

## **Envisioning Equitable Pathways to STEM Graduate Education: Creating a Coalition including University of Maryland Eastern Shore, Bowie State University, and University of Maryland College Park to Make It Happen**

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# **Envisioning Equitable Pathways to STEM Graduate Education: Creating a Coalition including two public HBCUs and a public Research 1 University to Make It Happen**

## **Abstract**

Two public HBCUs and a public Research 1 University established a coalition to develop pathways to STEM M.S. and Ph.D. programs among Black, Latinx, and Native American students. Through a mixed-methods research project, the team: (1) identified Faculty Champions to support and advocate for the students; (2) developed a Memorandum of Understanding for STEM programs between the institutions to facilitate sustained effort by our coalition; and (3) identified Pilot Undergraduate Programs to serve as Pathways to Selected STEM Graduate Programs. We will describe the recommendations of the team with respect to curriculum alignment, early undergraduate research opportunities; holistic review of graduate applications; building a more inclusive and accessible climate at the Research 1 Institution, and continued partnership building among the three institutions.

## **Introduction**

In November 2021, two public HBCUs and a public Research 1 University was awarded a planning grant by the Alfred P. Sloan Foundation to develop pathways to STEM M.S. and Ph.D. degrees among Black, Latinx, and Native American students. All three schools are part of the state's public higher education system. The Research 1 Institution is the state's flagship institution and the largest provider of tech workers in the region. This tri-institution collaboration leveraged existing relationships as an opportunity to expand current efforts to broaden participation in STEM majors and careers between the state's flagship institution and the two HBCUs. The goal of this coalition was to identify barriers to pursuing and earning STEM M.S. and Ph.D. degrees faced by Black, Latinx, and Native American students from the three institutions; to identify and cultivate internal champions and mentors who can help to overcome institutional biases; and to develop a framework for these institutions to work together in creating a pathway to graduate degrees that could be extended to other institutions.

Following a mixed methods research approach, the team conducted surveys and interviews and used the data to build an understanding of the student, faculty, and administrator perspectives of the graduate school climate at the Research 1 Institution; we performed the analysis of 2018-2022 graduate school application, admission, and enrollment data. The team: (1) identified Faculty Champions to support and advocate for the students; (2) developed a Memorandum of Understanding for STEM programs between the two HBCUs and the Research 1 Institution to facilitate sustained effort by our coalition; and (3) identified Pilot Undergraduate Programs to serve as Pathways to Selected STEM Graduate Programs.

Make background section more descriptive

Analysis is a little thin on quantitative to be mixed methods but it does support recommendations

## **The Problem**

The 2021 National Science Foundation (NSF) Women, Minorities and Persons with Disabilities in Science & Engineering report (data from 2019) [1] shows that while underrepresented minorities (URMs) comprise more than a third of the U.S. population, only 11% of the total doctorate degrees in Science & Engineering were awarded to African American, Latinx, and Native American students. At the Research 1 institution only 5.4% of the doctoral degrees in Engineering, Agriculture & Natural Resources, and Computer, Mathematics, and Natural Sciences (CMNS) were awarded to minorities. In order to make a significant change in the number of URMs earning graduate degrees in STEM, top universities must undergo a paradigm shift. It is critical to study why the current paradigm is not producing sufficient URM STEM graduates and to identify the root-level challenges which must be ameliorated to sustain long-term change. HBCUs are playing a pivotal role in increasing diversity in STEM by preparing URMs for graduate studies in Science & Engineering (S&E). By working with HBCUs, Predominantly White Institutions (PWIs) can help change the diversity landscape of STEM graduate education. Our partnership seeks to demonstrate the strength of a systematic change approach.

## **Systemic Change Approach**

The CEPATH (Creating Equitable Pathways to Graduate Education) project laid a foundation to address identified structural barriers inhibiting systemic change. The focus was on identifying critical points in the ecosystem that are biased against URM students such that if they are ameliorated or removed, the graduate STEM environment will be more welcoming and attractive to URM students in general. The long-term plan is to create new pathways as a concerted effort to affect systemic changes beyond individual groups of students on a regional level in the state, with potential future expansions to the other institutions and regional higher education centers. This initial study and evaluation underscore a unique opportunity to bring together students, scientists/engineers, and administrative leaders to shape change for the future, while leveraging existing programs such as the Minority Engineering Program (MEP). Following the theory of change of fixing the system and not the student, the outcomes will impact not just individual students, but generational cohorts of URM students and higher education broadly.

## **Institutional Data**

From the institutional data gathered from the three institutions, it is evident there are significant barriers that have inhibited the matriculation and graduation of URMs in STEM graduate programs at other schools. At HBCU 1, surveys of 120 engineering graduates from 2012-2020 indicated that only 14 (12%) attended graduate programs after earning their B.S. degrees. HBCU 2 has a strong record of Natural Science graduates pursuing or completing graduate degrees; however, only 5% of alumni surveyed about their intentions to pursue advanced degrees, have enrolled in science Ph.D. programs. 13% are enrolled in science M.S. programs with the remainder obtaining professional degrees (M.D., Pharm.D., M.B.A.).

The Graduate School at the Research 1 Institution demonstrated strong support for the CEPATH team by sharing application, admission, and enrollment data allowing us to evaluate trends and identify areas for improvement. In 2020, institutional data showed that only 10% of enrolled STEM graduate students were URM students. At the Ph.D. level, the percentage of URM STEM candidates remained flat at 6% from 2016 – 2020.

For Engineering, with the exception of 2020 at the height of the COVID Pandemic, the data shows that the total number of underrepresented minority and other U.S. citizen applicants decreased over time as has been observed nationally. However, the admission and enrollment yield rates for URMs increased over that time period. In 2021 and 2022, while the number of applicants was relatively constant, the admit rate and yield rate for African American Ph.D. students increased substantially. In 2018, the admit rate was 33% and the enrollment rate was 50% while in 2022, the admit rate was 54% and the yield rate was 69%. This is a positive trend because it indicates that the Research 1 Institution has an environment with the potential to change and increase the number of successful URM students at the Ph.D. level. This suggests that we need to examine what was working in 2022 so that we can duplicate it in the future. While the trends in CMNS and AGNR aren't as positive, the yield rates are high enough to indicate that those colleges could also be open to change.

