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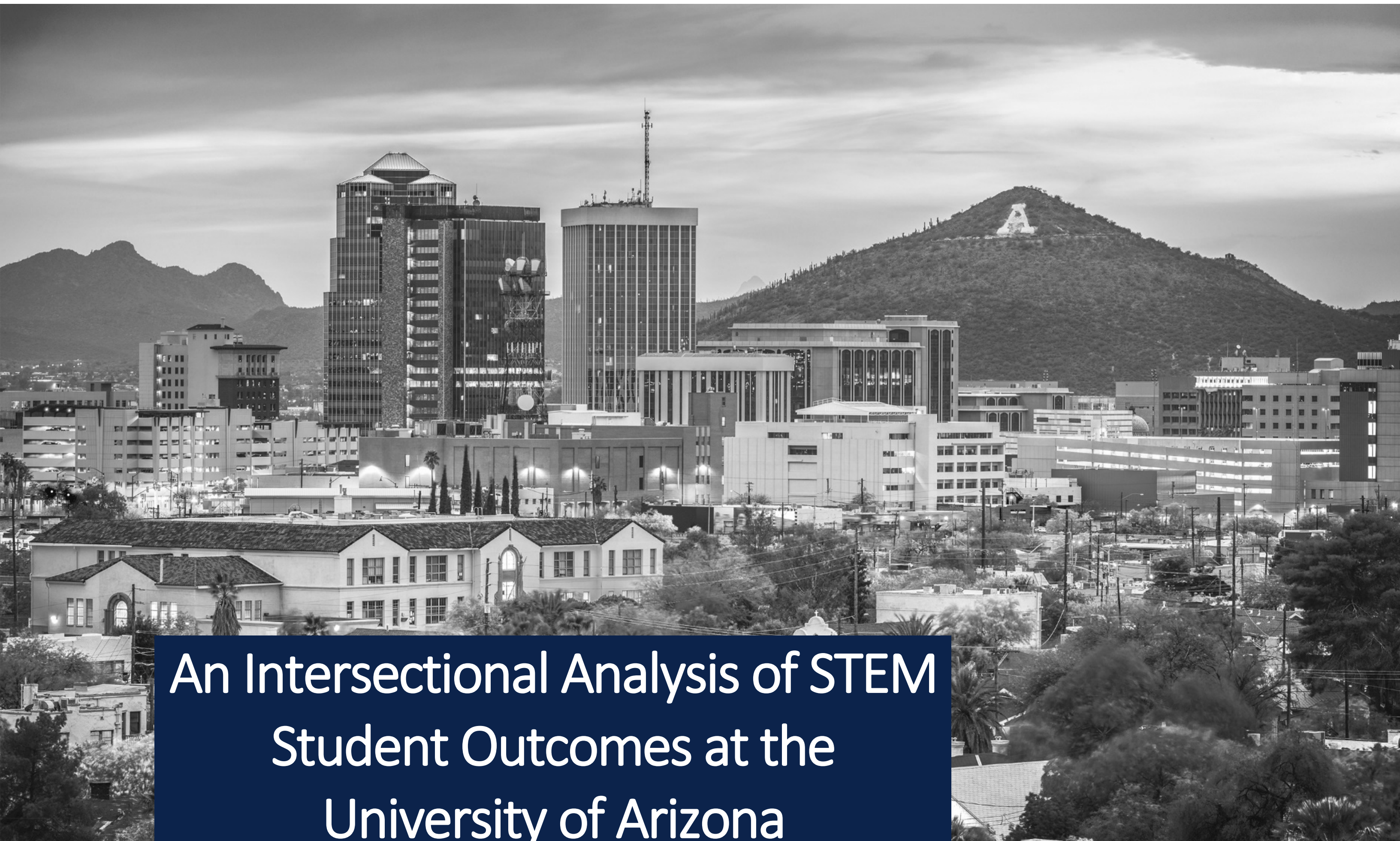

An Intersectional Analysis of STEM Student Outcomes at the University of Arizona

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INTRODUCTION

A large body of interdisciplinary research has pointed to disparities in STEM outcomes across various student populations (National Science Board 2014; National Student Clearinghouse Research Center 2015; National Science Foundation 2021) including: women (Blackburn 2017); under-represented minorities (e.g., Black, Latinx, Native American, Alaskan Native) (Anderson and Kim 2006; Hurtado et al 2007; Change et al. 2014); first generation college students (Chen 2005; Fernandez et al. 2008; Shaw and Barbuti 2010); and students from lower-income households (Conrad et al. 2009). Intersectional analysis of STEM student outcomes has further pointed to the way in which different identity categories can combine to exacerbate disparities leading to, for example, heighted disparities for women of color in STEM (Ong et al. 2011). However, the unique demographic compositions and institutional structures and culture of specific institutions of higher education presents challenges to understanding how disparities in STEM outcomes manifest and shape student experiences within the context of a single institution, requiring site-specific analysis in order to inform targeted programming capable of addressing disparities.

In 2019, researchers with the Women in Science and Engineering Program (WISE) and Southwest Institute for Research on Women (SIROW) released the first comprehensive analysis of female student enrollment, retention, and graduation rates across the primary STEM colleges (Engineering; Science; Agriculture and Life Sciences; Optical Science) and departments at the University of Arizona (Murphy and Williams 2019). This report provided university administrators, policy makers, and student support staff with information necessary to understand trends in female student enrollment, retention, and graduation and assess the degree to which trends vary across colleges and departments.

In addition to filling institutional knowledge gaps, the report prompted important conversations regarding different approaches for assessing STEM student outcomes across units. The STEM Student Outcomes Working Group was created to develop agreed upon methods and procedures for assessing STEM student outcomes relevant and useful for faculty and staff across the institution. This working group was composed of individuals from across STEM colleges, Student Affairs and Enrollment Management Office of Evaluation and Assessment, Student Success and Retention Innovation, University Analytics and Institutional Research, and cross-institutional STEM student support programs (e.g., WISE, ASEMS).

A key question that emerged from working group conversations was the degree to which sex was more or less influential than other axes of difference in shaping STEM student outcomes. In particular, questions were raised regarding the degree to which underrepresented minority (URM) status, first-generation college going status, and Pell-eligible status affected STEM student outcomes compared to sex. In response, this report builds on our early work to take an intersectional approach to assessing and analyzing STEM student outcomes. Drawing on over 40,000 student records, this report first outlines rates of enrollment, STEM retention, and STEM and non-STEM graduation across four different social identity groups based on sex, under-represented minority status, first generation status, and Pell-eligible status. We then report the results of statistical analysis conducted to assess the degree to which membership in these different groups drives disparities in STEM outcomes. In doing so, this report provides policy makers across the institution with data necessary to understand how general disparities in STEM outcomes manifest at the University of Arizona in particular so that they can use this information to target student success and support efforts in an efficient and impactful manner. At the same time, the methods developed in this report provide stakeholders across the university with a blueprint for assessing disparities in STEM student outcomes across different social groups, over time, and/or at different scales.

