3	2	0	3	3

6.5 Discussion and Conclusion

Our results show several items related to welcoming and supportive departments that high scoring physics departments tend to include on their websites. Most of the departments with high physics WoC effectiveness scores that we investigated have more women faculty than the national average. They also have language encouraging undergraduates to participate in research. Both observable items help students develop a physics identity. The other most common information found on these websites is related to degree pathways and physics careers. Providing students with these options and information helps support them academically and personally. It is less common to see information about teaching practices and activities for majors on these websites. The absence of this information does not imply that these items are not present in the department; rather it suggests that department websites are not a good source for this information. This lack of information about many of things that departments are likely doing to support their undergraduates may imply that departments are not aware of all the ways in which they create a supportive and welcoming environment. For departments where this is the case, examining the TEAM-Up Report and Rubric for departments [44] may help them develop an awareness of the ways in which they provide a supportive and welcoming environment for students, particularly those from historically excluded minority groups.

In comparing departments at the same institution, we see that websites at the same institution tend to include similar information. This is possibly because institutions have expectations about what types of information should be presented on a department's website. It is also possible that when creating websites, departments focus more on shared institutional values than on shared departmental values.

The results of this study point to large scale interview or observational based studies as the next step investigating department culture.

Chapter 7 - Conclusions and Future Work

In this dissertation, I have discussed a contribution to the Centering Women of Color in STEM (CWCS) project. This project asks, “Where are women of color (WoC) thriving in STEM?” and seeks to contribute to the answer by finding and analyzing STEM departments that are good at graduating WoC with bachelor’s degrees in physics, math, and computer science.

In this portion of that larger project, I have discussed the large set of data that we gathered to help answer this question. Using this data, we developed an effectiveness score that can be used to compare institutions. Using that score, we compared the data to common narratives related to where WoC earn physics degrees. The results showed that minority serving institutions (MSIs) and women’s colleges are better at graduating WoC in physics than co-educational predominantly white institutions (PWIs), although this factor did not completely explain the variation that we see in scores. Other institutional characteristics, like size, location, and research mission, did not affect this score. One implication of this result is that we need to look for other factors that could help explain this variation. A possible area to look is at institutional practices and culture that is not represented by the factors we considered and at departmental characteristics, practices, and culture. Many of these characteristics are difficult to measure quantitatively so qualitative studies need to be employed to understand more about factors that contribute to a department’s success in graduating WoC with STEM degrees.

As a first step towards using qualitative studies of department culture to engage with the CWCS data, I performed two preliminary studies investigating department culture. The first study is a contrastive, autoethnographic case study of two physics departments. From this analysis, we were able to see how their departmental practices suggest different shared values for the two department. These shared values are informed by characteristics of the department and

the ways in which the constituent groups interact and point to possible shared practices that center undergraduate students.

The final study in this dissertation was an exploratory case studies of STEM departments using their websites to gather information about departmental practices. We used the calculated WoC effectiveness scores to select departments for this study and used the results of the autoethnographic comparison to help choose factors to look for. In this study, we see that many departments, regardless of effectiveness score, include information related to research opportunities, career options, and degree paths. There are likely many other things that these departments are doing to support their majors that are not included in their website. One possibility is that departments are not always aware of what they are doing well. This is anecdotally confirmed by informal interviews with physics faculty who were interacting with the CWCS data through our portal and were often surprised to find that their department had a high effectiveness score. This study also confirms that departmental websites are an incomplete source of data about departmental culture.

The results of these three studies point to possible areas of future work. Chapter 4 points to qualitative studies of departmental culture as a key step toward understanding differences in how departments support WoC. Chapter 5 highlights the differences between two physics departments in what they value and how those values are interacted in their shared practice. Chapter 6 points to departmental websites as an incomplete source of information about departmental practices. The next step is to perform large scale interviews or observational based studies of high scoring departments to better understand how these departments are creating spaces where WoC thrive in STEM.

CWCS is an international collaboration involving a team from the U.S. and a team from the U.K. For many reasons, including different rules about data, different definitions of underrepresented minority groups, and different higher education systems, we have not been able to compare U.S. data to U.K. data. Finding a way to compare across countries is an ongoing area for future work.

Another area for future exploration is to compare physics, math, and computer science scores. One difference between these three disciplines is that math has much higher effectiveness scores than physics and computer science. There are also larger numbers in the math and computer science data which could help elucidate trends.

Finally, more information from other datasets could be combined with our quantitative data. For example, information about institution cost could allow for an analysis of return on investment for STEM degrees at various institutions.

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Appendix A - R Code Used to Download and Clean Data

```
# Copyright (c) Dan Li <danli2004@gmail.com> 2020-2022
# Some rights reserved: CC BY-NC-ND 4.0 (https://creativecommons.org/licenses/by-nc-nd/4.0/)

if (TRUE) {
  library(openxlsx)
  library(readr)
  library(dplyr)
  library(stringr)
  library(tidyr)
  library(forcats)
  library(vroom)
  library(purrr)
  library(glue)

  library(janitor)
  # library(raster)
  library(sp)
  library(tidylog)
  library(zipcodeR)

  options(scipen=999)

  # We use CIP code 2010 because most of our data were collected in the 2010s
  cip2010 <- readr::read_csv('https://nces.ed.gov/ipeds/cipcode/Files/CIPCode2010.csv') %>%
    mutate(cipcode_6digit = stringr::str_remove_all(CIPCode, '[="\\.]'))
```

```
# see https://nces.ed.gov/ipeds/cipcode/cipdetail.aspx?y=55&cip=40.08 for details
CIP6_PHYS <- cip2010 %>% filter(stringr::str_detect(cipcode_6digit, '^4008\\d{2}')) %>%
pull(cipcode_6digit)
```

```
# Detail for CIP Code 27: MATHEMATICS AND STATISTICS
# https://nces.ed.gov/ipeds/cipcode/cipdetail.aspx?y=55&cipid=88406
# Per discussion with Ellie and Jessy, we decided to use 27 for math majors
CIP6_MATH <- cip2010 %>% filter(stringr::str_detect(cipcode_6digit, '^27\\d{4}')) %>%
pull(cipcode_6digit)
```

```
# CIP code 11 for computer science
CIP6_CS <- cip2010 %>% filter(stringr::str_detect(cipcode_6digit, '^11\\d{4}')) %>%
pull(cipcode_6digit)
```

```
label_race <- c("white", "black", "hispa", "asian", "amind",
               "pacis", "twora", "international", "unknown", "total")
```

```
path_dict_inst_sc_raw <- 'data/raw/dict_inst_sc_raw.RDS'
path_dat_inst_sc_raw <- "data/raw/dat_inst_sc_raw.RDS"
path_dat_ipeds_directory_raw <- 'data/raw/dat_ipeds_directory_raw.RDS'
path_dat_inst_directory_raw <- "data/raw/dat_inst_directory_raw.RDS"
path_dat_inst_awards_raw <- "data/raw/dat_inst_awards_raw.RDS"
path_dat_inst_awards_phys <- "data/raw/dat_inst_awards_phys.RDS"
path_dat_inst_awards_math <- "data/raw/dat_inst_awards_math.RDS"
path_dat_inst_awards_cs <- "data/raw/dat_inst_awards_cs.RDS"
path_dat_inst_awards <- "data/raw/dat_inst_awards.RDS"
```

```
path_dat_inst_ug_profile <- "data/raw/dat_inst_ug_profile.RDS"
path_dat_us_awards <- 'data/dat_us_awards.RDS'
path_dat_inst_compgroup_dfr <- 'data/raw/dat_inst_compgroup_dfr.RDS'
```

```

path_dat_awards_year <- 'data/dat_us_awards_year.RDS'

path_dat_inst_year <- 'data/dat_inst_year.RDS'
path_dat_inst_info <- 'data/dat_inst_info.RDS'

CWCS_DATA_YEARS <- 2008:2020
}

##-----##
##          Retrieve Raw Data          ----
##-----##

##-----##
##          CWCS institution UnitIDs          ----
##-----##
#
# CWCS_DAT_US_PHYS      <- "data/raw/us/phys_data_score.csv"
# CWCS_DAT_US_CS        <- "data/raw/us/cs_data_score.csv"
# CWCS_DAT_US_MATH      <- "data/raw/us/math_data_score.csv"
#
# dat_inst_unitid <- read_csv(CWCS_DAT_US_PHYS, col_select = 1) %>%
#   bind_rows(read_csv(CWCS_DAT_US_MATH, col_select = 1)) %>%
#   bind_rows(read_csv(CWCS_DAT_US_CS, col_select = 1)) %>%
#   distinct(unitid) %>%
#   pull(unitid)

##-----##
##          Download College Scorecard data through Web          ----
##-----##

# Info page