### **Examination of Graduate Admission Processes**

We have compared the graduate admission processes used by some other institutions in the nation which are intended to minimize barriers to underrepresented student groups in the admission process.

The School of Physical Sciences at the University of California at Irvine conducted a study on equity in graduate admissions in 2020[2]. It focused on the role of typical admissions criteria and practices in influencing inequalities in graduate education. This study revealed that there were admissions mindsets and practices that tended to inhibit access for underrepresented groups across programs. The development and introduction of strategies rethinking typical admission criteria and processes focusing on equity-based holistic review was recommended. Embedding attention to equity throughout the admissions and recruitment process was also suggested to improve student diversity and equity. After the study, the American Association for the Advancement of Sciences (AAAS)[ 3] launched a large slate of initiatives aimed at increasing all persons' access, engagement, and success within STEM pathways. AAAS's initiatives emphasized a systemic approach to transforming the STEM ecosystem to support workforce development and diverse representation in all STEM areas. Furthermore, these initiatives intend to increase the capacity of both individuals and organizations to mutually reinforce transformation to advance science and serve society. The initiatives recognize various identities or terms like "underrepresented groups" (URG), "underrepresented minorities" (URM), or "broadening participation" should include representations of race, ethnicity, gender identity and gender expression, persons with disabilities, neurodiverse persons, and members of the LGBTQIA+ community to reflect the true richness of our society when it comes to equality, diversity and inclusion.

The ETS and GRE (Graduate Record Exam) programs [4] have developed guidelines to facilitate institutions' holistic admissions processes. The recommended admission process includes the following steps: setting a timeline and goals for the admissions process; collecting applicant information; reviewing applicant files; selecting applicants and making final decisions; and evaluating the admissions process. They note that GRE test score should only be one part of the admission process. However, when applying this information to our institutions, we have identified some engineering faculty at the Research 1 Institution who found GRE scores have acted as a barrier to the admission of otherwise qualified URM applicants. Thus, we have chosen to include the Mechanical Engineering Department as one of our pilot CEPATH programs because they are not only enthusiastic about participating, they no longer require graduate applicants to submit a GRE score.

Holistic review of applicants is suggested for all graduate programs at the University of Oregon by the Division of Graduate Studies (UODGS) [5]. Holistic review challenges the assumption that quantitative measures alone are the best predictor of success in a graduate program. Rather, UODGS encourages the use of a variety of resources, including the ETS "additional questions" document [6], the University of Michigan's Rackham Graduate School processes [7], and the recommendations of the American Association of Collegiate Registrars and Admissions Officers (AACRAO) [8], among others, as models that provide a much broader approach to analyzing applicants and evaluating their promise of success in graduate programs, thereby supporting a more inclusive admission process.

This review of graduate admission processes followed across the nation supports expanded admissions processes beyond standardized test scores to better assess the potential for URM students to succeed at the graduate level.

### **Issues Affecting HBCU Student Interest in STEM Graduate Programs**

In order to extend our understanding of the current attitudes and perspectives of graduate STEM education programs in the state system, the CEPATH project disseminated surveys and conducted interviews with key stakeholders. The analysis focused on three research questions:

1. What programmatic obstacles deter URM students from pursuing STEM graduate degree?
2. What are the key embedded institutional biases that limit URM entry and degree completion?
3. How can our institutions work together to develop pathways for successful URM STEM graduate education?

### **Programmatic Obstacles**

Data was collected from a variety of sources: HBCU undergraduate students (n=117), HBCU STEM faculty (n=11), and the Research 1 Institution STEM faculty and administrators (n=22). Addressing the question, "What programmatic obstacles deter URM students from pursuing STEM graduate degree?", the results illustrated that perceptions of

funding deter URM students from pursuing STEM graduate degrees. 76% of students felt “financially burdened” at least once per week. Additionally, 40% of respondents do not want to borrow money for their graduate education. These financial concerns may lead to graduates pursuing full-time employment opportunities immediately after graduation instead of continuing their education in graduate programs.

Advising shapes students’ perceptions of opportunities beyond the undergraduate degree. 77% of respondents were satisfied with the overall relationship with their faculty advisor. Yet, advisors of URM undergraduate students have limited information about opportunities at the Research 1 Institution graduate programs. Specifically, 44% of students surveyed do not know if information is available about applying to graduate school. This suggests a missing opportunity to share relevant information that will shape pathway decisions.

Finally, data indicates that HBCU students were exposed to a diverse array of undergraduate research opportunities. At the time of the survey, 51% of survey respondents had already participated in undergraduate research. However, students expressed an unclear connection between these activities and preparation for graduate study. Generally, undergraduates surveyed are uncertain about the impact undergraduate research will have on them. 28% neither agree/disagree with the statement that “doing research confirmed my interest in my field of study.” These results suggest that there is a missed opportunity to promote undergraduate research experiences as a mechanism to increase graduate school aspirations, and provide students with foundational research skills necessary to thrive at the graduate level.

### **Institutional Biases**

The second research question focused on exposing institutional biases that shape recruitment and retention of URM attending graduate programs at the Research 1 Institution. A survey instrument and interview protocol were designed by the CEPATH project team. Data were collected as follows: HBCU STEM Faculty survey (n=8), the Research 1 Institution Graduate STEM Faculty and Staff survey (n=22), the Research 1 Institution Graduate Faculty and Staff interview (n=7), and the Research 1 Institution graduate students/alumni (n=5).

Despite limited responses from the Research 1 Institution Graduate Students, the results suggest that students perceive the climate for URM students at the Research 1 Institution is a barrier to graduate student admission and retention. Broadly, from the graduate and alumni survey, URM respondents did not have positive impressions of the climate for URM students at the Research 1 Institution. 50% agreed “I have been subjected to racism” and 50% did not believe that “faculty are aware of issues facing URM students”. In terms of whether the program’s climate was overall helpful in promoting success, student respondents were ambivalent: 80% neither agree or disagree that “This program is/was doing a good job helping minority graduate students succeed”.