The results of our analysis indicate statistically significant disparities in some STEM student outcomes across intersectional groups and offer a more fine-tuned understanding of the degree to which sex, under-represented minority status, first generation college status, and Pell-eligible status shapes the likelihood that students will enter, persist, or succeed in STEM fields at the University of Arizona. In what follows, we document our guiding research questions and methods and summarize our findings. We then offer some practical recommendations related to our findings and possible areas for further analysis.

RESEARCH QUESTIONS

The following research questions guided this report:

1. To what extent are students from groups historically underserved in STEM (women, under-represented minorities (URM), first generation, low income) underrepresented in STEM entry, STEM retention, and STEM graduation at the University of Arizona?

2. To what extent does one's status as female, underrepresented minority, first generation, Pell eligible predict the likelihood that a UA student will experience the following:
    A. Enter UA as a STEM major
    B. Graduate UA with a STEM degree after entering as a STEM major
    C. Graduate UA with a non-STEM degree after entering as a STEM major
    D. Drop out of UA after entering as a STEM major

METHODS

Dataset

To address the above questions, we first worked with UAnalytics to procure a database of student demographic, retention, and graduation records from entry cohorts 2014-2020. This large dataset totaled 43,156 student records. 713 student records were removed because they could not be verified. After cleaning, the overall dataset included 42,443 individual student records. Relevant demographic variables included students' sex, IPEDS race/ethnicity, first generation status, and Pell eligibility status. Relevant academic variables included college, department, and major enrollment at particular time points including entry, end of year 1, and graduation. A STEM flag is used at these different time points to designate whether the student's major falls within any one of three (NSF, ABOR, and DOE) institutionally available indexes of STEM majors. For more information on the STEM major index used in this report, see Appendix A.

Descriptive Statistical Analysis

To answer research question 1, we first measured the rate at which students from the subject populations entered the University of Arizona as first time/full time (FT/FT) STEM majors. We then tracked STEM enterers to see the rates at which the different subject populations were retained in STEM; graduated in STEM or Non-STEM degree programs; and withdrew from the University. Descriptive statistics on the demography of the cohorts and rates of STEM entry, STEM retention, STEM and non-STEM graduation, and UA withdrawal rates are reported at the university-wide and college level and key findings are summarized.

We report the portion of STEM enterers, persisters, and graduators that were underrepresented students as well as the STEM entry, persistence, and graduation rates for underrepresented students compared to their historically represented peers. These comparative proportions and rates provide useful baselines from which to set forthcoming goals and measure improvements.

Inferential Statistical Analysis

Logistic regression is commonly used tool for intersectional analyses (Bauer, Churchill, Mahendran et al 2021). It is a popular approach among researchers of higher education interested in student retention and graduation and educational equity looking to understand the causal mechanisms of multiple factors upon student outcomes.

To answer research question 2, we used logistic regression to create first-level main effects models where four demographic independent predictor variables related to STEM diversity and underrepresented status (sex, URM status, first-generation status, Pell-eligible) were used to predict a series of binary dependent variables, all STEM related event outcomes such as entry, graduation, and drop out.

Multivariate binary logistic regression is particularly well-suited to approach the intersectional and classificatory nature of student demographic data and the binary structure of STEM outcomes in this dataset. Firstly, entry, retention and graduation are events with binary mutually exclusive outcomes (i.e.: graduated vs. did not graduate) and underrepresented STEM groups are also organized as mutually exclusive (i.e.: first generation vs. not first generation). Secondly, logistic regression is appropriate complex variable interaction as it places predictor variables into competition with one another for explanatory power while controlling for their influence upon one another. In addition, the interaction effects between variables can also be explored to give insight into the multiplicative and compounding dimensions of intersectional experiences (Christofferson 2017). As such, logistic regression modelling also creates a means gauge the differential effects of predictor variables. ***This type of analysis can help elucidate intersections of compounding advantage or disadvantage so as to provide insight into the groups who are most impacted by disparate odds of successful STEM outcomes and to help strategically plan for the allocation of resources to more effectively mitigate these disparities.***

Logistic regression is a predictive classification algorithm that uses a logistic function to calculate the conditional probability that an event will occur. Logistic regression attempts uses maximum likelihood estimation (MLE) to obtain regression coefficients and uses these to establish a sigmoid curve of best fit. The regression coefficient gives a sense as to the relative importance of each predictor in standardized terms and the direction of its association with the dependent variable (outcome). For each independent variable(predictor) in the model, the regression coefficient(β) represents the predicted change in log odds of falling into the target group as compared to the reference group when controlled against the other predictors in the model. Each log odds which can be exponentiated as an odds ratio. In a multivariate model, the odds ratios are adjusted wherein the odds ratio measures the strength of the association between that predictor variable and the outcome in question, while controlling for the other predictor variables. Here, relative odds of success for each sub-group in comparison to the other can be determined. Finally, predicted probabilities of success can be calculated for discrete individuals based on their membership in multiple predictor variable groups. The relevant logistic transformation equations used in the analysis are described in the Table 1 below.

Table 1. Logistic Regression Model Equations

Where Y = dependent variable, x_{1-4} = independent variables, and β = regression coefficient: $Y = \beta 0 + \beta 1_{Female} + \beta 2_{URM} + \beta 2_{First\ Gen} + \beta 2_{Pell}$		
Probability	Number of successful events / Number of total events	p
Odds	Probability of successful event/ Probability of failed event	(p/1-p)
Logit(p)	Natural logarithm of odds	$Log(p/1-p) = \beta 0 + \beta 1_{Female} + \beta 2_{URM} + \beta 2_{First\ Gen} + \beta 2_{Pell}$
Odds Ratio	Odds of referent group / Odds of target group	$(p/1-p) = exp(\beta 0 + \beta 1_{Female} + \beta 2_{URM} + \beta 2_{First\ Gen} + \beta 2_{Pell})$
Predicted Probability	Probability of successful event based on group membership	$(p/1-p) / (1+(p/1-p) = exp(\beta 0 + \beta 1_{Female} + \beta 2_{URM} + \beta 2_{First\ Gen} + \beta 2_{Pell}) / 1+ exp(\beta 0 + \beta 1_{Female} + \beta 2_{URM} + \beta 2_{First\ Gen} + \beta 2_{Pell}$

Because, we sought to build an initial baseline demographic model, we purposely excluded other commonly tested indicators that are also influential. These include other demographic factors like parental education; pre-college metrics such as High School GPA, SAT/ACT score; college metrics like honors status, GPA, course flow, and academic engagement; as well as more qualitative metrics like sense of belonging and climate. These other factors are undoubtedly important and future study would enrichen any predictive model. However, at this stage, we sought to better understand the four demographic influences. To be expected, these initial demographic baseline models saw limited performance in terms of explaining the apparent disparities. This is unsurprising given the complexity of the real-life factors that influence a student's academic choices and performance. However, because the samples used strongly reflect the actual student population, this contributes to the statistical power of this inferential analysis and its accuracy in documenting disparities along the axes of underrepresented in STEM status. Our interest here was not solely predictive potential but more so to begin to identify more intersectional benchmarks for assessing and improving diversity in STEM at the UA.