```

```

# https://data.ed.gov/dataset/college-scorecard-all-data-files

# Data dictionary
# https://data.ed.gov/dataset/college-scorecard-all-data-files/resources
# Update DICT_INST_SC_RAW_URL with the link to College Scorecard Data Dictionary

if (!file.exists(path_dict_inst_sc_raw)) {
  DICT_INST_SC_RAW_URL <- 'https://data.ed.gov/dataset/9dc70e6b-8426-4d71-b9d5-
70ce6094a3f4/resource/658b5b83-ac9f-4e41-913e-
9ba9411d7967/download/collegescorecarddatadictionary_02072022.xlsx'

  # Double-check if the sheet index is correct
  dict_inst_sc_raw <- read.xlsx(DICT_INST_SC_RAW_URL, sheet = 4) %>%
    janitor::clean_names() %>%
    tidyr::fill(-c(value, label, shown_use_on_site), .direction = 'down') %>%
    filter(dev_category != 'repayment',
           !stringr::str_detect(variable_name,
'^{(PCIP|BBRR|LOAN|NOLOAN|PELL|NOPELL|PLUS|COMP|CIP|DEATH|DEP|HI_INC|IND|
LP|MD_INC|MTHCMP|NOT1STGEN|NOTFIRSTGEN|OMACHT|OVERALL|POOLYRS|RET
_|TRANS_|UNKN|WDRAW)'),
           !stringr::str_detect(variable_name, '_(L4|[24]YR_TRANS)_')
    ) %>%
    mutate(variable_name = tolower(variable_name))

  saveRDS(dict_inst_sc_raw, path_dict_inst_sc_raw)
} else {
  dict_inst_sc_raw <- readRDS(path_dict_inst_sc_raw)
}

var_msi <- dict_inst_sc_raw %>%
  filter(grepl('minority_serving', developer_friendly_name)) %>%

```

```

pull(variable_name)

# Most Recent Institution Level Data
# Update DAT_INST_SC_RAW_URL with the link to Most Recent Institution Level Data

if (!file.exists(path_dat_inst_sc_raw)) {
  DAT_INST_SC_RAW_URL <- 'https://data.ed.gov/dataset/9dc70e6b-8426-4d71-b9d5-
70ce6094a3f4/resource/823ac095-bdfc-41b0-b508-4e8fc3110082/download/most-recent-
cohorts-all-data-elements_02072022.zip'

  DAT_INST_SC_RAW_PATH <- 'data/raw/Most-Recent-Cohorts-All-Data-Elements.csv'

# Download the file if not found in the data folder
if (!file.exists(DAT_INST_SC_RAW_PATH)) {
  message("Downloading College Scorecard most recent institution level data...")
  download.file(DAT_INST_SC_RAW_URL,
    quiet = FALSE, method = 'wget', internet.info = 0,
    destfile = 'data/raw/us/sc_most_recent_cohorts.zip')
} else {
  message('College Scorecard most recent institution level data found!!')
}

dat_inst_sc_raw <- readr::read_csv(DAT_INST_SC_RAW_PATH, na = 'NULL') %>%
  janitor::clean_names(case = 'snake') %>%
  select(unitid,
    # inst_religious      = relaffil,
    locale,
    inst_undergrad_degree_seeking = ugds,
    inst_admission_rate      = adm_rate,
    inst_accreditor          = accredagency,
    inst_accreditor_code     = accredcode,

```

```

    inst_menonly          = menonly,
    inst_womenonly        = womenonly,
    inst_under_investigation = hcm2,
    all_of(var_msi)) %>%
rename_with(~ paste0('inst_msi_', .x), c(all_of(var_msi))) %>%
# Get locale labels from data dict
left_join(dict_inst_sc_raw %>% filter(variable_name == 'locale') %>%
  mutate(locale = as.numeric(value)) %>%
  select(locale, inst_locale = label), by = 'locale') %>%
mutate(inst_admission_rate = scales::percent(inst_admission_rate, accuracy = .1)) %>%
select(-c(locale))

saveRDS(dat_inst_sc_raw, path_dat_inst_sc_raw)
}
##-----##
##          Education Data Portal          ----
##-----##

# Citation:
# Education Data Portal (Version 0.9.0), Urban Institute, Center on Education
# Data and Policy, accessed Month, DD, YYYY,
# https://educationdata.urban.org/documentation/, [datasets].
#
# Datasets included in this portal are the US Department of Education Common
# Core of Data, the US Department of Education Civil Rights Data Collection,
# the US Census Bureau Small Area Income and Poverty Estimates, the US Department
# of Education Integrated Postsecondary Education Data System, the US Department
# of Education College Scorecard, and the National Historical Geographic
# Information System.
#
# education data portal endpoint info (CWCS relevant only)

```

```

#
# tibble::tribble(
#   ~endpoint_id, ~endpoint_url,
#   ~topic, ~sub_topic, ~var_list_id,
#   ~required_vars, ~optional_vars,
#   ~parsed_years,
#   1L, "/api/v1/college-university/ipeds/directory/{year}/",
#   "directory", "Directory", 1L,
#   year, NA, c(1980, 1984:2019),
#   2L, "/api/v1/college-university/ipeds/institutional-characteristics/{year}/",
#   "institutional-characteristics", "Institutional Characteristics",
#   2L, year, NA, c(1980, 1984:2019),
#   3L, "/api/v1/college-university/ipeds/admissions-enrollment/{year}/",
#   "admissions-enrollment", "Applications, admissions, and enrollments",
#   3L, year, NA, 2001:2018,
#   8L, "/api/v1/college-university/ipeds/program-year-tuition-cip/{year}/",
#   "program-year-tuition-cip", "Tuition and fees by CIP code",
#   8L, year, NA, 1987:2019,
#   9L, "/api/v1/college-university/ipeds/enrollment-full-time-
#   equivalent/{year}/{level_of_study}/", "enrollment-full-time-equivalent",
#   "Full-time equivalent", 9L, c("year", "level_of_study"), NA, 1997:2018,
#   13L, "/api/v1/college-university/ipeds/fall-
#   enrollment/{year}/{level_of_study}/race/sex/", "fall-enrollment", "Fall enrollment by
#   level of study, full-time/part-time status, race, and sex", 10L, c("year", "level_of_study"),
#   c("race", "sex"), 1986:2018,
#   18L, "/api/v1/college-university/ipeds/enrollment-
#   headcount/{year}/{level_of_study}/", "enrollment-headcount",
#   "Headcount", 25L, c("year", "level_of_study"), NA, 1996:2018,
#   98L, "/api/v1/college-university/ipeds/sfa-all-undergraduates/{year}/",
#   "sfa-all-undergraduates", "All undergraduates", 66L,
#   year, NA, 2007:2017,

```

```

# 20L, "/api/v1/college-university/ipeds/grad-rates/{year}/",
"grad-rates", "150 percent", 14L,
year, NA, 1996:2017,
# 19L, "/api/v1/college-university/ipeds/grad-rates-200pct/{year}/",
"grad-rates-200pct", "200 percent", 13L,
year, NA, 2007:2017,
# 31L, "/api/v1/college-university/ipeds/completers/{year}/",
"completers", "Completers", 24L,
year, NA, 2011:2018,
# 33L, "/api/v1/college-university/ipeds/completions-cip-6/{year}/",
"completions-cip-6", "By 6-digit CIP code", 44L,
year, NA, 1983:2018,
#

```

```

##-----##
##      dat_inst_directory_raw      ----
##-----##

```

```

download_csv <- function(url, dest = 'data/raw') {
  if (tools::file_ext(basename(url)) != 'csv') {
    message("URL has to be a CSV file!")
  } else {
    tmp <- tempfile(fileext = glue::glue('.{tools::file_ext(basename(url))}'))
    tryCatch(download.file(url, tmp, quiet = FALSE, method = 'wget', internet.info = 0),
      error = function(e) print(paste(url, 'does not exist')))
    if (file.size(tmp) > 0) {
      try(zip(file.path(dest, glue::glue('{basename(url)}.zip')), tmp))
    }
  }
}

```

```

DAT_IPEDS_DIRECTORY_RAW_URL <-
'https://educationdata.urban.org/csv/ipeds/colleges_ipeds_directory.csv'

DAT_IPEDS_DIRECTORY_RAW_PATH <- "data/raw/colleges_ipeds_directory.csv"

if (!file.exists(DAT_IPEDS_DIRECTORY_RAW_PATH)) {
  message('Downloading IPEDS directory data from Urban Institution...')
  download_csv(DAT_IPEDS_DIRECTORY_RAW_URL)

} else {
  message('IPEDS directory data found!!')
}

if (!file.exists(path_dat_ipeds_directory_raw)) {
  dat_ipeds_directory_raw <- readr::read_csv(DAT_IPEDS_DIRECTORY_RAW_PATH,
trim_ws = TRUE,
                                     guess_max = 8000) %>%

  select(
    unitid,
    year,
    year_deleted,
    date_closed,
    inst_status,
    degree_granting,
    institution_level,
    offering_highest_level,
    currently_active_ipeds,
    inst_name,
    inst_state_abbr      = state_abbr,

```

```

inst_state_fips      = fips,
inst_zip            = zip,
inst_city           = city,
inst_county         = county_name,
inst_county_fips    = county_fips,
inst_region         = region,
inst_urban_centric_locale = urban_centric_locale,
inst_longitude      = longitude,
inst_latitude       = latitude,
inst_control,
inst_cc_size_setting_2018 = cc_size_setting_2018,
inst_size,
inst_url            = url_school,
inst_system_name,
inst_comparison_group = comparison_group,
inst_comparison_group_custom = comparison_group_custom
) %>%
# keep 5-digit ZIP code only
mutate(inst_zip = str_sub(inst_zip, start = 1L, end = 5L))

saveRDS(dat_ipeds_directory_raw, path_dat_ipeds_directory_raw)
}

dat_ipeds_directory_raw <- readRDS(path_dat_ipeds_directory_raw)

if (!file.exists(path_dat_inst_directory_raw)) {
  # Institutions that are
  # 1) present in the latest IPEDS data as active and
  # 2) Four or more years
  # See https://educationdata.urban.org/documentation/colleges.html for data dictionary
  dat_inst_unitid_open_latest <- dat_ipeds_directory_raw %>%