Additionally, academic preparedness at the undergraduate level (low GPA, curricular misalignment) was identified as an institutional barrier to URM graduate student admission and retention. Generally, the Research 1 Institution Graduate Faculty and Staff

have a limited perception of the academic preparedness of URM students in their programs, with 36.3% reporting they “neither agree nor disagree” with the statement “URM students enter graduate programs prepared academically”.

24% of the Research 1 Institution Graduate Faculty and Staff surveyed disagree with the statement that “URM students from HBCUs are well prepared for my program,” suggesting there may be negative perceptions of the academic rigor of HBCU programs among the Research 1 Institution Graduate Faculty and Staff.

The Faculty and Staff at the Research 1 Institution reported that their program has been successful at recruiting (70%), retaining (75%), and promoting the success of (75%) URM STEM graduate students. These responses, however, are not fully aligned with the perceptions of other institutional stakeholders and students. These results suggest that there are likely differences in perceptions of institutional barriers biases based upon the Faculty or Staff member’s role at the institution.

### **Developing Pathways**

From the data collected across all sources utilized in this project, several recommendations were offered by stakeholders to both improve the program climate and promote student success among URM STEM graduate students. These recommendations will be used to inform the implementation of the pilot programs and engagement with faculty champions on these initiatives. From the perspective of undergraduate students, they suggest “scholarship and financial aid” should be a priority to mitigate financial barriers, while “more hands-on and visual learning” opportunities could help foster deeper interests and competencies in the content areas. Undergraduate students also advocated for more opportunities for “diverse, community engaging clubs and activities” that can bring URM students and professionals together to share their experiences.

Faculty and staff across the three institutions emphasized the importance of establishing an academic network of scholars across campuses. This would lead to “more visibility of programs, admissions requirements and the financial support mechanisms”. Acknowledging the current climate in STEM programs, faculty suggest that “appropriate faculty” should be identified to engage in mentorship relationships with URM students. Professional development will be necessary to allow STEM faculty to reflect on their practices and adopt new advising and mentoring strategies. Partnerships with existing initiatives such as the LSAMP Bridge to the Doctoral Program could meet this aim. Finally, stakeholders agree that there should be intentional efforts to recruit and retain URM and women faculty with established research programs who can model opportunities in STEM careers.

### **Outcomes**

This planning grant achieved four outcomes. A Memorandum of Understanding has been signed by the three respective universities. Faculty champions have been identified at all three schools. Pilot Programs at the Research 1 Institution have been identified.

Collaborative efforts between the institutions have been initiated.

### **Memorandum of Understanding**

A Memorandum of Understanding (MOU) was established by the grant team which captures the collaborative efforts that will take place over the next 5 years. It describes 5 potential pathways for HBCU students to enter graduate education at the Research 1 Institution including a 4+2 B.S./M.S., B.S./Ph.D., B.S./M.S., Post Baccalaureate research, and an Industry to graduate degree path. It also identifies the supportive elements which will be implemented to increase the potential for HBCU students to be: (1) successful prior to entering graduate school through participation in research opportunities and professional development; (2) successful in completing graduate school applications, (3) entering graduate school through an improved admissions processes; (4) supported by Faculty Champions; and finally (5) supported by efforts to seek funding to support the long-term viability and broader implementation of the program. This MOU has been signed by the three provosts and appropriate deans at each university.

### **Champions**

Faculty and staff leadership is essential to permanently improve the graduate climate. We call these leaders “Champions”. Faculty champions were identified by committee members at each institution as individuals who displayed excellence in administration and who have a history of engaging with URM students within research environments. Champions will cultivate and sustain an environment conducive to the success of URM -and by extension- all graduate students. Primarily, Champions will advocate for URM graduate admissions and support inclusive student success. They will assist in cultivating an environment in which all graduate students can thrive academically and personally. Champions will be widely known as effective points of contact for student inquiries/concerns and will provide information for fellow Champions and faculty at the undergraduate institutions. Stronger communication between the Research 1 Institution and the two HBCUs faculty can ensure HBCU students have the information and skills they need to successfully enter and complete graduate programs, and the Research 1 Institution faculty are aware of the talented students at these local HBCUs.

In addition, the Research 1 Institution Champions may host or facilitate opportunities for HBCU undergraduate students to participate in short or long-term research experiences. They may participate in joint institutional professional development workshops or discussions with faculty and students. Through these activities, they may provide service as external expert advisors to HBCU students as early as possible in their undergraduate experience to help more URM students understand how their undergraduate studies are aligned with, and fundamental to, their success in future graduate studies at the Research 1 Institution and how a graduate degree can positively impact their careers.

Champions will be supported and encouraged by the multi-institutional team to develop a pipeline for URM students to enroll in and successfully complete graduate STEM programs at the Research 1 Institution. A successful program will require that Champions be fully engaged in this process for 2-3 years and that they engage with their faculty



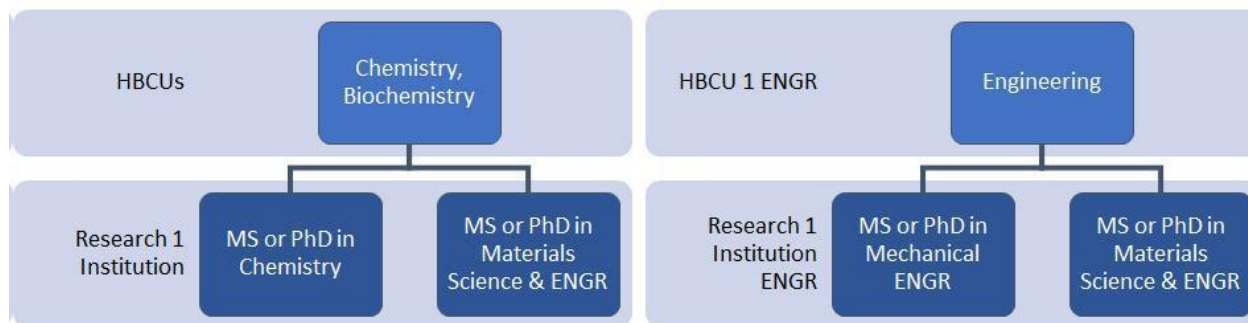
colleagues to help them appreciate the strengths diverse students bring to their research projects. In addition, Champions will work with faculty and staff to model and maintain a positive environment. A total of 32 Champions have already been identified across STEM Departments in three partner institutions.