After that preliminary analysis, we chose to focus on odds of STEM graduation. We added STEM entry as an additional predictor variable to our preliminary models. This STEM entry predictor variable allowed us to get a sense of the cascading effects of high-school to college STEM entry pipeline and the continued influence of sex, race, and socioeconomic status. This model was deemed acceptable in terms of performance and from it, we calculated predicted probabilities to give a sense of the intersectional odds of STEM graduation based on a student's composite demographic categorization.

Variable Coding

Independent Variables (Predictors)

Dummy coding was used to dichotomously recode 4 categorical demographic predictor variables: sex, race/ethnicity, first generation status, and Pell eligibility (see Table 2).

Table 2. Independent Variable Coding

Original Variable	Original Values and Counts
Gender	Female (n=23147); Male (n=19288); Unknown (n=8)
Recoded Variable	**Recoded Values**
Female	Female = 1; Not Female =0
Male	Male = 1; Not Male =0

Original Variable	Original Values and Counts*
Race/Ethnicity	American Indian or Alaska Native (n=398); Native Hawaiian or Pacific Islander (n=91); Black or African American (n=1448); Hispanic or Latinx (n=10187); Asian (n=2542); White (n=22704); Nonresident alien (n=2299); Two or more races (n=2164); Unknown (n=610)
Recoded Variable	**Recoded Values**
URM	URM=1; not URM=0
Non-URM	NONURM=1; not NONURM=0

*URM groups are underlined.

Original Variable	Original Values and Counts
First Generation Flag	Yes (n=11232); No (n=19288)
Recoded Variable	**Recoded Values**
First Gen	First generation =1; Not First generation =0
Non- First Gen	Not First generation =1; First generation =0

Original Variable	Original Values
Pell Eligible Flag	Yes (n=12436); No (n=30007)
Recoded Variable	**Recoded Values**
Pell	Pell Eligible =1; Not Pell Eligible =0
Non- Pell	Not Pell Eligible =1; Pell Eligible =0

As shown above, the institutionally available sex variable included three values (male, female, unknown). A dummy coded female variable was used to recode these values into 1 (female) and 0 (not female) and a dummy coded male variable was used inversely recoded these as 1 (male) and 0 (not male).1 Institutionally available IPEDS designated race and ethnicity categories were used to determine URM status. The 9 IPEDS race/ethnicity categories were re-coded with the values: 1 (URM) or 0 (non-URM).2 Here, URM designation includes the following groups: American Indian or Alaska Native; Native Hawaiian or Pacific Islander; Black or African American; and Hispanic or Latinx. It is important to note that in this dataset, the URM group is almost 84% Hispanic or Latinx. Existing institutional data already captures first generation, and Pell eligibility/receipt status dichotomously with "Yes" and "No" flags. These were recoded numerically where Yes=1 and No = 0 and then again in the inverse.

Dependent Variables (Outcomes)

The five types of binary outcomes that were to be modelled were: a) STEM Entry, b) STEM Graduation, c) STEM Entry and STEM Graduation d) STEM Entry and non-STEM Graduation, and d) UA withdrawal (see Table 3).

Table 3. Dependent Variable Coding

Predicted Outcome	Dependent Variable	Values
A. Enter UA as a STEM major	STEM_Entry	1= STEM major at entry; 0=NONSTEM major at entry
B. Graduate UA with a STEM degree (among graduators)	STEM_Alum	1= STEM degree; 0=NONSTEM degree
C. Graduate UA with a STEM degree (among STEM enterers)	STEM_Alum2	1= STEM entry and STEM degree; 0=STEM entry and NONSTEM degree OR withdrawal
D. Graduate UA with a NONSTEM degree (among STEM entry graduators)	NONSTEM_Alum	1= STEM entry and NONSTEM degree; 0= STEM entry and STEM degree
E. Withdraw from UA (among STEM enterers)	UA_Dropout	1= UA Withdrawal; 0= Did not Withdraw (Graduated or in progress at UA)

1 While there are only 8 records of unknown sex, one shortcoming of this method is that these 8 records have been recoded as "Not Female" and are thus included in the Male group for the analysis.

2 This method of classification presents some limitations in general and in the specific case of the University of Arizona. Firstly, the URM group aggregates students who identify as American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Black or African American, or Hispanic or Latinx. However, it should be noted that the great majority of this group (83.9%) identified as Hispanic or Latinx and only 16% identified as Black or Native. Secondly, the non-URM group aggregates a variety of heterogeneous racial and ethnic groups, including white students, nonresident alien students of any ethnicity, Asian students, students who report two or more races, and students who do not report their race or ethnicity. 2207 students reported two or more races and while this group might include, for example, students who are both Black and Native, they are here identified as non-URM because individuals' ethnicities could not be verified beyond being multiracial.

All cohorts (2014-2020) were included for outcome A (STEM entry) since admissions data was available for each cohort. For outcomes B, C, and D related to STEM/NONSTEM graduation, we included cohorts that have experienced a normative cycle of at least 4 years to degree (cohorts 2014-2016). Thus, here “graduation” can be defined as having graduated sometime before the end of year 6. Similarly, for outcome E related to UA attrition, we used only data from cohorts 2014-2019 and excluded cohort 2020 since those students have not yet been tracked beyond year 1. Here, “attrition” can be defined as withdrawing from the university at any point of one’s academic career.

For outcomes related to STEM graduation, only certain sub-groups are included in the sample. Only students who entered in STEM are sampled for the outcome C and D. Whereas, the sample pool for outcome B only includes graduators regardless of their STEM status at entry. Some of the nuances to thinking about STEM based retention can also be seen in the different scenarios modelled between Outcome B and C. Both Outcome B and C refer to the experience of a STEM graduation. The sample for Outcome B was restricted to only those students who graduated and excludes all students who withdrew. The sample for Outcome C includes all students who entered, including those who ended up graduating and those who withdrew from UA.

In addition to UA-wide reporting, each of these outcomes was modelled separately by entry college. We report on the 5 largest STEM degree granting colleges (COS, COE, CALS, COM, SBS) to provide greater insight the status of these groups within colleges. Some colleges, like CALS and SBS offer a variety of NONSTEM majors whereas others COE and COM only offer STEM majors. Where appropriate, statistical analysis at the college and major level is provided.

DESCRIPTIVE ANALYSIS FINDINGS

UA Entry Cohort Demographic Composition

Across all available entry cohorts (2014-2020, n=42443), 40.9% of UA enterers declared a STEM major at entry.