```

```

filter(year == max(dat_ipeds_directory_raw$year),
       year_deleted != max(dat_ipeds_directory_raw$year),
       currently_active_ipeds == 1,
       # institution_level
       # 1-Less than two years (below associate's)
       # 2-At least two but less than four years
       # 3-Less than four years
       degree_granting == 1, !institution_level %in% 1:3)

dat_inst_unitid_latest <- dat_ipeds_directory_raw %>%
  filter(unitid %in% dat_inst_unitid_open_latest$unitid, year >= 1998) %>%
  mutate(date_closed = ifelse(date_closed == '-2', NA_character_, date_closed),
         year_deleted = ifelse(year_deleted == '-2', NA_integer_, year_deleted)) %>%
  group_by(unitid) %>%
  mutate(year_latest = max(year)) %>%
  ungroup() %>%
  group_by(unitid, year_latest, currently_active_ipeds, inst_control, date_closed) %>%
  summarize(year_deleted = max(year_deleted), # grab the latest year_deleted if existing
            # get the latest year
            year = max(year, na.rm = TRUE)) %>%
  ungroup() %>%
  group_by(unitid) %>%
  # has the institution changed control?
  mutate(n_control = n_distinct(inst_control),
         deleted = as.integer(!is.na(year_deleted))) %>%
  ungroup() %>%
  # retain those not deleted
  filter(deleted == 0, is.na(date_closed)) %>%
  arrange(unitid, desc(year))

dat_inst_directory_raw <- dat_ipeds_directory_raw %>%

```

```

filter(unitid %in% dat_inst_unitid_open_latest$unitid,
       year == max(dat_ipeds_directory_raw$year)) %>%
select(-c(year_deleted, date_closed, inst_status, currently_active_ipeds,
          institution_level, offering_highest_level,
          inst_comparison_group, inst_comparison_group_custom))

saveRDS(dat_inst_directory_raw, path_dat_inst_directory_raw)
}

##-----##
##           Awards: Physics           ----
##-----##

# Ensure files exists in data/raw/completion_6digcip/ folder
# https://educationdata.urban.org/csv/ipeds/colleges_ipeds_completions-6digcip_2001.csv
# https://educationdata.urban.org/csv/ipeds/colleges_ipeds_completions-6digcip_2002.csv
# ...
# https://educationdata.urban.org/csv/ipeds/colleges_ipeds_completions-6digcip_2019.csv

if (!file.exists(path_dat_inst_awards_raw)) {
  dat_inst_directory_raw <- readRDS(path_dat_inst_directory_raw)

  if (FALSE) {
    DAT_INST_AWARDS_RAW_URL <-
paste0("https://educationdata.urban.org/csv/ipeds/colleges_ipeds_completions-6digcip_",
        2007:lubridate::year(Sys.Date()), '.csv')

    # Depending on your Internet speed, the following code chunk will take a while to run
    # Download raw data files and save them as zip files in local folder
    lapply(DAT_INST_AWARDS_RAW_URL,

```

```

    function(x) download_csv(x, dest = "data/raw/completion_6digcip"))
  }

files <- fs::dir_ls(path = "data/raw/completion_6digcip/", recurse = FALSE, type = "file",
  regexp = "colleges_ipeds_completions-6digcip_20")

dat_inst_awards_raw <- vroom::vroom(files, delim = ",", col_types = 'iiiiiii',
  trim_ws = TRUE) %>%
  filter(award_level == 7, #Bachelor's degree
    race %in% c(1:9, 99),
    year %in% 2007:lubridate::year(Sys.Date()),
    majornum %in% 1:2, # first major & second major
    cipcode_6digit %in% c(CIP6_PHYS, CIP6_MATH, CIP6_CS, 99),
    unitid %in% dat_inst_directory_raw$unitid) %>%
  select(everything(), -c(fips, award_level), awards = awards_6digit)

saveRDS(dat_inst_awards_raw, path_dat_inst_awards_raw)
} else {

dat_inst_awards_raw <- readRDS('data/raw/dat_inst_awards_raw.RDS')
}

reshape_awards <- function(.data, cipcode) {
  .data %>%
    filter(cipcode_6digit %in% cipcode) %>%
    select(-cipcode_6digit) %>%
    group_by(unitid, year, race, sex) %>%
    summarize(awards = sum(awards)) %>%
    ungroup()
}

```

```

if (!file.exists(path_dat_inst_awards_phys)) {

  dat_inst_awards_phys <- reshape_awards(dat_inst_awards_raw,
                                         cipcode = CIP6_PHYS)

  saveRDS(dat_inst_awards_phys, path_dat_inst_awards_phys)
}

##-----##
##          Awards: Mathematics          ----
##-----##

if (!file.exists(path_dat_inst_awards_math)) {

  dat_inst_awards_math <- reshape_awards(dat_inst_awards_raw, cipcode = CIP6_MATH)

  saveRDS(dat_inst_awards_math, path_dat_inst_awards_math)
}

##-----##
##          Awards: Computer Science      ----
##-----##

if (!file.exists(path_dat_inst_awards_cs)) {
  dat_inst_awards_cs <- reshape_awards(dat_inst_awards_raw, cipcode = CIP6_CS)

  saveRDS(dat_inst_awards_cs, path_dat_inst_awards_cs)
}

##-----##
##          Awards                        ----
##-----##

```

```

unitids <- unique(c(dat_inst_awards_phys$unitid,
                    dat_inst_awards_math$unitid,
                    dat_inst_awards_cs$unitid))

if (!file.exists(path_dat_inst_awards)) {
  dat_inst_awards <- dat_inst_awards_raw %>%
    filter(unitid %in% unitids) %>%
    reshape_awards(cipcode = 99)

  saveRDS(dat_inst_awards, path_dat_inst_awards)
}

if (TRUE) {

  dat_inst_awards_phys <- readRDS(path_dat_inst_awards_phys)
  dat_inst_awards_math <- readRDS(path_dat_inst_awards_math)
  dat_inst_awards_cs <- readRDS(path_dat_inst_awards_cs)
  dat_inst_awards <- readRDS(path_dat_inst_awards)

  add_colname_suffix <- function(.data, suffix) {
    .data %>%
      dplyr::rename_with(~ paste(.x, suffix, sep = "_"), .cols = c(starts_with("count")))
  }

  pivot_awards_data <- function(.data) {

    # .data = dat_inst_awards_phys

    .data %>%
      mutate(sex = factor(sex, levels = c(1:2, 99), labels = c("men", "women", "total")),

```

```

    race = factor(race, levels = c(1:9, 99), labels = c(label_race))) %>%
tidyr::pivot_wider(id_cols = c(unitid, year),
    names_from = c(sex, race),
    names_prefix = "count_",
    values_from = awards,
    values_fill = 0L) %>%
mutate(
    count_women_color = count_women_amind + count_women_black + count_women_hispa
+
    count_women_asian + count_women_pacis + count_women_twora,
    count_total_color = count_total_amind + count_total_black + count_total_hispa +
    count_total_asian + count_total_pacis + count_total_twora,
    count_women_hem = count_women_black + count_women_amind + count_women_hispa,
    count_total_hem = count_total_black + count_total_amind + count_total_hispa,
    across(where(is.numeric), tidyr::replace_na, 0)
) %>%
select(unitid, year,
    count_women_total, count_women_color, count_women_hem,
    count_women_white, count_women_black, count_women_hispa,
    count_women_asian, count_women_amind, count_women_pacis,
    count_women_twora,
    count_total_total, count_total_color, count_total_hem,
    count_total_white, count_total_black, count_total_hispa,
    count_total_asian, count_total_amind, count_total_pacis,
    # count_total_international, count_total_unknown,
    count_total_twora)
}

```

```

reshape_awards_year <- function(.data_disc, disc) {

```

```

# .data_disc <- dat_inst_awards_phys

.data_inst <- .data_disc %>%
  distinct(unitid, year) %>%
  left_join(dat_inst_awards, by = c('unitid', 'year'))

dat <- pivot_awards_data(.data_inst) %>%
  add_colname_suffix('inst') %>%
  left_join(pivot_awards_data(.data_disc) %>%
    add_colname_suffix('disc'),
    by = c("unitid", "year")) %>%
  tibble::add_column(disc = disc, .after = 'unitid')

dat
}

compute_awards_score <- function(.data, disc = 'disc') {

.data %>%
  group_by(unitid) %>%
  summarise(n_year = n(),
    across(starts_with('count'), sum)) %>%
  compute_awards_pct() %>%
  mutate(
    disc = disc,
    # excluded = as.integer(count_total_total_disc < MINIMAL_DISC_COUNT),
    excluded = as.integer(count_total_total_disc < n_year),
    score_women_total_disc = pct_women_total_disc / pct_women_total_inst,
    score_women_color_disc = pct_women_color_disc / pct_women_color_inst,
    score_women_hem_disc = pct_women_hem_disc / pct_women_hem_inst,

```

```

      .after = 'unitid'
    )
  }

compute_awards_pct <- function(.data) {
  .data %>%
    mutate(
      pct_women_total_inst = count_women_total_inst / count_total_total_inst,
      pct_women_total_disc = count_women_total_disc / count_total_total_disc,

      pct_women_color_inst = count_women_color_inst / count_total_total_inst,
      pct_women_color_disc = count_women_color_disc / count_total_total_disc,

      pct_women_hem_inst = count_women_hem_inst / count_total_total_inst,
      pct_women_hem_disc = count_women_hem_disc / count_total_total_disc,
      .before = 'count_women_total_inst'
    ) %>%
    mutate(across(everything(), ~ ifelse(is.nan(.x), 0, .x)))
}

dat_awards_year <- dat_inst_awards_phys %>%
  reshape_awards_year('phys') %>%
  compute_awards_pct() %>%
  bind_rows(dat_inst_awards_math %>%
    reshape_awards_year('math') %>%
    compute_awards_pct()) %>%
  bind_rows(dat_inst_awards_cs %>%
    reshape_awards_year('cs') %>%
    compute_awards_pct())