### **Pilot Programs**

Three graduate departments, Chemistry, Mechanical Engineering and Materials Science and Engineering were identified as demonstration departments based on:

- 1) Match between undergraduate programs at the HBCUs and graduate opportunities at the Research 1 Institution.
- 2) Interest in participation by the Research 1 Institution graduate programs as expressed in discussions with CEPATH leaders.
- 3) Ph.D. graduates who teach at HBCU's in the state.

A program that increases the number of HBCU students who successfully complete a M.S. or Ph.D. STEM degree must match the interests and background of the HBCU students with STEM graduate programs. Thus, the first step was identifying graduate programs where STEM undergraduate coursework and student interest at the two HBCUs that would be compatible. The figure below shows the potential matches that were identified.



Both HBCUs have relatively large programs in biology and chemistry so it was important to have good pathways for them. While it is a small field compared to some of the other engineering disciplines, Materials Science and Engineering is a broad field that happily accepts graduate students from a variety of backgrounds. Mechanical Engineering is one of the largest graduate programs in Engineering at the Research 1 Institution, they are a good match for engineering students coming from HBCU 1, and they have dropped the GRE as a requirement for admission. When Mechanical Engineering was approached as a potential demonstration department, they were enthusiastic about participating.

### **Collaborative Efforts**

Chemistry and Plant Science Symposium. As a part of the planning grant the Natural Science departments at the HBCUs and the Research 1 Institution student chapter of National Organization of Black Chemists and Chemical Engineers (NOBCCHE) hosted a Chemistry and Plant Science Symposium on April 14th, 2023. This Symposium brought together the Chemistry and Plant Science Programs at the three institutions to discuss research and graduate school at the Research 1 Institution. This hybrid event featured

faculty, graduate students and guest speakers representing the Chemistry & Biochemistry, and Plant Science Departments from the Research 1 Institution. It also included a poster session from students at the HBCUs to share their research experiences with faculty and students from the Research 1 Institution. There were 55 attendees in total. From HBCUs there were Seven (7) faculty/administrators, 28 undergraduate students, and 1 postdoc. From the Research 1 Institution there were Six (6) faculty/administrators, 5 graduate students, and 1 postdoc.

One of the goals of our CEPATH collaboration was to introduce HBCU students to research and potential graduate degree opportunities at the Research 1 Institution. To do this it is important to encourage HBCU students to participate in ongoing research programs at the Research 1 Institution such as NSF-funded REU/RET Site: Summer Research Experiences in Renewable and Sustainable Energy Technology (ReSET). In Summer 2022, the team developed a collaboration with the LSAMP Program in the state. This led to LSAMP advertising the ReSET REU to all of the schools and students in their coalition and sharing seminars between the two summer research programs. To strengthen the LSAMP connection, HBCU 1 students were encouraged to apply. One engineering student applied and was accepted to the program. While that student ultimately chose to participate in a different REU, their introduction to the Materials Science and Engineering (MSE) Department at the Research 1 Institution through the ReSET REU led them to apply to the MSE Ph.D. program in Fall 2022. That student began the Ph.D. program in Fall 2023. This is a great example, as what this project team has advocated and envisioned, of creating a pathway for a URM student at HBCU 1's engineering program to embark on a journey of graduate education.

After reviewing the planning grant we will establish goals for the program

Make clear how the partnership benefits the hbcu universities

## **Recommendations**

In summary, based on the findings of this project, the team offers the following recommendations to develop pathways to STEM M.S. and Ph.D. programs among Black, Latinx, and Native American students.

- 1) Create curriculum alignment from undergraduate curricula through pilot graduate programs.
- 2) Identify and promote early undergraduate research opportunities at all three institutions.
- 3) Conduct a holistic review of graduate applicants with optional submission of GRE scores.
- 4) Engage faculty champions to create connections among the three institutions and encourage a more inclusive and accessible climate at the Research 1 Institution.
- 5) Continue to seek funding opportunities to empower the partnership to increase minority student success in STEM graduate programs at the Research 1 Institution.
- 6) Create a professional development round robin seminar series to connect the three institutions and create a relationship between HBCU students and faculty and graduate STEM programs at the Research 1 Institution.

For the conclusion provide additional recommendations even if they weren't adopted in this collaboration

## REFERENCES

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- [2] Women, Minorities. "Persons with Disabilities in Science and Engineering. National Science Foundation." *National Center for Science and Engineering Statistics* (2021).
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**Appendix: Ph.D. and M.S. Application, Admission and Enrollment Data for Engineering (ENGR), Agriculture and Natural Resources (AGNR), and Computer, Mathematical and Natural Sciences (CMNS)**