STEM entry rates vary when compared along single axis demographic groups such as sex, URM, first generation status, and Pell eligible status (see Table 4). The most pronounced difference was between male and female students, with only 38% of female students entering as STEM majors compared to 44% of their male counterparts. This is consistent with other research that has shown females are less likely to enter many STEM fields than males, despite entering higher education in greater numbers overall (National Center for Science and Engineering Statistics, 2021). Importantly, URM and first generation students entered as STEM majors at rates (41%) equal to that of non-URM and non-first generation students. Pell eligible students experienced a slightly higher rate of STEM entry (42%) in comparison to non-Pell eligible students (40%). This pattern reflects research findings elsewhere that indicate that URM, first-generation, and lower income students are just as likely to enter STEM as other demographic groups, with disparities emerging later in the academic lifecycle (Lichtenberger et al 2013; Riegle-Crumb et al 2019).

Table 4: Single Axis Demographic Distribution of Students by STEM Entry vs. Non-STEM Entry

Entry Cohorts 2014-2020 (n=42443)	Female	Male	URM	Non-URM	First Gen	Non-First Gen	Pell	Non-Pell
STEM Entry (n=17346)	38.5%	43.8%	41.3%	40.7%	41.1%	40.8%	42.1%	40.4%
Non-STEM Entry (n=25097)	61.5%	56.2%	58.7%	59.3%	58.9%	59.2%	57.9%	59.6%
Total*	23147	19288	12124	30319	11232	31211	12436	30007

*Total count for sex excludes 8 (3 STEM Entry and 5 non-STEM Entry) students categorized as "unknown."

In addition to profiling the distribution of STEM Entry and non-STEM entry majors across the four single axis demographic groups, we chose to further disaggregate females and male rates of entry by their URM, first generation, and Pell eligible statuses. When we look at entry rates intersectionally (i.e., broken down by multiple composite identities), even more variability is apparent. Table 5 documents the proportion of each intersectional demographic group who entered in STEM and non-STEM. The groups with the 3 highest and lowest STEM entry rates are indicated in green and red respectively. The group comprised of non-URM males who were first generation and Pell Eligible saw the highest rate (49%) of STEM Entry majors across the UA, whereas URM females who were first generation but not Pell eligible saw the lowest rate of STEM Entry majors (37%).

Table 5. Intersectional Demographic Distribution of Students by STEM Entry vs. Non-STEM Entry

Entry Cohorts 2014-2020				STEM Entry	Non STEM Entry
Female	URM	First Gen	Pell	38.1%	61.9%
			Non Pell	36.6%	63.4%
		Non First Gen	Pell	41.0%	59.0%
			Non Pell	40.3%	59.7%
	Non URM	First Gen	Pell	41.9%	58.1%
			Non Pell	37.4%	62.6%
		Non First Gen	Pell	39.2%	60.8%
			Non Pell	37.6%	62.4%
Male	URM	First Gen	Pell	44.5%	55.5%
			Non Pell	44.0%	56.0%
		Non First Gen	Pell	45.2%	54.8%
			Non Pell	43.8%	56.2%
	Non URM	First Gen	Pell	48.9%	51.1%
			Non Pell	43.3%	56.7%
		Non First Gen	Pell	45.4%	54.6%
			Non Pell	42.9%	57.1%
Total				**40.9%**	**59.1%**

Across all UA cohorts from 2014-2020, the STEM Entry group (n=17343) was 51% female, 29% URM, 27% first generation, 31% Pell students. In the most recent 2020 entry cohort, the STEM Entry group (n=2517) was 53% female, 29% URM, 24% first generation, 24% Pell students. While URM, first generation and Pell students enter STEM at similar rates (around 40-42%) to their peers from dominant groups, because these students remain underrepresented within the University of Arizona writ large, they account for a smaller portion of all STEM students (see Table 6). In a somewhat different trend, more female students are entering higher education than males. Thus, while a smaller portion of these females enter STEM in comparison to non-STEM, females who do enter in STEM comprise a slight majority of the overall STEM group.

Table 6. Intersectional Demographic Composition of STEM Entry Cohorts

Entry Cohorts 2014-2020		First Gen		Non First Gen		Total
		Non Pell	Pell	Non Pell	Pell	
Female	Non URM	3.6%	3.9%	23.3%	4.8%	35.6%
	URM	1.9%	5.7%	5.3%	2.8%	15.7%
Male	Non URM	3.3%	2.5%	25.5%	4.2%	35.5%
	URM	1.6%	4.0%	5.2%	2.3%	13.1%
Total		10.5%	16.1%	59.3%	14.0%	100.0%

College Level STEM Entry Cohorts Demographic Composition

National-level data indicates that there are significant disparities in participation across STEM fields (NSF 2021). This is reflected at the institutional level when STEM entry rates are broken down by entry college and then further by major.

As shown below in Table 7, almost 94% (n=16283) of all UA STEM enterers enrolled in one of the following five colleges: Colleges of Science (COS), Engineering (COE), Medicine (COM), and Agriculture and Life Sciences (CALS), and Social and Behavioral Science (SBS). The Colleges of Engineering and Medicine only offer STEM majors, while the College of Science and Agriculture and Life Sciences and the College of Science, College of Social and Behavioral Sciences offer a number of Non-STEM majors. The College of Science is by far the largest STEM Entry college, housing 44.5% of all new STEM students between 2014-2020.

Table 7. Distribution of UA STEM Entry Cohorts Across 5 Most Popular Entry Colleges, 2014-2020

Rank	Entry College	STEM Entry Count	% of overall UA STEM Entry
1	College of Science	7722	44.5%
2	College of Engineering	3848	22.2%
3	College of Medicine	3231	18.6%
4	College of Agriculture and Life Sciences	1151	6.6%
5	College of Social & Behavioral Science	331	1.9%

Female, URM, first-generation, and Pell eligible students are represented at varying rates across the 5 colleges (see Table 8). For example, 73% of CALS STEM enters were female, while females comprised only 30% of COE STEM enters. The highest representation of URM (36%), first generation (33%), and Pell students (37%) was seen in COM whereas COE saw the lowest representation of URM (23%), first generation (20%), and Pell students (23%) at entry.

Table 8. Single Axis Demographic College Distribution of STEM Entry Cohorts (2014-2020)

Entry College	Female	Male	URM	Non URM	First Gen	Non First Gen	Non Pell	Pell	Total Count
College of Agriculture and Life Sciences	73.2%	26.8%	28.2%	71.8%	30.1%	69.9%	33.6%	66.4%	1151
College of Engineering	29.5%	70.5%	23.1%	76.9%	19.5%	80.5%	23.1%	76.9%	3848
College of Medicine	67.9%	32.1%	35.8%	64.2%	32.8%	67.2%	36.7%	63.3%	3231
College of Science	50.2%	49.8%	28.8%	71.2%	27.2%	72.8%	30.3%	69.7%	7720
College of Social & Behavioral Science	67.1%	32.9%	29.9%	70.1%	25.4%	74.6%	31.1%	68.9%	331
Total Count	**8266**	**8015**	**4697**	**11584**	**4336**	**11945**	**4907**	**11374**	**16281**

Major Level STEM Entry Cohort Demographic Composition

Disaggregating the college level STEM entry by the primary major declared at the time of entry yielded insight into the most popular majors overall and more specifically, among underrepresented STEM entry students. Table 9 reports the proportion of underrepresented students within each STEM entry major that had at least 25 student enterers.