```

```

dat_awards <- dat_awards_year %>%
  filter(disc == 'phys') %>%
  compute_awards_score(disc = 'phys') %>%
  bind_rows(dat_awards_year %>%
    filter(disc == 'math') %>%
    compute_awards_score(disc = 'math')) %>%
  bind_rows(dat_awards_year %>%
    filter(disc == 'cs') %>%
    compute_awards_score(disc = 'cs')) %>%
  filter(count_total_total_disc > 0)

saveRDS(dat_awards, path_dat_us_awards)

dat_awards_year <- dat_awards_year %>%
  filter(unitid %in% dat_awards$unitid)

saveRDS(dat_awards_year, path_dat_awards_year)

}

##-----##
##      Undergraduate Profile Classification      ----
##-----##

# Source
# https://carnegieclassifications.iu.edu/downloads.php

# Data dictionary

```

```
INST_UG_PROFILE_URL <- 'https://carnegieclassifications.iu.edu/downloads/CCIHE2021-
PublicData.xlsx'
```

```
if (!file.exists(path_dat_inst_ug_profile)) {
  dict_inst_ug_profile <- openxlsx::read.xlsx(INST_UG_PROFILE_URL, sheet = 3) %>%
  janitor::clean_names() %>%
  tidyr::fill(variable, .direction = 'down') %>%
  mutate(variable = tolower(variable),
         value = as.integer(value)) %>%
  select(variable, value, label = label_2)
```

```
dat_inst_ug_profile <- openxlsx::read.xlsx(INST_UG_PROFILE_URL,
                                           sheet = 4) %>%
janitor::clean_names() %>%
filter(unitid %in% unitids) %>%
dplyr::select(unitid,
               inst_cc_2021 = basic2021,
               inst_ipug = ipug2021,
               inst_enroll_profile = enrprofile2021,
               inst_msi = msi,
               inst_coplac = coplac, # Council of Public Liberal Arts Colleges Member
               inst_cusu = cusu, # Coalition of Urban Serving Universities Member
               inst_cumu = cumu # Coalition of Urban and Metropolitan Universities
```

Member

```
) %>%
mutate(
  inst_cc_2021 = factor(inst_cc_2021,
                       levels = dict_inst_ug_profile %>%
                         filter(variable == 'basic2021') %>%
                         pull(value),
                       labels = dict_inst_ug_profile %>%
```

```

        filter(variable == 'basic2021') %>%
        pull(label)),
inst_enroll_profile = factor(inst_enroll_profile,
        levels = dict_inst_ug_profile %>%
        filter(variable == 'enrprofile') %>%
        pull(value),
        labels = dict_inst_ug_profile %>%
        filter(variable == 'enrprofile') %>%
        pull(label)),
inst_ipug = factor(inst_ipug,
        levels = dict_inst_ug_profile %>%
        filter(variable == 'ipug2021') %>%
        pull(value),
        labels = dict_inst_ug_profile %>%
        filter(variable == 'ipug2021') %>%
        pull(label)
))

saveRDS(dat_inst_ug_profile, path_dat_inst_ug_profile)
}

##-----##
##          Comparison Group          ----
##-----##

dat_us_awards <- readRDS(path_dat_us_awards)
dat_inst_directory_raw <- readRDS(path_dat_inst_directory_raw)

dat_ipeds_compgroup_raw <- dat_ipeds_directory_raw %>%
  filter(unitid %in% dat_inst_directory_raw$unitid,
    !(is.na(inst_comparison_group) & is.na(inst_comparison_group_custom))) %>%

```

```

select(
  unitid, year,
  inst_name, inst_state_abbr, inst_city,
  inst_comparison_group, inst_comparison_group_custom) %>%
mutate(
  comparison_group = ifelse(inst_comparison_group_custom != 1 |
is.na(inst_comparison_group_custom),
                          inst_comparison_group, 999999)) %>% # 999999 indicates custom group
filter(comparison_group > 0) %>%
select(-c(inst_comparison_group, inst_comparison_group_custom))

# NCES automatic group scheme
dat_inst_compgroup_auto <- dat_ipeds_directory_raw %>%
  filter(!(is.na(inst_comparison_group) & is.na(inst_comparison_group_custom)),
         inst_comparison_group > 0) %>%
  select(year_compgroup = year, comparison_group = inst_comparison_group,
         unitid_compgroup = unitid, inst_name_compgroup = inst_name)

# Only retain the latest year data
dat_inst_compgroup_year <- dat_ipeds_compgroup_raw %>%
  group_by(unitid) %>%
  mutate(year_compgroup = max(year, na.rm = TRUE)) %>%
  filter(year == year_compgroup) %>%
  ungroup()

# Campuses that use auto comparison group
unitid_compgroup_auto <- dat_inst_compgroup_year %>%
  filter(unitid %in% unitids, comparison_group != 999999) %>%
  left_join(dat_inst_compgroup_auto, by = c('comparison_group', 'year_compgroup')) %>%
  # Drop institution from its own comparison group
  filter(unitid != unitid_compgroup)

```

```

# https://stackoverflow.com/a/57441619
get_comparison_group <- function(unitid) {
  url = URLencode(paste0("https://nces.ed.gov/ipeds/dfr/2020/ReportHTML.aspx?unitId=",
unitid))
  dat <- xml2::read_html(url) %>%
    rvest::html_nodes(".FullTextColumn .compgroup") %>%
    rvest::html_text() %>%
    as_tibble()

  # Some institutions' DFR report use a different tag
  if (nrow(dat) == 0) {
    dat <- xml2::read_html(url) %>%
      rvest::html_nodes(".LeftTextColumn .compgroup") %>%
      rvest::html_text() %>%
      as_tibble()
  }

  dat %>%
    tidyr::separate(value, c('inst_name', 'location'), sep = '\\(\\)') %>%
    dplyr::mutate(
      unitid = unitid,
      inst_name = trimws(inst_name),
      inst_state_abbr = stringr::str_sub(location, start = -2L, end = -1L),
      inst_city = stringr::str_sub(location, end = -5L)
    ) %>%
    dplyr::select(-location)
}

if (!file.exists(path_dat_inst_compgroup_dfr)) {

```

```

# Download comparison groups from Data Feedback Report
# CAUTION: This will scrape data from the web
dat_inst_compgroup_dfr <- purrr::map_dfr(dat_inst_compgroup_year %>%
  filter(unitid %in% unitids, comparison_group == 999999) %>%
  pull(unitid), function(x) {
    message("Retrieving comparison group for ", x)
    get_comparison_group(x)
  })

# https://nces.ed.gov/ipeds/DataCenter/DfrFiles/IPEDSDFR2018_443128.pdf
compgroup_443128 <- tibble::tribble(
  ~inst_name, ~unitid, ~inst_state_abbr, ~inst_city,
  'Claremont Graduate University', 443128, 'CA', 'Claremont',
  'CUNY Graduate School and University Center', 443128, 'NY', 'New York',
  'Fielding Graduate University', 443128, 'CA', 'Santa Barbara',
  'Golden Gate University-San Francisco', 443128, 'CA', 'San Francisco',
  'Naval Postgraduate School', 443128, 'CA', 'Monterey',
  'Pennsylvania State University-Penn State Great Valley', 443128, 'PA', 'Malvern',
  'Rensselaer at Hartford', 443128, 'CT', 'Hartford'
)

saveRDS(dat_inst_compgroup_dfr, path_dat_inst_compgroup_dfr)
}

dat_inst_compgroup_dfr <- readRDS(path_dat_inst_compgroup_dfr)

if (FALSE) {
  unitid_compgroup_missing <- setdiff(dat_inst_compgroup_year %>%
    filter(unitid %in% unitids, comparison_group == 999999) %>%
    pull(unitid),
    dat_inst_compgroup_dfr %>% distinct(unitid) %>% pull(unitid))

```

```

dat_ipeds_directory_raw %>%
  filter(unitid %in% unitid_compgroup_missing, year >= 2007) %>%
  View()

```

```

dat_inst_compgroup_dfr_missing <- purrr::map_dfr(unitid_compgroup_missing,
  function(x) {
    message("Retrieving comparison group for ", x)
    get_comparison_group(x)
  })

```

```

dat_inst_compgroup_dfr <- dat_inst_compgroup_dfr %>%
  bind_rows(dat_inst_compgroup_dfr_missing) %>%
  distinct()

```

```

saveRDS(dat_inst_compgroup_dfr, path_dat_inst_compgroup_dfr)
}

```

```

dat_inst_compgroup <- dat_inst_compgroup_dfr %>%
  left_join(dat_ipeds_directory_raw %>%
    select(unitid_compgroup = unitid, inst_name, inst_state_abbr, inst_city) %>%
    distinct(),
    by = c("inst_name", "inst_state_abbr", "inst_city")) %>%
  mutate(unitid_compgroup = case_when(
    inst_name == 'Albizu University-Miami' ~ 132842,
    inst_name == 'Arizona State University Campus Immersion' ~ 104151,
    inst_name == 'Arizona State University Digital Immersion' ~ 483124,
    inst_name == 'Arkansas State University' ~ 106458,
    inst_name == 'Assumption University' ~ 164562,
    inst_name == 'Bushnell University' ~ 209409,
    inst_name == 'Carolina University' ~ 489937,