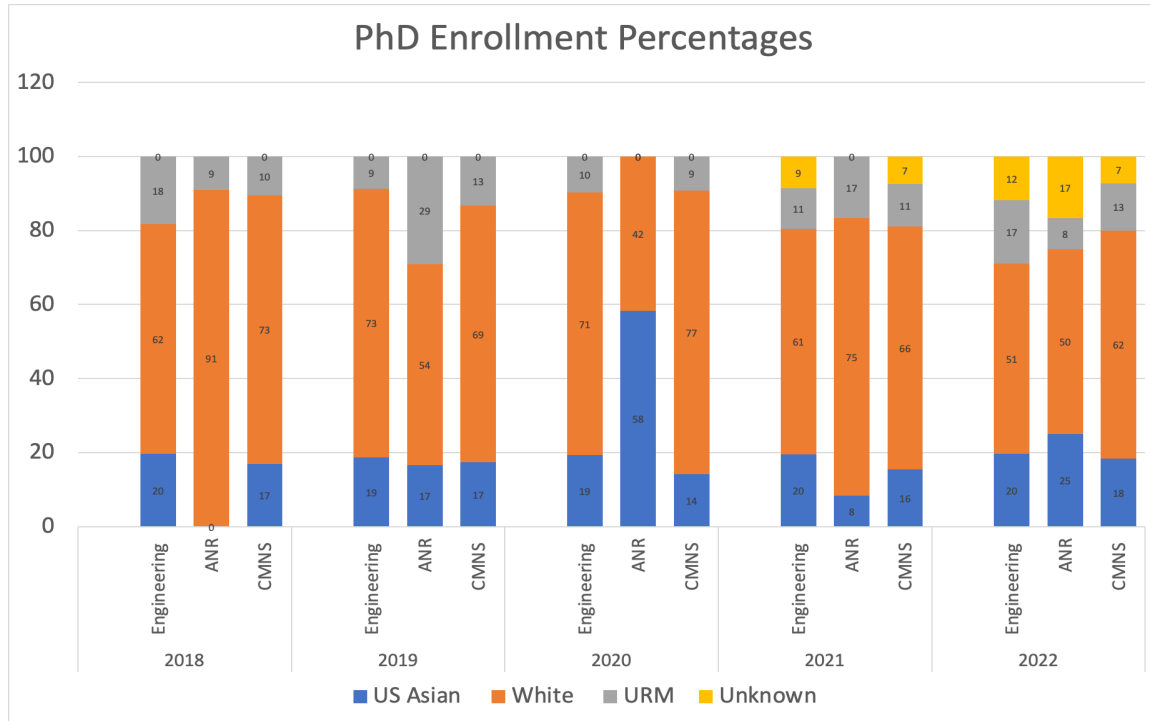


Figure A1: Domestic Ph.D. Enrollment Rates from 2018 to 2022. *Note: The percentage of international students for Engineering was 50%, ANR was 53%, and CMNS was 48%.*

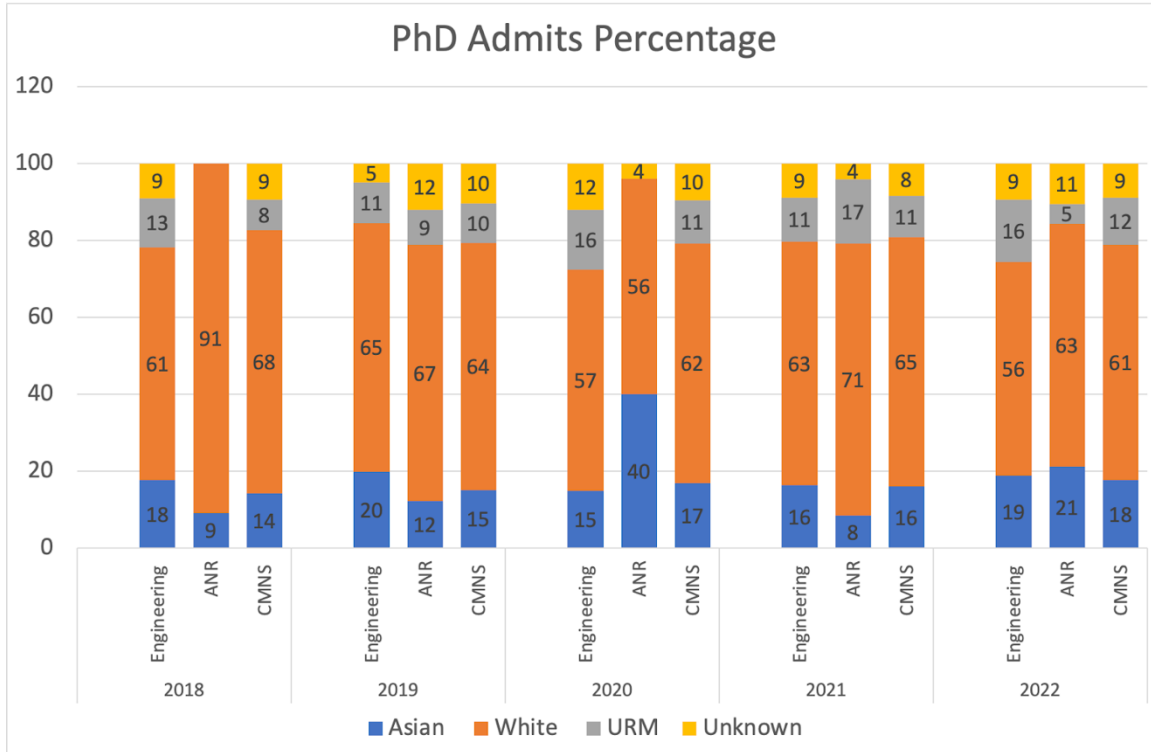


Figure A2: Domestic Ph.D. Admission Rates from 2018-2022. *Note: The percentage of international students for Engineering was 50%, ANR was 57%, and CMNS was 41%.*