As a trend, CALS saw some of the highest rates of female, URM, first generation, and Pell students as a portion of their overall STEM entry group, whereas COE serves by far the fewest in many cases. Veterinary Science and pre-Physiology are the two entry majors with the highest representation of underrepresented students, well above the cohort average in all categories.

Some fields like Nutritional Sciences, Animal Sciences and Psychological Science are comprised of a great majority of female students, all over 80%. However, in computing-based fields, like Electrical and Computer Engineering and Computer Science, the opposite is true, less than 20% of those STEM entry declarers were female.

At the high end, URM accounted for 47% of Pre-Nutritional Science majors, followed by Sustainable Plant Systems (40%). Interestingly, Pre-Computer Science (BA track) enrolled the third highest proportion of URM students (39%). Yet, the following entry majors, Geosciences (10%), Chemical Engineering (13%), Ecology and Evolutionary Biology (17%) saw the lowest rates of URM representation among enterers.

As to be expected some of the trends for first generation students map similarly with respect to Pell eligibility/recipient status. All housed in CALS, Veterinary Science (46%), Sustainable Plant Systems (48%), Microbiology (39%) saw the three highest rates of representation for Pell students, followed by Pre-Physiology in COM (39%), and Environmental Studies in SBS (38%). On the low side, Geosciences (8%), Chemical Engineering (8%), and Aerospace Engineering (12%) saw very low rates of representation for Pell students.

Table 9. Proportion of Historically Underrepresented STEM Enterers by College and Major, 2014-2020					
College	**% Female**	**% URM**	**% First Gen**	**% Pell**	**Total Count**
College of Agriculture and Life Sciences	73.4%	28.1%	29.8%	33.5%	**1097**
Nutritional Sciences	81.1%	28.6%	26.0%	32.8%	381
Environmental Science	63.6%	25.3%	24.7%	25.8%	198
Microbiology	58.5%	28.1%	34.5%	39.2%	171
Animal Sciences	83.0%	28.4%	33.3%	35.5%	141
Natural Resources	71.3%	20.2%	30.9%	28.7%	94
Veterinary Science	89.1%	30.9%	41.8%	45.5%	55
Pre-Nutritional Sciences	81.3%	46.9%	34.4%	31.3%	32
Sustainable Plant Systems	44.0%	40.0%	40.0%	48.0%	25
College of Engineering	29.3%	23.4%	19.7%	23.2%	**3765**
No Major Selected Engineering	28.3%	23.5%	20.3%	23.8%	3394
Biomedical Engineering	65.9%	24.8%	14.7%	18.6%	129
Electrical & Computer Engineer	11.5%	17.9%	10.3%	16.7%	78
Chemical Engineering	36.5%	12.7%	15.9%	7.9%	63
Aerospace Engineering	26.3%	26.3%	10.5%	12.3%	57
Mechanical Engineering	27.3%	31.8%	20.5%	36.4%	44
College of Medicine	67.9%	35.8%	32.8%	36.7%	**3230**
Pre-Physiology	67.8%	37.3%	34.9%	39.1%	2478
Physiology & Medical Sciences	68.5%	30.7%	25.8%	29.0%	752
College of Science	50.2%	28.9%	27.3%	30.4%	**7671**
Biology	68.5%	33.6%	29.1%	32.8%	1637
Biochemistry	58.9%	31.3%	31.7%	36.1%	876
Pre-Computer Science	13.4%	28.2%	24.4%	30.0%	812
Pre-Neurosci & Cognitive Sci	73.8%	33.0%	26.2%	31.5%	787
Pre-Computer Science, BS	18.6%	24.3%	29.9%	29.6%	676
Molecular & Cellular Biology	68.5%	28.6%	25.2%	31.5%	409
Chemistry	49.1%	29.0%	30.3%	34.4%	389
Physics	23.5%	23.2%	21.6%	26.1%	375
Pre-Psychological Science	78.4%	33.3%	32.8%	34.7%	357
Astronomy	43.6%	25.7%	24.0%	23.1%	342
Mathematics	39.9%	22.2%	26.3%	26.6%	338
Geosciences	30.2%	9.5%	12.4%	7.9%	242
Pre-Computer Science, BA	17.8%	39.3%	31.8%	33.6%	107
Ecology & Evolutionary Biology	64.5%	16.8%	16.8%	22.4%	107
Psychology	75.6%	35.9%	32.1%	29.5%	78
No Major Selected Science	40.6%	15.6%	42.2%	23.4%	64
Statistics and Data Science	28.6%	24.5%	10.2%	18.4%	49
Bioinformatics	46.2%	26.9%	19.2%	30.8%	26
College of Social & Behav Science	60.8%	28.1%	24.8%	28.1%	**153**
Environmental Studies	69.6%	25.0%	23.2%	37.5%	56
Information Science & eSociety	78.2%	30.9%	27.3%	25.5%	55
Information Science & Tech	26.2%	28.6%	23.8%	19.0%	42
UA Overall	51.3%	28.8%	26.6%	30.5%	17343

* only entry majors with atleast 25 student records are included.

Major Level STEM Graduation Cohort Demographic Composition

Disaggregating the college level representation by the primary major degree yielded insight into the most popular degree fields among underrepresented STEM entry students who graduated. Table 10 reports the proportion of underrepresented students in each degree field that had at least 25 alumni.

Expectedly similar to patterns observed at STEM entry, CALS saw some of the highest rates of female, URM, first generation, and Pell students as a portion of their overall graduates, whereas COE served by far the fewest in many cases and COS saw high variability in representation by degree field. With respect to specific degree fields, Animal Sciences, Environmental Studies, and Ecology and Evolutionary Biology saw the highest representation of underrepresented students.

Some fields like Natural Resources (81%), Animal Sciences (89%) and Communication (94%) are comprised of a great majority of female students. However, in some engineering and computing-based fields, like Aerospace Engineering (12%), Computer Science (14%), Mechanical Engineering (15%), and Physics (16%) the opposite was true.

URM students were most well-represented in Ecology and Evolutionary Biology degrees (33%), followed closely by Animal Sciences (32%), Biology (31%), and Information Science and Arts (31%). However, URM students were quite under-represented among Physics (6%) and Geosciences (11%) graduators.

First generation students comprised 39% of all graduators in Animal Sciences, 35% of all graduators in Environmental Studies and 32% of all graduators in Natural Resources. On the low end, first generation students accounted for only 9% of Engineering Management, 10% of Geosciences, 12% of Biosystems Engineering, and 13% of Mathematics, Astronomy, and Physics degrees.