```

```

inst_name == 'Clarks Summit University' ~ 211024,
inst_name == 'Cogswell University of Silicon Valley' ~ 112394,
inst_name == 'Colorado State University Pueblo' ~ 128106,
inst_name == 'Concordia College' ~ 190248,
inst_name == 'DeVry University-New Jersey' ~ 482556, # inst_city didn't match
inst_name == 'Edmonds College' ~ 235103,
inst_name == 'Elmhurst University' ~ 144962,
inst_name == 'Flagler College' ~ 133711,
inst_name == 'Hodges University' ~ 367884,
inst_name == 'Lake Area Technical College' ~ 219143,
inst_name == 'Limestone University' ~ 218238,
inst_name == 'Linfield University-McMinnville Campus' ~ 209065,
inst_name == 'Linfield University-Online and Continuing Education' ~ 437325,
inst_name == 'Linfield University-School of Nursing' ~ 437316,
inst_name == 'Maharishi International University' ~ 153861,
inst_name == 'Mount Marty University' ~ 219198,
inst_name == 'Pierce College District' ~ 439145,
inst_name == 'Saint Elizabeth University' ~ 186618,
inst_name == "Southeast Technical College" ~ 219426,
inst_name == "St. John's University-New York" ~ 195809,
inst_name == "Strayer University-Delaware" ~ 450298, # inst_city didn't match
inst_name == 'SUNY Brockport' ~ 196121,
inst_name == 'The University of Texas Permian Basin' ~ 229018,
inst_name == 'University of Health Sciences and Pharmacy in St. Louis' ~ 179265,
inst_name == 'University of South Florida' ~ 137351,
TRUE ~ unitid_compgroup
)
) %>%
rename(inst_name_compgroup = inst_name) %>%
left_join(dat_inst_compgroup_year %>%
  select(unitid, inst_name, year, year_compgroup, comparison_group),

```

```

    by = "unitid") %>%
bind_rows(unitid_compgroup_auto) %>%
group_by(unitid) %>%
mutate(size_compgroup = n()) %>%
select(unitid, inst_name, year, comparison_group, size_compgroup,
        unitid_compgroup, inst_name_compgroup) %>%
ungroup() %>%
arrange(unitid, inst_name_compgroup) %>%
filter(!is.na(unitid_compgroup))

saveRDS(dat_inst_compgroup, "data/dat_us_compgroup.RDS")
saveRDS(dat_inst_compgroup, "../CWCS/data/dat_us_compgroup.RDS")

##-----##
##          INSTITUTION INFO          ----
##-----##

if (TRUE) {
  # Score Card data
  dat_inst_sc_raw      <- readRDS(path_dat_inst_sc_raw)
  dict_inst_sc_raw     <- readRDS(path_dict_inst_sc_raw)
  # Undergraduate profile
  dat_inst_ug_profile  <- readRDS(path_dat_inst_ug_profile)
  # Directory
  dat_inst_directory_raw <- readRDS(path_dat_inst_directory_raw)

  dat_inst_awards_phys <- readRDS(path_dat_inst_awards_phys)
  dat_inst_awards_math <- readRDS(path_dat_inst_awards_math)
  dat_inst_awards_cs   <- readRDS(path_dat_inst_awards_cs)

  dat_awards           <- readRDS(path_dat_us_awards)

```

```

dat_awards_year      <- readRDS(path_dat_awards_year)

}

unitids <- unique(c(dat_inst_awards_phys$unitid,
                    dat_inst_awards_math$unitid,
                    dat_inst_awards_cs$unitid))

dat_inst_sc <- dat_inst_sc_raw %>%
  mutate(across(where(is.numeric), ~ replace_na(.x, 0L))) %>%
  dplyr::na_if(".")

dat_inst_info <- dat_inst_directory_raw %>%
  filter(unitid %in% unitids) %>%
  mutate(
    inst_region = factor(
      inst_region,
      levels = as.integer(dict_inst_sc_raw %>% filter(developer_friendly_name == 'region_id')
%>% pull(value)),
    labels = dict_inst_sc_raw %>% filter(developer_friendly_name == 'region_id') %>%
pull(label)),

    inst_urban_centric_locale = factor(
      inst_urban_centric_locale,
      levels = as.integer(dict_inst_sc_raw %>% filter(developer_friendly_name == 'locale') %>%
pull(value)),
      labels = dict_inst_sc_raw %>%
        filter(developer_friendly_name == 'locale') %>%
        mutate(label = stringr::str_extract(label, '^(\w+)')) %>%
        pull(label)
    ),

```

```

inst_control = factor(
  inst_control,
  levels = as.integer(dict_inst_sc_raw %>% filter(developer_friendly_name == 'ownership')
%>% pull(value)),
  labels = dict_inst_sc_raw %>% filter(developer_friendly_name == 'ownership') %>%
pull(label)
) %>%
forcats::fct_drop(),

inst_size = factor(
  inst_size,
  levels = 1:5,
  labels = c("Under 1,000", "1,000 - 4,999", "5,000 - 9,999", "10,000 - 19,999", "20,000 and
above"),
  ordered = TRUE
),

inst_cc_size = factor(
  inst_cc_size_setting_2018,
  levels = 1:18,
  labels = c("very small", "small", "medium", "large", "very large", # two-year
rep("very small", 3), rep("small", 3), rep("medium", 3), rep("large", 3), # four-year
"exclusive grad") %>% tools::toTitleCase(),
  ordered = TRUE
),

inst_cc_setting = factor(
  inst_cc_size_setting_2018, levels = 6:17,
  labels = rep(c("primarily nonresidential", "primarily residential", "highly residential"), 4),
  ordered = TRUE

```

```

)
) %>%
left_join(
  tibble(inst_state = c(state.name, "District of Columbia", "Guam", "Puerto Rico", "Virgin
Islands"),
    state.abb = c(state.abb, "DC", "GU", "PR", "VI")),
  by = c("inst_state_abbrev" = "state.abb")) %>%
select(unitid, inst_name, starts_with("inst_"), everything()) %>%
left_join(dat_inst_ug_profile %>% select(unitid, inst_msi, inst_cc_2021), by = "unitid") %>%
left_join(dat_inst_sc, by = "unitid") %>%
select(-c(inst_cc_size_setting_2018, inst_system_name)) %>%
mutate(across(c(starts_with("inst_msi_"), inst_msi,
  # inst_coplac, inst_cusu, inst_cumu,
  inst_menonly, inst_womenonly), ~ replace_na(.x, 0L))) %>%
# Add discipline abbreviation to variable names
left_join(dat_awards %>%
  select(-c(contains('_international_'), contains('_unknown_'))) %>%
  split(.$disc) %>%
  map(function(x) {
    names(x) <- c('unitid', paste(names(x)[-1], x$disc[1], sep = '_'))
    x %>% select(-starts_with('disc_'))
  }) %>%
  reduce(full_join, by = "unitid"),
  by = 'unitid') %>%
mutate(across(starts_with("excluded_"), ~ replace_na(.x, 1L)),
  # No private for-profit institutions granted physics degrees
  # There are only 2 private for-profit institutions for math, manually remove them
  excluded_math = ifelse(inst_control == "Private for-profit", 1L, 0L)) %>%
arrange(unitid)

dat_inst_info %>%

```

```

filter(excluded_cs == 0, inst_control == "Private for-profit",
       is.na(inst_accreditor)) %>%
pull(inst_name)

##-----##
##          dat_awards          ----
##-----##

dat_inst_year <- dat_awards_year %>%
  select(unitid, year, everything()) %>%
  split(.$disc) %>%
  map(function(x) {
    names(x) <- c('unitid', 'year', paste(names(x)[-c(1:2)], x$disc[1], sep = '_'))
    x %>% select(-starts_with('disc_'))
  }) %>%
  reduce(full_join) %>%
  mutate(across(c(unitid, year, starts_with('count_')), as.integer)) %>%
  select(unitid, year, matches('^count_.*_disc_.*$')) %>%
  left_join(dat_inst_info %>% select(unitid, inst_name), by = 'unitid') %>%
  arrange(unitid, year)

saveRDS(dat_inst_year, path_dat_inst_year)
saveRDS(dat_inst_year, "../data/dat_us_inst_year.RDS")
saveRDS(dat_inst_info, path_dat_inst_info)
saveRDS(dat_inst_info, "../data/dat_us_inst_info.RDS")

#####
###                                     ###
###          CLEAN UP          ###
###                                     ###