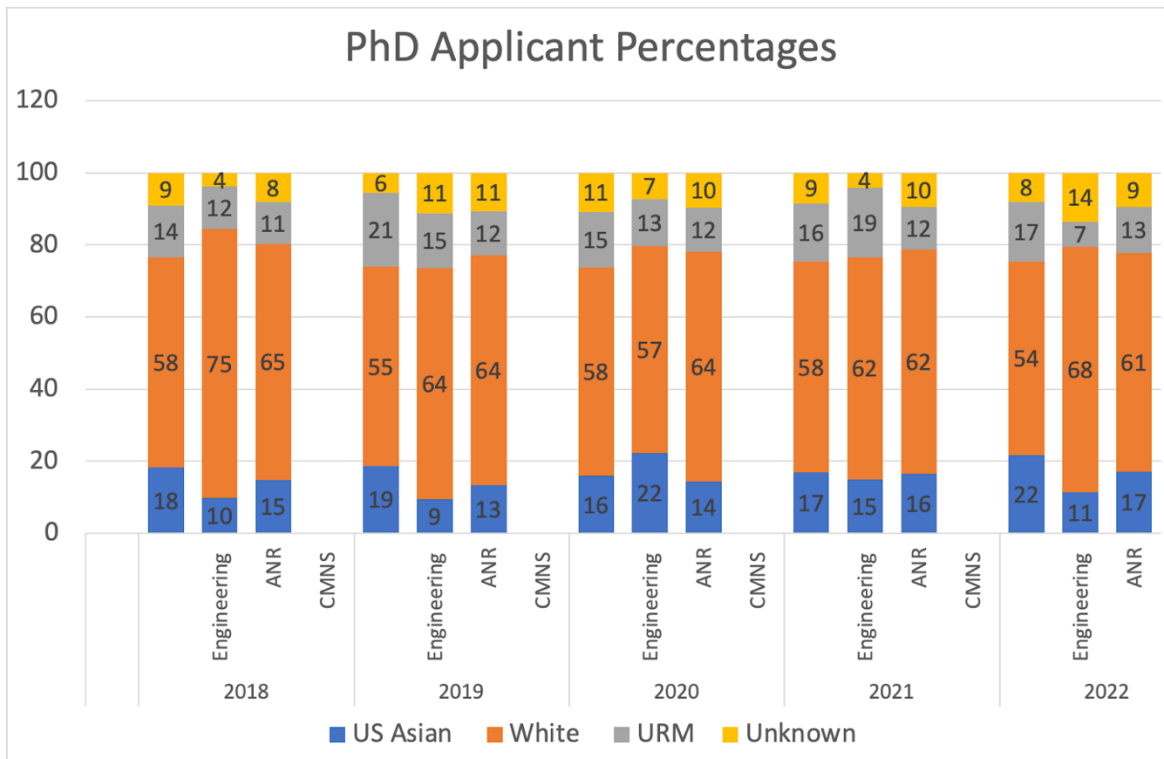


Figure A3: Domestic Ph.D. Application Rates from 2018-2022. *Note: The percentage of international students for Engineering was 74%, ANR was 73%, and CMNS was 55%.*

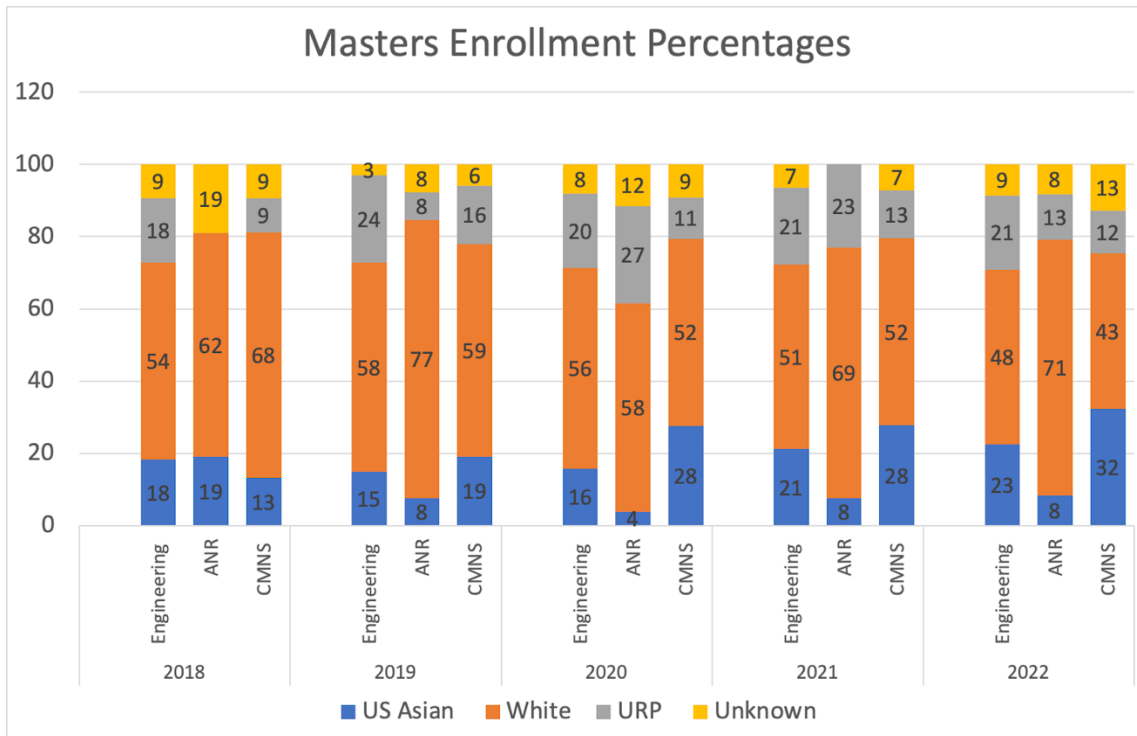


Figure A4: Domestic M.S. Enrollment Rates from 2018 to 2022. *Note: The percentage of international students for Engineering was 53%, ANR was 11%, and CMNS was 31%*