Pell students were very well-represented in the field of Environmental Studies and Animal Sciences, where they accounted for 55% and 48% of the degrees respectively. However, Pell students accounted for less than 15% of degrees granted in Physics (6%), Geosciences (9%), and Aerospace Engineering (14%).

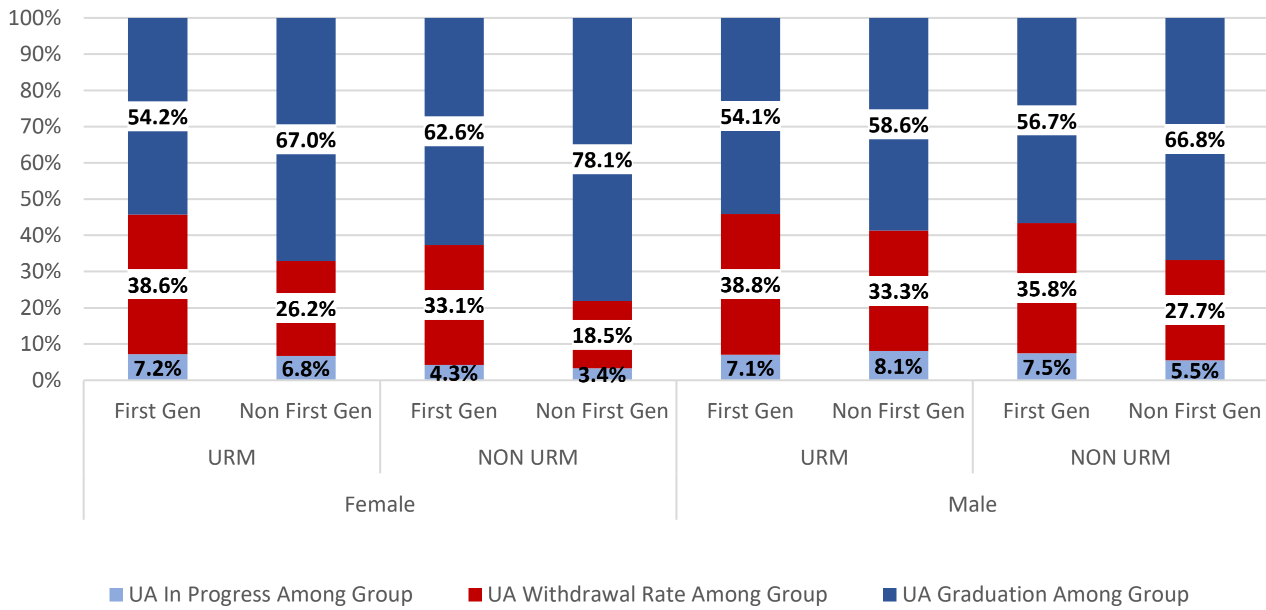
Table 10. Proportion of Historically Underrepresented STEM Graduators by College and Major, 2014-2016					
	% Female	% URM	% First Gen	% Pell	Total Count
College of Agric and Life Sci	**76%**	**26%**	**24%**	**33%**	**529**
Nutritional Sciences	79%	27%	25%	35%	262
Microbiology	69%	21%	16%	31%	77
Natural Resources	81%	20%	32%	31%	59
Environmental Science	58%	26%	19%	25%	53
Animal Sciences	89%	32%	39%	48%	44
Biosystems Engineering	76%	26%	12%	26%	34
College of Engineering	**26%**	**22%**	**19%**	**24%**	**953**
Mechanical Engineering	15%	27%	23%	26%	213
Electrical & Computer Engineer	19%	21%	23%	26%	208
Chemical Engineering	38%	19%	15%	17%	143
Biomedical Engineering	51%	19%	16%	24%	116
Aerospace Engineering	12%	28%	16%	14%	69
Systems Engineering	29%	15%	14%	18%	65
Industrial Engineering	25%	17%	17%	23%	53
Civil Engineering	25%	27%	25%	41%	51
Engineering Management	37%	17%	9%	31%	35
College of Medicine - Tucson	**65%**	**28%**	**22%**	**32%**	**594**
Physiology	65%	28%	22%	32%	594
College of Science	**46%**	**21%**	**21%**	**26%**	**1472**
Computer Science	14%	17%	17%	25%	300
Neuroscience & Cognitive Sci	72%	27%	24%	30%	227
Molecular & Cellular Biology	61%	20%	30%	33%	183
Biology	63%	31%	21%	28%	160
Biochemistry	50%	27%	30%	32%	151
Mathematics	40%	13%	13%	22%	133
Geosciences	24%	11%	10%	9%	91
Chemistry	29%	17%	17%	25%	65
Psychological Science	66%	29%	25%	31%	59
Ecology & Evolutionary Biology	73%	33%	30%	28%	40
Astronomy	41%	16%	13%	16%	32
Physics	16%	6%	13%	6%	31
College of Social & Behav Sci	**49%**	**23%**	**23%**	**28%**	**309**
Information Science & Tech	19%	22%	20%	23%	107
Information Science & eSociety	71%	21%	25%	27%	103
Information Science & Arts	22%	31%	22%	25%	36
Communication	94%	16%	16%	19%	32
Environmental Studies	68%	29%	35%	55%	31
Grand Total	**1866**	**899**	**823**	**1067**	**3857**
* only degree majors with atleast 25 student records are included.					

UA-Wide STEM Entry Cohort UA Graduation and UA Attrition Rates

Figure 1 below documents the progress of STEM entry students from the 2014-2016 cohorts. Here, we focus on general UA graduation and UA attrition rates of STEM entry students. Following this, Figure 2 explores the STEM and non-STEM graduation rates for those STEM entry students who graduated. For ease of reporting, the category of Pell/non-Pell has been excluded from this portion of the analysis.

As evidenced here, among STEM enterers non-first-generation, non-URM, females experience the highest rates of UA graduation (78%) among all groups whereas URM, first-generation males and females experience almost the lowest (54%). Among STEM enterers, withdrawal rates were highest for first generation URM females (39%) and first generation URM males (39%). Withdrawal rates were lowest (19%) for non-first generation, non-URM females, almost 8% lower than the next lowest group (non-first generation, URM males, 28%). Similar trends are apparent with respect to the students who were still enrolled and working toward their degree. First-generation and URM groups see higher in progress rates than their peers, suggesting longer time to degree for these groups.