```

```
#####
```

```
relabel_cc <- function(x) {  
  x[grepl("^Doctoral Universities", x)] <- "PhD-granting institution"  
  x[grepl("^Doctoral/Professional Universities", x)] <- "PhD-granting institution"  
  x[grepl("^Master's Colleges & Universities", x)] <- "Masters-granting institution"  
  x[grepl("^Baccalaureate Colleges: Arts & Sciences Focus", x)] <- "Liberal arts institution"  
  x[grepl("^Baccalaureate/Associate's Colleges", x)] <- "Other four-year institution"  
  x[grepl("^Baccalaureate Colleges: Diverse Fields", x)] <- "Other four-year institution"  
  x[grepl("^Special Focus Four-Year:", x)] <- "Other four-year institution"  
  x[grepl("^Associate's Colleges:", x)] <- "Associate's Colleges"  
  x <- gsub(' institution', "", x)  
}
```

```
dat_inst_year <- readRDS(path_dat_inst_year)
```

```
dat_inst_info <- readRDS(path_dat_inst_info)
```

```
DISCIPLINE <- c('phys', 'cs', 'math')
```

```
dat_us <- lapply(DISCIPLINE, function(x) {  
  # TODO: waiting for Jessie's updated files  
  read_csv(get(glue::glue('CWCS_DAT_US_{toupper(x)}')) %>%  
    janitor::clean_names() %>%  
    mutate(disc = x, .after = 'unitid') %>%  
    select(-c(name)) %>%  
    rename(  
      score_women_hem_disc = score_women_hemw_disc,  
      index_women_total_disc = score_women,  
      index_women_color_disc = score_woc,  
      index_women_hem_disc = score_hemw,  
    ) %>%  
  })
```

```

filter(index_women_total_disc != 'ex_ass') %>%
mutate(
  exclude = grepl('^ex', index_women_total_disc) %>% as.integer(),
  across(starts_with('index_women_'),
    function(x) x <- ifelse(x %in% c('0', '1', '2', '3'), x, '-')
  ) %>%
  # add discipline as suffix to col names
  rename_with(~ paste0(.x, '_', x), -c(unitid))
}) %>%
reduce(full_join) %>%
tidyr::unite('disc', disc_phys, disc_math, disc_cs, na.rm = TRUE) %>%
{
  x <- .
  y <- dat_inst_info %>%
    select(-any_of(names(x)), unitid)
  left_join(x, y, by = 'unitid')
} %>%
mutate(
  inst_cc_cwcs = forcats::fct_relabel(inst_cc_2021, relabel_cc) %>%
    ordered(levels = c("PhD-granting",
      "Masters-granting",
      "Liberal arts",
      "Other four-year")),
  disc_phys = ifelse(excluded_phys == 0L, "phys", NA_character_),
  disc_math = ifelse(excluded_math == 0L, "math", NA_character_),
  disc_cs = ifelse(excluded_cs == 0L, "cs", NA_character_),
  across(starts_with('excluded_'), replace_na, 1L),
  inst_cc_size = forcats::fct_drop(inst_cc_size),
  # across(where(is.factor), forcats::fct_drop),
  inst_locale_note = stringr::str_extract(inst_locale, "\\(..*\\)") %>% str_remove("\\(") %>%
  str_remove("\\)"),

```

```

  inst_locale = stringr::str_remove(inst_locale, "\\(.*$")
) %>%
purrr::map_dfc(replace_na, 0L) %>%
dplyr::mutate(
  # columns for bar charts in reactable
  pct_total_total_disc_phys = count_total_total_disc_phys / max(count_total_total_disc_phys,
na.rm = TRUE),
  pct_total_total_disc_math = count_total_total_disc_math / max(count_total_total_disc_math,
na.rm = TRUE),
  pct_total_total_disc_cs = count_total_total_disc_cs / max(count_total_total_disc_cs, na.rm
= TRUE),
  across(c(unitid, starts_with('count_')), as.integer),
  inst_url = inst_url %>%
    tolower() %>%
    # remove / at the end of URL
    stringr::str_remove('/$') %>%
    # remove http(s)://
    stringr::str_remove('^.*//') %>%
  select(-c(degree_granting)) %>%
dplyr::select(unitid, inst_name, inst_cc_cwcs, disc,
  inst_control, inst_size, inst_longitude, inst_latitude,
  starts_with("inst_"), starts_with('n_year'),
  dplyr::one_of(
    expand.grid(c('score', 'index', 'pct', 'count'),
      c('women'),
      c('total', 'color', 'hem'),
      c('disc'),
      c('math', 'cs', 'phys')) %>%
    bind_rows(expand.grid(c('count'),
      c('total'),
      c('total'),

```

```

      c('disc', 'inst'),
      c('math', 'cs', 'phys')))) %>%
  bind_rows(expand_grid(c('count'),
    c('women'),
    c('total', 'color', 'hem'),
    c('inst'),
    c('math', 'cs', 'phys')))) %>%
  tidyr::unite(var) %>% pull(var)),
  starts_with("pct_"), starts_with('excluded_'))

dat_inst_info_long <- dat_us %>%
  select(unitid, inst_name, inst_cc_cwcs, inst_control,
    # inst_size,
    inst_state_abbr,
    inst_undergrad_degree_seeking, inst_locale, inst_locale_note,
    inst_admission_rate,
    inst_city, inst_state,
    inst_urban_centric_locale,
    # inst_land_grant,
    inst_url,
    # inst_cc_size,
    inst_cc_setting,
    # inst_ipug,
    # inst_enroll_profile,
    # inst_coplac, # Council of Public Liberal Arts Colleges Member
    # inst_cusu, # Coalition of Urban Serving Universities Member
    # inst_cumu, # Coalition of Urban and Metropolitan Universities Member
    starts_with("inst_msi"),
    inst_menonly,
    inst_womenonly) %>%
  mutate(

```

```

# inst_undergrad_degree_seeking = paste(inst_undergrad_degree_seeking, 'undergraduate
students'),
inst_undergrad_degree_seeking = format(inst_undergrad_degree_seeking, big.mark = ','),
inst_cc_setting = tools::toTitleCase(as.character(inst_cc_setting)),
# inst_admission_rate = paste(inst_admission_rate, 'admission rate'),
across(where(is.numeric), as.character),
# inst_size = paste(inst_size, 'students'),
# inst_land_grant = ifelse(inst_land_grant == 1, "Land grant", NA),
# inst_coplac = ifelse(inst_coplac == 1, "Council of Public Liberal Arts Colleges Member
(COPLAC)", NA),
# inst_cusu = ifelse(inst_cusu == 1, "Coalition of Urban Serving Universities Member
(CUSU)", NA),
# inst_cumu = ifelse(inst_cumu == 1, "Coalition of Urban and Metropolitan Universities
Member (CUMU)", NA),
inst_msi      = ifelse(inst_msi      == 1, "Minority serving institution (MSI)", NA),
inst_msi_hbcu  = ifelse(inst_msi_hbcu  == 1, "Historically Black college or university
(HBCU)", NA),
inst_msi_pbi   = ifelse(inst_msi_pbi   == 1, "Predominantly Black institution (PBI)", NA),
inst_msi_annhi = ifelse(inst_msi_annhi == 1, "Alaska Native and Native Hawaiian-serving
institution (ANNH)", NA),
inst_msi_tribal = ifelse(inst_msi_tribal == 1, "Tribal college or university", NA),
inst_msi_aanapii = ifelse(inst_msi_aanapii == 1, "Asian American and Native American
Pacific Islander-serving institution (AANAPII)", NA),
inst_msi_hsi    = ifelse(inst_msi_hsi    == 1, "Hispanic-serving institution (HSI)", NA),
inst_msi_nanti  = ifelse(inst_msi_nanti  == 1, "Native American-serving nontribal institution
(NANTI)", NA),
inst_menonly    = ifelse(inst_menonly    == 1, "Men's college", NA),
inst_womenonly  = ifelse(inst_womenonly  == 1, "Women's college", NA)
) %>%
tidyr::pivot_longer(-c(unitid)) %>%
filter(!is.na(value)) %>%

```

```

mutate(type = case_when(
  name == 'inst_cc_cwcs' ~ 'Type',
  name == 'inst_control' ~ 'Control',
  name == 'inst_undergrad_degree_seeking' ~ 'Undergraduate Students',
  name == 'inst_locale' ~ 'Urbanicity',
  # name == 'inst_cc_size' ~ 'Size',
  name == 'inst_admission_rate' ~ 'Admission Rate',
  grepl('inst_msi_', name) ~ 'Minority serving institution',
  # include both Men's and Women's colleges
  grepl('menonly', name) ~ 'Specialized Mission',
  TRUE ~ NA_character_
))

saveRDS(dat_us, "../CWCS/data/dat_us.RDS")
saveRDS(dat_inst_info_long, "../CWCS/data/dat_us_inst_info_long.RDS")

dat_us <- readRDS("../CWCS/data/dat_us.RDS")
dat_inst_info_long <- readRDS("../CWCS/data/dat_us_inst_info_long.RDS")

##-----
##          Sanity check          -
##-----

if (TRUE) {
  # check institutions with the same unitid (should be 0)
  dat_us %>%
    count(unitid) %>%
    filter(n > 1)

  dat_us %>%
    count(inst_name) %>%

```

```

filter(n > 1)

}

library(spatialrisk)

process_radius <- function(radius = 10) {

  dist_within_radius <- function(x, y, z, radius_mile = 5) {
    spatialrisk::points_in_circle(dat_us %>%
      dplyr::select(unitid, inst_longitude, inst_latitude),
      x, y, lon = inst_longitude, lat = inst_latitude, radius = radius_mile *
1609.34) %>%
    dplyr::mutate(unitid_home = z,
      distance_m = distance_m * 0.000621371) %>%
    dplyr::filter(unitid != unitid_home) %>%
    dplyr::select(-c(inst_longitude, inst_latitude))
  }

  pmap_dfr(list(dat_us$inst_longitude, dat_us$inst_latitude, dat_us$unitid, radius),
dist_within_radius) %>%
  mutate(dist = case_when(
    between(distance_m, 0, 10) ~ 10,
    between(distance_m, 10, 25) ~ 25,
    between(distance_m, 25, 50) ~ 50,
    between(distance_m, 50, 100) ~ 100,
    between(distance_m, 100, 250) ~ 250,
    # between(distance_m, 250, 500) ~ 500,
    # between(distance_m, 500, 1000) ~ 1000,
    TRUE ~ 10000
  ),

```

```

    combo = map2_chr(unitid, unitid_home, ~toString(sort(c(.x, .y)))) %>%
      stringr::str_replace(', ', '|')
  ) %>%
  distinct(combo, .keep_all = TRUE) %>%
  select(unitid = combo, unitid_1 = unitid, unitid_2 = unitid_home, dist)

}