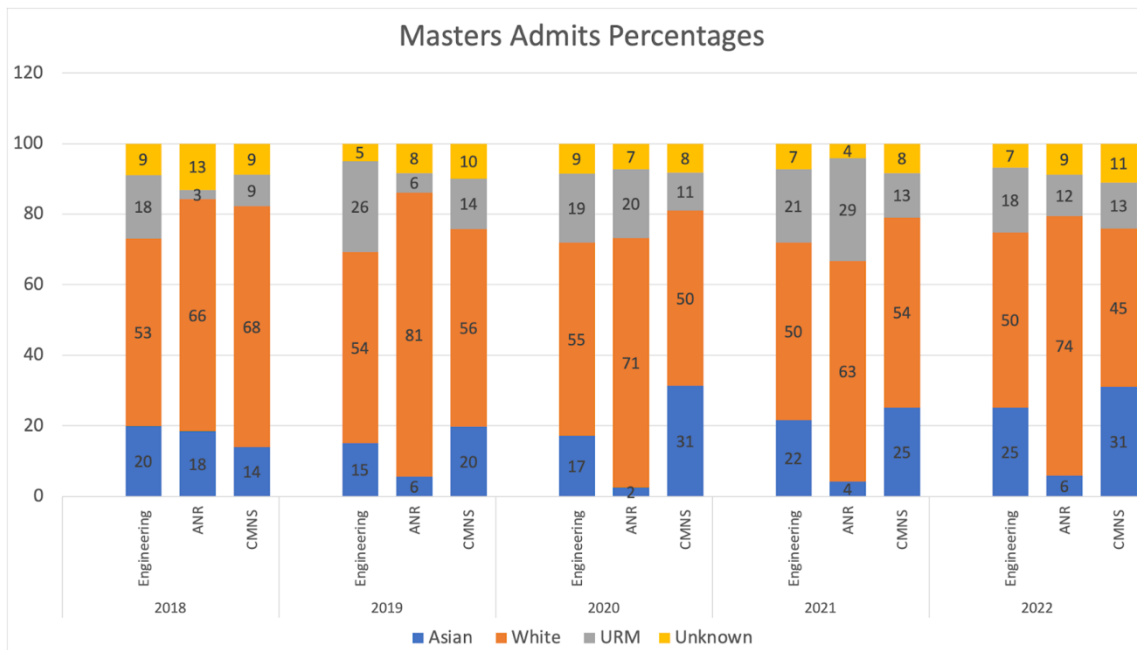


Figure A5: Domestic M.S. Admission Rates from 2018-2022. *Note: The percentage of international students for Engineering was 72%, ANR was 22%, CMNS was 55%.*

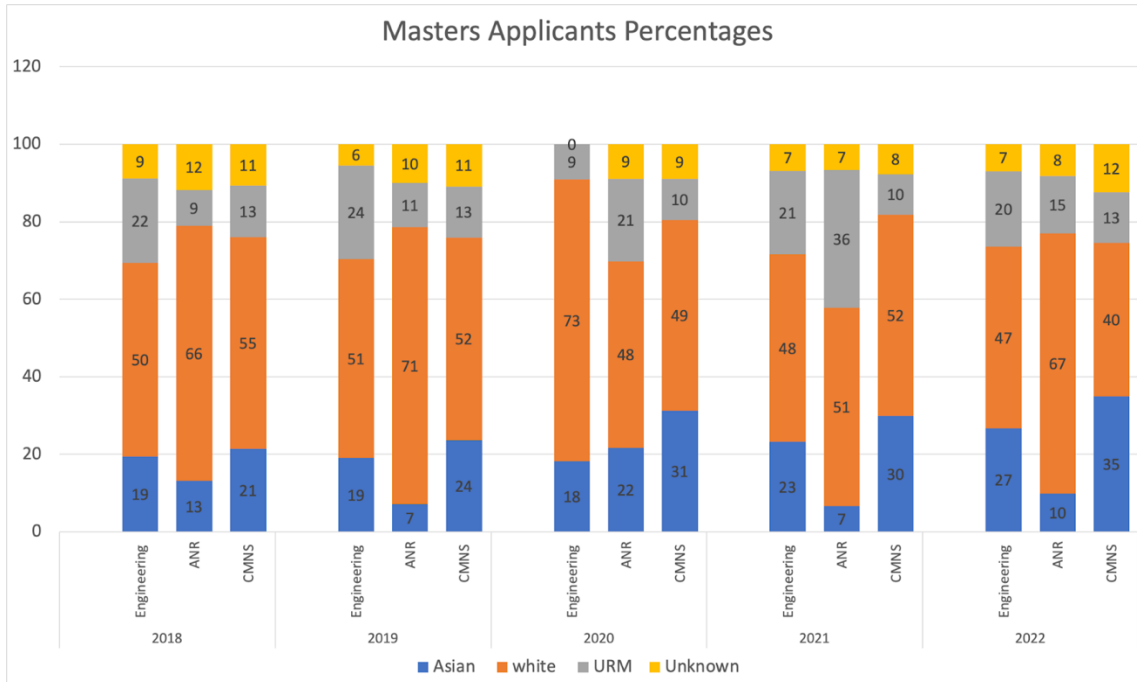


Figure A6: Domestic M.S. Application Rates from 2018-2022. *Note: The percentage of international students for Engineering was 79%, ANR was 51%, and CMNS was 80%.*

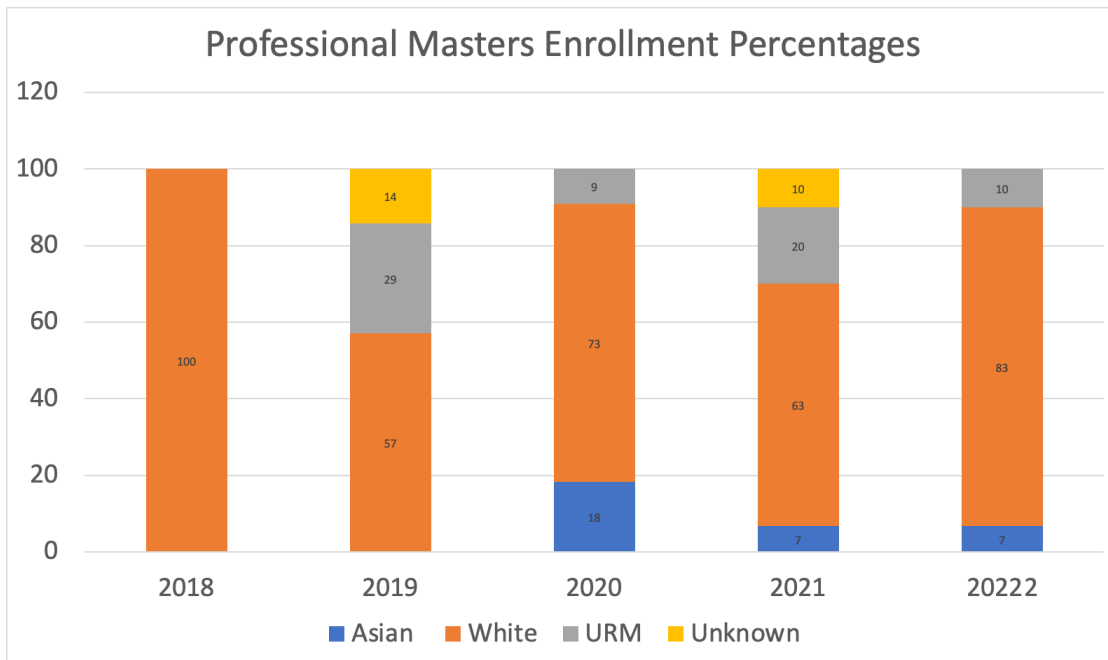


Figure A7: Domestic Professional M.S. Enrollment Rates in AGNR from 2018 to 2022. *Note: The percentage of international students was 3%.*