Figure 1. UA Graduation and Attrition Rates of STEM Enterers by Demographic Groups: Entry Cohorts 2014-2016, All Colleges

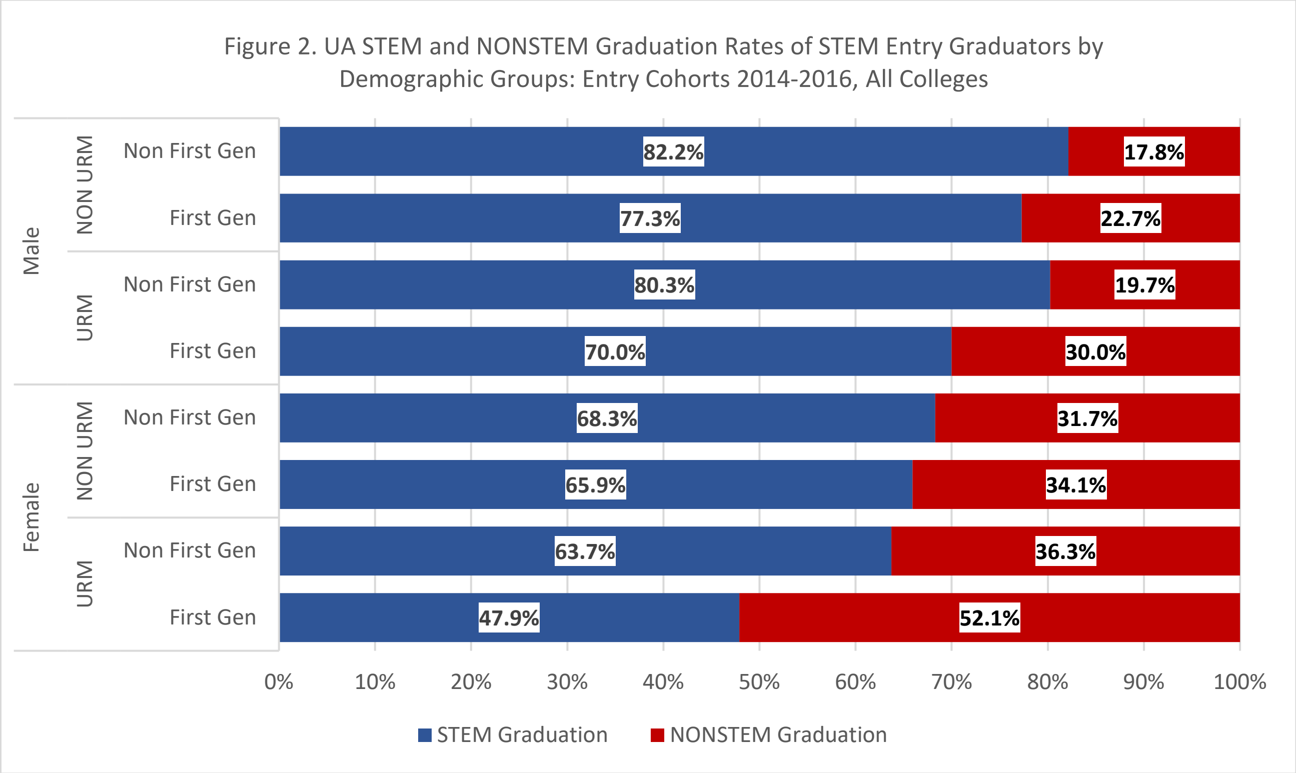


UA -Wide STEM Entry Cohort STEM and Non-STEM Graduation Rates

While examining University graduation and attrition provides insight on the general outcomes of students who enter the university as STEM majors, examining the rate at which students who graduate complete STEM versus non-STEM degrees provides insight into persistence and attrition in Stem in particular. Figure 2 below documents the STEM and non-STEM graduation rates of STEM entry students who graduated from the 2014-2016 cohort; this does not include students who were still enrolled or who withdrew from the university.

While the UA graduation rate for these STEM entry students is quite high relative to overall UA rates, some of these students leave STEM to graduate in a non-STEM field, and rates of STEM persistence and attrition vary across the demographic groups under study. Among students who entered in STEM and graduated from the UA, the highest STEM graduation rate was experienced by non-first-generation non-URM males (82%) followed by non-first generation URM males (80%). First generation URM females experienced the lowest STEM graduation rate (48%). More than half of this group left STEM to graduate in a non-STEM field.

Across the board, non-first generation, non-URM, and male students had higher STEM graduation rates than their peers. Further, male students had higher UA STEM graduation rates than females in their same URM and first-generation status groups. This is even more pronounced for URM females. Within the group of first-generation females, 48% of URM females graduated in STEM whereas 66% of non-URM females graduated in STEM. The significantly lower rates of STEM graduation among female students in general and URM females specifically is particularly noteworthy in light of the fact that females have higher UA graduation rates overall (see previous section and associated table). ***This finding suggests that female students overall face disproportionate challenges persisting in STEM at the University of Arizona and that when female-ness is compounded by URM or first-generation status the challenges compound.***



College Level STEM Entry Cohort Graduation and Attrition Rates

Analysis of UA and STEM graduation for STEM enterers at the college-level provides a finer grained account of the rates at which students persist and graduate overall and in STEM in particular and how these rates vary across the demographic groups under study. This section provides data for the 5 primary STEM colleges.

College of Agriculture and Life Sciences

Figure 3 documents UA graduation and attrition rates in the College of Agriculture and Life Sciences by demographic group. Among students who entered in STEM in the College of Agriculture and Life Science, non-first generation non-URM females experienced the highest graduation rate (78%) whereas first generation URM females experienced the lowest graduation rate (54%). First generation non-URM males experienced the highest attrition rate (42%) followed closely by non-first generation URM males (40%). Non-first generation URM females and first generation non-URM females experienced the lowest attrition rates (21%) followed by first generation non-URM females (24%).