```

```

dat_us_dist <- process_radius(radius = 250)

```

```

saveRDS(dat_us_dist, "data/dat_us_dist.RDS")
saveRDS(dat_us_dist, "../CWCS/data/dat_us_dist.RDS")

```

```

data(zip_code_db)

```

```

dat_us_dist <- readRDS("data/dat_us_dist.RDS")

```

```

# Download zipcode info
# http://download.geonames.org/export/zip/US.zip
# NCES use ZIP Code latitude and longitude provided by GeoNames

```

```

zip_coord <- readr::read_tsv('data/raw/us/US.txt',
  col_select = c(2, 10, 11),
  col_names = FALSE) %>%
  setNames(c('zipcode', 'lat_us', 'lng_us')) %>%
  mutate(across(c(lat_us, lng_us), ~ round(.x, 3)))

```

```

data(zip_code_db)

```

```

dat_zipcode <- zipcodeR::zip_code_db %>%
  select(zipcode,

```

```

    # zipcode_type, county, state,
    lat, lng,
    # radius_in_miles,
    bounds_west, bounds_east, bounds_north, bounds_south) %>%
# mutate(prefix = stringr::str_extract(zipcode, '^\\d{3}')) %>%
left_join(zip_coord, by = "zipcode") %>%
mutate(lat = ifelse(is.na(lat), lat_us, lat),
       lng = ifelse(is.na(lng), lng_us, lng)) %>%
select(-c(lat_us, lng_us))

get_zipcode_coord <- function(zipcode) {
  message("retrieving coord for ", zipcode)
  Sys.sleep(.5)
  url = URLencode(paste0("https://www.zipdatamaps.com/",zipcode))
  page <- rvest::read_html(url) %>%
    rvest::html_text("body")
  lat <- page %>%
    stringr::str_extract('latitude.*')

  lng <- page %>%
    stringr::str_extract('longitude.*')

  tibble(zipcode = zipcode, lat = lat, lng = lng) %>%
    dplyr::mutate(across(c(lat, lng), ~ stringr::str_extract(.x, '\\d+\\.\\d+') %>%
      as.numeric()))
}

if (FALSE) {
  dat_zip_no_coord <- dat_zipcode %>%
    filter(is.na(lat)) %>%
    pull(zipcode) %>%

```

```

map_dfr(get_zipcode_coord) %>%
  rename_with(~ paste0(.x, '_new'), c(lat, lng))

saveRDS(dat_zip_no_coord, 'data/dat_zip_no_coord.RDS')
}

dat_zip_no_coord <- readRDS('data/dat_zip_no_coord.RDS')

dat_zipcode <- dat_zipcode %>%
  left_join(dat_zip_no_coord, by = "zipcode") %>%
  mutate(lat = ifelse(is.na(lat), lat_new, lat),
         lng = ifelse(is.na(lng), lng_new, lng)) %>%
  select(-c(lat_new, lng_new))

saveRDS(dat_zipcode, '../CWCS/data/dat_zipcode.RDS')

# charts data -----
# Function to create drilldown data for charts

make_dat_drilldown <- function(.data, discipline = "phys",
                              .index, .group, .score,
                              ordered = FALSE, drilldown_index = 'Above Average',
                              top_n = 10) {

  legend_index <- c('Above Average', 'Average', 'Below Average', '0')

  data <- .data %>%
    filter(grepl(discipline, disc, ignore.case = TRUE),
           {{.index}} %in% 0:3)

  cat_order <- data %>%

```

```

filter(!is.na({{.index}}) & !is.na({{.group}})) %>%
mutate(binary = ifelse({{.index}} %in% 1:2, 0, 1)) %>%
group_by({{.group}}, binary) %>%
# use .groups = "drop" to remove annoying warnings
# credit: https://stackoverflow.com/a/62140681/4714891
summarize(n = n(), .groups = "drop") %>%
mutate(freq = n / sum(n)) %>%
filter(binary == 1)

if (ordered) {
  cat_order <- cat_order %>%
    arrange(desc(freq)) %>%
    pull({{.group}})
} else {
  cat_order <- cat_order %>%
    pull({{.group}})
}

dat <- data %>%
  filter(!is.na({{.index}})) %>%
  mutate(
    {{.group}} := factor({{.group}}, levels = cat_order,
                        labels = cat_order),
    {{.index}} := factor({{.index}}, levels = 0:3,
                        labels = rev(legend_index))) %>%
  dplyr::count({{.group}}, {{.index}}) %>%
  mutate(
    drilldown := paste({{.group}}, {{.index}}, sep = "_"),
    # Hide drilldown unwanted
    drilldown = ifelse(grepl(drilldown_index, drilldown), drilldown, NA_character_)
  )

```

```

dat_drilldown <- data %>%
  select(inst_name, {{.index}}, {{.group}}, {{.score}}) %>%
  filter(!is.na({{.index}}), {{.index}} == 3) %>%
  mutate(
    {{.index}} := factor({{.index}}, levels = 0:3,
      labels = rev(legend_index))
  ) %>%
  dplyr::group_by({{.group}}, {{.index}}) %>%
  dplyr::slice_max(order_by = {{.score}}, n = top_n) %>%
  ungroup() %>%
  group_nest({{.group}}, {{.index}}) %>%
  mutate(
    id = paste({{.group}}, {{.index}}, sep = "_"),
    type = "column",
    # in the drilldown we'll give the mapping via creating the columns
    data = purrr::map(data, mutate, name = inst_name, y = {{.score}}) %>%
      purrr::map(select, name, y),
    data = purrr::map(data, highcharter::list_parse)
  ) %>%
  mutate({{.group}} := NA)

list(dat = dat, dat_drilldown = dat_drilldown)
}

dat_us <- readRDS("../CWCS/data/dat_us.RDS")

dat_charts <- list(
  inst_size = make_dat_drilldown(dat_us, "phys", index_women_color_disc_phys,
inst_cc_size, score_women_color_disc_phys),

```

```

inst_cc_cwcs = make_dat_drilldown(dat_us, "phys", index_women_color_disc_phys,
inst_cc_cwcs, score_women_color_disc_phys),
inst_control = make_dat_drilldown(dat_us, "phys", index_women_color_disc_phys,
inst_control, score_women_color_disc_phys),
inst_urban_centric_locale = make_dat_drilldown(dat_us, ordered = TRUE, "phys",
index_women_color_disc_phys, inst_urban_centric_locale, score_women_color_disc_phys),
inst_region = make_dat_drilldown(dat_us, ordered = TRUE, "phys",
index_women_color_disc_phys, inst_region, score_women_color_disc_phys),
inst_accreditor = make_dat_drilldown(
  dat_us %>%
  filter(!inst_accreditor %in% c("0", "EXEMPT", "Transnational Association of Christian
Colleges and Schools"),
  !is.na(inst_accreditor)), ordered = TRUE, "phys", index_women_color_disc_phys,
inst_accreditor, score_women_color_disc_phys)
)

saveRDS(dat_charts, "../CWCS/data/dat_charts.RDS")

```

Appendix B - Notes from Department Websites

Table B-1 Creighton University Department of Physics

	Notes	Score
How many faculty and how many are not men?	10 total, 2 not men	NA
How are research Experiences encouraged?	From department description “undergrads and grads participate in research”	1
What can students do with degree?	“lays foundations for careers like” “High acceptance rate”	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Physics club, sigma pi sigma, scholarships	3
Degree Pathways	Multiple paths with explanations	3

Table B-2 Creighton University Department of Mathematics

	Notes	Score
How many faculty and how many are not men?	7 total, 2 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	List of careers with salaries	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Math club, pi epsilon mu	2
Degree Pathways	Multiple paths with explanations, link to catalog	3

Table B-3 Creighton University Department of Computer Science

	Notes	Score
How many faculty and how many are not men?	5 total, 1 not men	NA
How are research Experiences encouraged?	Mentions internships	1
What can students do with degree?	No Information	0
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Computer Science club	2
Degree Pathways	Multiple paths with explanations, link to catalog	3

Table B-4 Jackson State University department of Chemistry, Physics and Atmospheric Science (Physics)

	Notes	Score
How many faculty and how many are not men?	14 total, 2 not men	NA
How are research Experiences encouraged?	“Faculty research provides undergraduate students with on-campus research opportunities”	1
What can students do with degree?	Implied by department goals: “To prepare students for careers in physical research, medicine, engineering, meteorology research, professional meteorologist, and other professional areas including teaching of physics and physical sciences.”	1
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	One path, link to courses	1

Table B-5 Massachusetts Institute of Technology Physics Department

	Notes	Score
How many faculty and how many are not men?	120 total, 16 not men	NA
How are research Experiences encouraged?	Senior thesis required, page with information about finding opportunities, writing a proposal, etc.	3
What can students do with degree?	“provides an excellent basis for graduate study in physics and related fields; it is also a great foundation for careers in industry, research, finance, management, law, medicine, or public policy”	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Clubs, jobs, mentor programs, awards	3
Degree Pathways	Multiple tracks and description of what you can do with each one, link to required courses	3

Table B-6 New Jersey Institute of Technology Department of Physics

	Notes	Score
How many faculty and how many are not men?	14 total. 1 not men	NA
How are research Experiences encouraged?	“numerous opportunities for student research”	1
What can students do with degree?	Meet some students section, link to AIP	3
Discourse that is enthusiastic and pro-teaching?	"research strengths mirrored in our educational programs"	2
Other exciting things for majors	No Information	0
Degree Pathways	Multiple paths with link to catalog	2