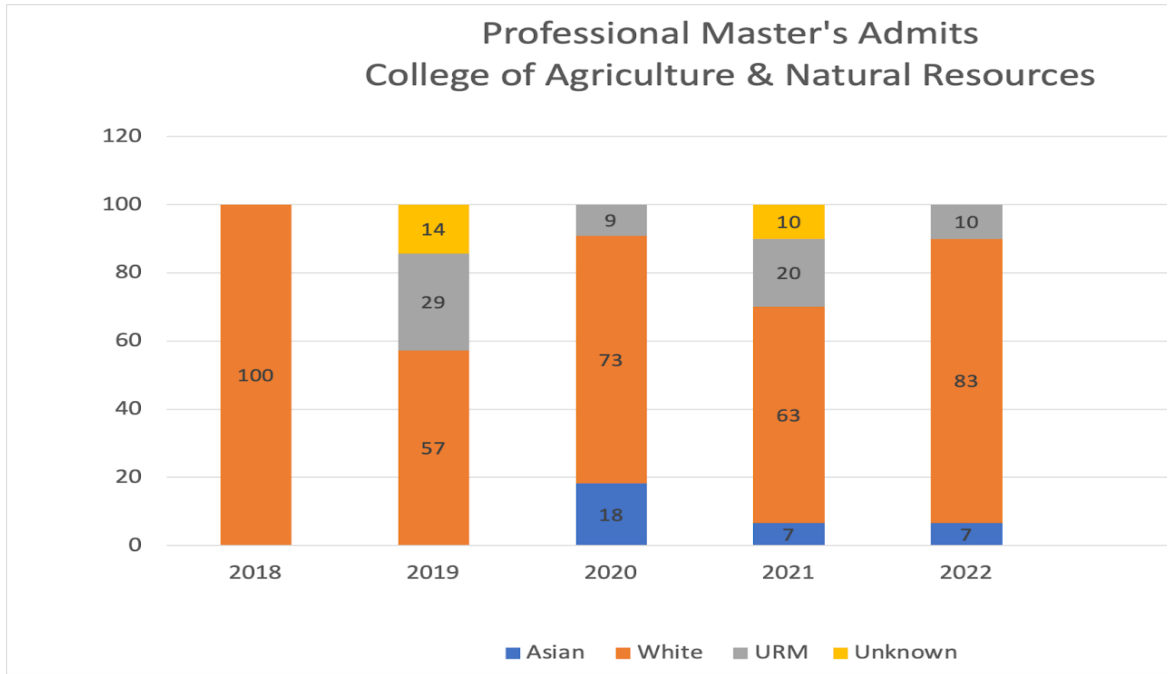


Figure A8: Domestic Professional M.S. Admission Rates in AGNR from 2018-2022. *Note: The percentage of international students was 3%.*

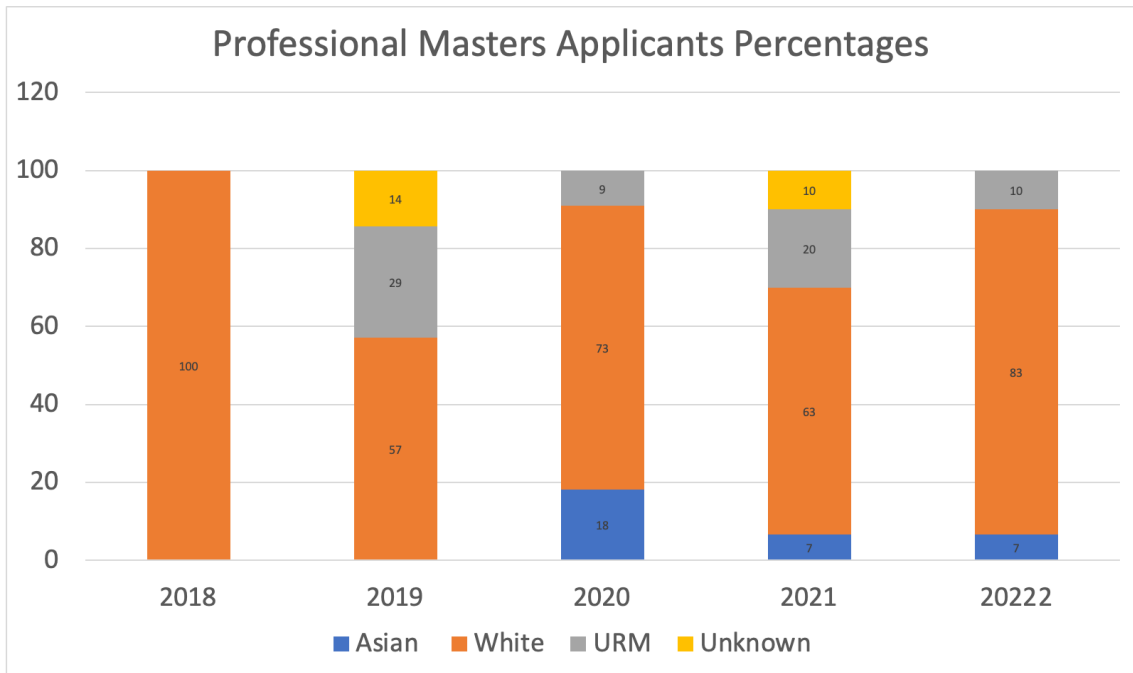


Figure A9: Domestic Professional M.S. Application Rates in AGNR from 2018-2022. *Note: The percentage of international was 3%.*