Table B-7 New Jersey Institute of Technology Department of Mathematical Sciences

	Notes	Score
How many faculty and how many are not men?	37 total. 5 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	Meet some students section, alumni page, co-op courses	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	Multiple paths with link to catalog, information about who to contact	3

Table B-8 New Jersey Institute of Technology Department of Computer Science

	Notes	Score
How many faculty and how many are not men?	13 total. 1 not men	NA
How are research Experiences encouraged?	No information	0
What can students do with degree?	“Training in problem solving” co-op course	2
Discourse that is enthusiastic and pro-teaching?	"research strengths mirrored in our educational programs"	2
Other exciting things for majors	No Information	0
Degree Pathways	Multiple paths	2

Table B-9 Notre Dame of Maryland University Department of Math, Computer Studies, and Physics (Physics)

	Notes	Score
How many faculty and how many are not men?	1 total, 0 not men, unclear if that is for the whole department or just physics	NA
How are research Experiences encouraged?	Welcome statement lists “original research projects” Capstone experience required with a list of examples	3
What can students do with degree?	Career options is listed as a feature of the program, list of places graduates have worked with links	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	Dual degree in engineering programs with other institutions, concurrent BA physics and MA Teaching	2

Table B-10 Saint Vincent College Physics/Physics Education

	Notes	Score
How many faculty and how many are not men?	No information	NA
How are research Experiences encouraged?	Results section mentions that students have published research and lists areas that students have done research in. One of the learning outcomes is "independent research." A senior thesis is required	3
What can students do with degree?	From welcome Statement: "our students continue their education in graduate school or begin a successful career in the field." Section called "What can I do with a degree in physics?" Lists potential area of physics and a few non-physics areas. Results section with acceptance rate to graduate school, discussion of teacher placement, places students have gotten jobs.	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	Physics and Physics Education with required courses	2

Table B-11 Seton Hall University Department of Physics

	Notes	Score
How many faculty and how many are not men?	8 total, 3 not men	NA
How are research Experiences encouraged?	“All students, including freshmen, are trained in and have access to all of our state-of-the-art instrumentation” “Work alongside faculty on cutting-edge research starting as early as your freshman year. More than 80% of our students conduct research with faculty!”	3
What can students do with degree?	Lists a few options	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	SPS	2
Degree Pathways	BS, BA, two dual MS, descriptions but no course information	3

Table B-12 Seton Hall University Department of Math and Computer Science (Math)

	Notes	Score
How many faculty and how many are not men?	18 total, 5 not men, count for entire department	NA
How are research Experiences encouraged?	Department head mentions in math welcome	1
What can students do with degree?	No Information	0
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	2 tracks and 3 concurrent options, descriptions and course listing	3

Table B-13 Seton Hall University Department of Math and Computer Science (Computer Science)

	Notes	Score
How many faculty and how many are not men?	18 total, 5 not men, count for entire department	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	Encourage internship	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	No Information	0

Table B-14 Simmons University Department of Chemistry and Physics (Physics)

	Notes	Score
How many faculty and how many are not men?	15 total, 6 not men	NA
How are research Experiences encouraged?	Senior thesis required. Phrases like “research centered curriculum”, “abundant research opportunities”, “students have published.” Description of research centered curriculum and examples of projects from previous students	3
What can students do with degree?	Statistics about graduates, examples from previous students	2
Discourse that is enthusiastic and pro-teaching?	“Small, teaching focused.”	2
Other exciting things for majors	No Information	0
Degree Pathways	Dual engineering program. Discussion on how to customize the degree by adding a second major or minor	2

Table B-15 South Carolina State University Department of Biological and Physical Sciences (Physics)

	Notes	Score
How many faculty and how many are not men?	No Information	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	No Information	0
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	No Information	0
Degree Pathways	Physics degree and dual with engineering, no other information	1

Table B-16 Spelman College Physics Department

	Notes	Score
How many faculty and how many are not men?	9 total, 2 not men	NA
How are research Experiences encouraged?	Features a quote from an alumnus that mentions research	1
What can students do with degree?	Only mentioned in the objectives: “demonstrate a breadth and depth of knowledge of physics that would lead to a successful career in a physics-related profession such as engineering or education.”	1
Discourse that is enthusiastic and pro-teaching?	Quote from alumnus mentions small class size	1
Other exciting things for majors	Quote from alumnus mentions tutors and study groups	1
Degree Pathways	Core courses plus 6 options for rest of course work with explanations of who should chose each one	3

Table B-17 University of North Carolina at Ashville Physics and Astronomy (physics)

	Notes	Score
How many faculty and how many are not men?	9 total, 3 not men	NA
How are research Experiences encouraged?	No information	0
What can students do with degree?	Links to external resources	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	SPS	2
Degree Pathways	"Customize curriculum" descriptions of what sort of classes majors take, course plans	3

Table B-18 University of North Carolina at Ashville Math and Statistics

	Notes	Score
How many faculty and how many are not men?	17 total, 5 not men	NA
How are research Experiences encouraged?	"high value in assisting our students with undergraduate research" list of past projects with descriptions	3
What can students do with degree?	List of possible careers	2
Discourse that is enthusiastic and pro-teaching?	"dedicated to quality undergraduate education"	1
Other exciting things for majors	Math department handbook for undergrads, multiple activities, student chapter of association for women in mathematics	3
Degree Pathways	concentrations with descriptions	3

Table B-19 University of North Carolina at Ashville Computer Science

	Notes	Score
How many faculty and how many are not men?	7 total, 3 not men	NA
How are research Experiences encouraged?	list research participation in department description, require senior project, highlight some previous projects	3
What can students do with degree?	"graduate studies or careers in ..."	2
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	two pathways, brief description of who they are for, link to catalog	3
Degree Pathways	concentrations with descriptions	3

Table B-20 The University of Texas at El Paso Department of Physics

	Notes	Score
How many faculty and how many are not men?	17 total, 4 not men	NA
How are research Experiences encouraged?	Required for honors, mentioned in department head's welcome	2
What can students do with degree?	"wide variety of careers"	1
Discourse that is enthusiastic and pro-teaching?	Mentions education research and encourages students to take the physics pedagogy course	3
Other exciting things for majors	No Information	0
Degree Pathways	No Information	0

Table B-21 Walla Walla University Department of Physics

	Notes	Score
How many faculty and how many are not men?	2 total, 0 not men	NA
How are research Experiences encouraged?	Recommends all students apply for REU, a few on campus research options	3
What can students do with degree?	Lists some options, link to AIP, graduate school resources in department	3
Discourse that is enthusiastic and pro-teaching?	Encourages students to interact with faculty (contact them at home?!?)	2
Other exciting things for majors	No Information	0
Degree Pathways	Physics and biophysics, info about contacting advisor and who should choose which option	3

Table B-22 Walla Walla University Department of Mathematics

	Notes	Score
How many faculty and how many are not men?	5 total, 0 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	Lists some options, links to other sites	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Scholarships	1
Degree Pathways	BA, BS, course listing and advising guide but it's a little hard to find and on a different site	3

Table B-23 Walla Walla University Department of Computer Science

	Notes	Score
How many faculty and how many are not men?	6 total, 0 not men	NA
How are research Experiences encouraged?	Capstone Project	2
What can students do with degree?	Professional development course and a list of some options	3
Discourse that is enthusiastic and pro-teaching?	“small class size”	2
Other exciting things for majors	Clubs, community service, extracurricular activities	3
Degree Pathways	Four options with 6 strands of electives, link to catalog	2

Table B-24 Wellesley College Physics

	Notes	Score
How many faculty and how many are not men?	13 total, 5 not men	NA
How are research Experiences encouraged?	Optional thesis, information about research off campus and with faculty	3
What can students do with degree?	Lists options and alum, links to resources	3
Discourse that is enthusiastic and pro-teaching?	Discusses courses and how they meet goals for the degree	3
Other exciting things for majors	SPS	2
Degree Pathways	Physics, astrophysics, chemical physics, information about who to contact for more information, interdisciplinary option	3

Table B-25 Western Kentucky University Physics and Astronomy (physics)

	Notes	Score
How many faculty and how many are not men?	16 total, 2 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	Link to AIP, alumni profiles	3
Discourse that is enthusiastic and pro-teaching?	No Information	0
Other exciting things for majors	Astronomy Club, sigma pi sigma, sps	3
Degree Pathways	Multiple tracks with description	3

Table B-26 Western Kentucky University Department of Mathematics

	Notes	Score
How many faculty and how many are not men?	36 total, 19 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	Detailed careers page	3
Discourse that is enthusiastic and pro-teaching?	Phrases like “sound instruction”, “study support”, “engage inquiry”	2
Other exciting things for majors	Student clubs and scholarships	3
Degree Pathways	Multiple pathways, link to catalog	2

Table B-27 Western Kentucky University Department of Computer Science

	Notes	Score
How many faculty and how many are not men?	7 total, 2 not men	NA
How are research Experiences encouraged?	mentioned in department head's welcome	1
What can students do with degree?	No Information	0
Discourse that is enthusiastic and pro-teaching?	"small class size"	2
Other exciting things for majors	Student clubs	2
Degree Pathways	Multiple pathways, link to Catalog, concurrent BS/MS	3

Table B-28 William Jewell College Physics

	Notes	Score
How many faculty and how many are not men?	3 total, 1 not men	NA
How are research Experiences encouraged?	No Information	0
What can students do with degree?	A few alums highlighted and options listed in welcome statement	2
Discourse that is enthusiastic and pro-teaching?	"Small classes taught by PhD professors" Multiple departments have this too.	2
Other exciting things for majors	Other college type activities	1
Degree Pathways	No Information	0