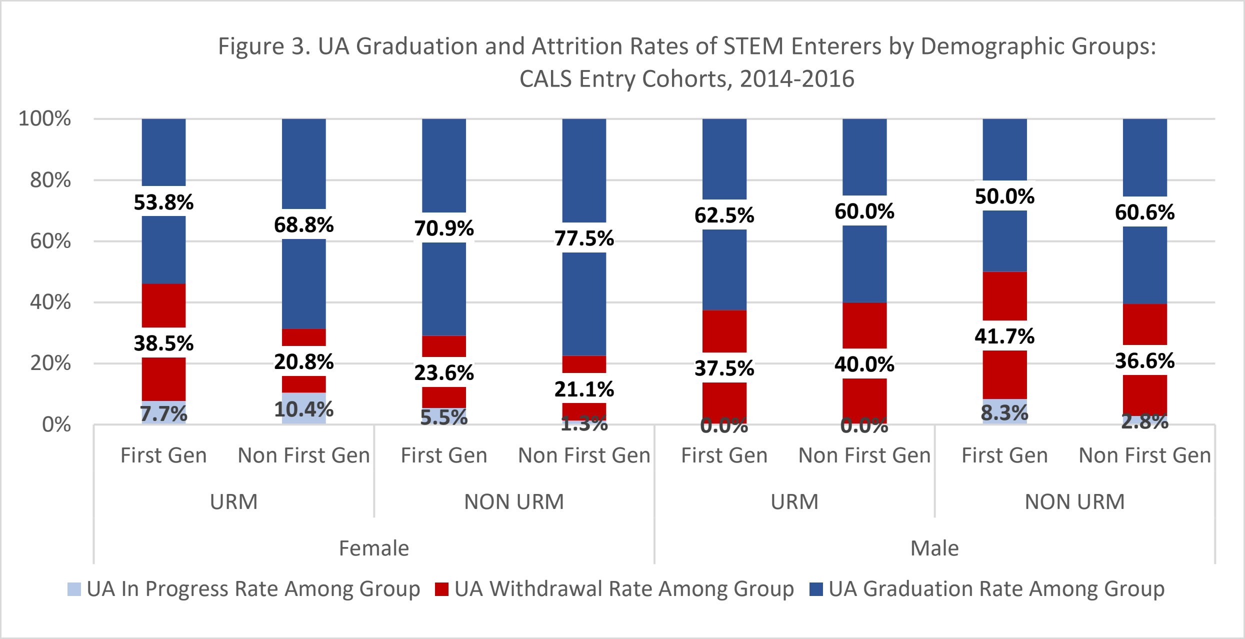
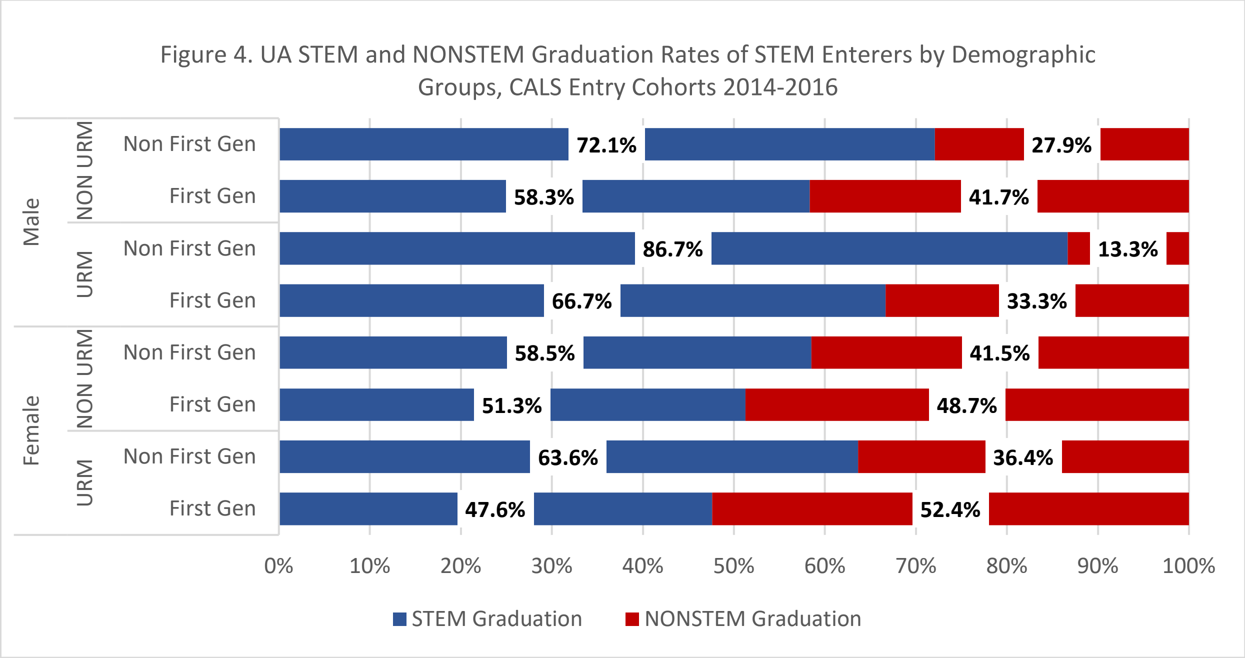


Figure 4 below documents STEM and non-STEM graduation rates of students who entered in STEM in CALS and graduated. Non-first generation URM males who entered in STEM in CALS only experienced a 60% UA graduation rate. However, among those non-first generation URM male students who did graduate, the overwhelming majority (87%) remained in STEM and graduated with a STEM degree. In contrast, non-first generation non-URM females who entered in STEM in CALS experienced a 78% UA graduation rate but among those non-first generation non-URM females who did graduate, only about 6 in 10 graduated with a STEM degree. Among those students who entered in STEM in CALS, non-first generation URM females saw the highest STEM graduation rates among all females but first generation URM students saw the lowest STEM graduation rate (48%) among females.



College of Science

Figure 5 below documents UA graduation and attrition rates in the College of Science. Among students who declared STEM majors in the College of Science upon entry, non-first generation, non-URM females saw the highest graduation rate (76%) Among all females first generation URM females saw the lowest graduation rate (52%), almost 25% less than their non-first generation non-URM peers. Non-first generation, non-URM males saw the highest graduation rate (63%). However, first generation males (both URM and non-URM) saw the lowest (49%). Expectedly, a similar but inverse pattern exists with respect to attrition rates.

Figure 5. UA Graduation and Attrition Rates of STEM Enterers by Demographic Groups: COS Entry Cohorts 2014-2016

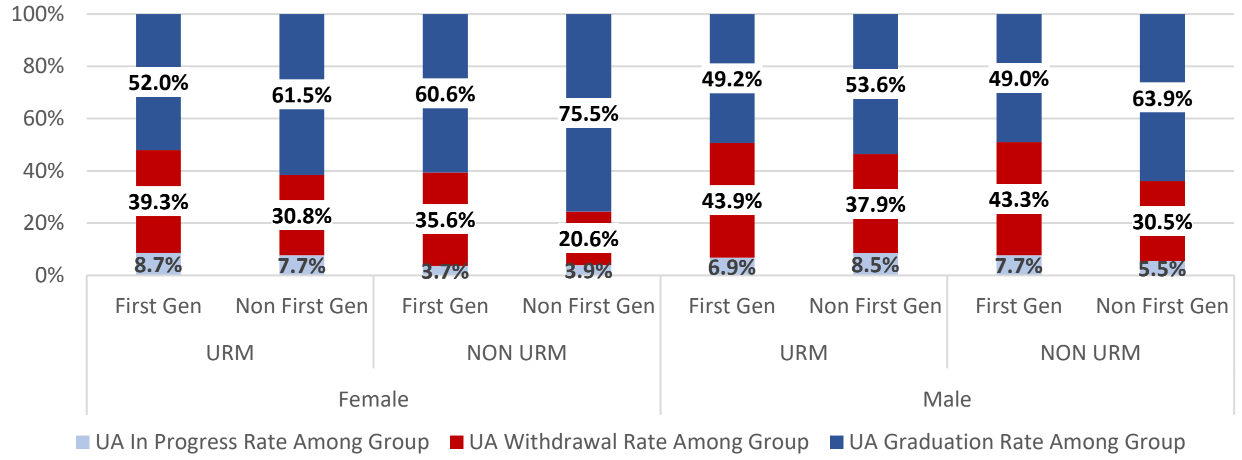
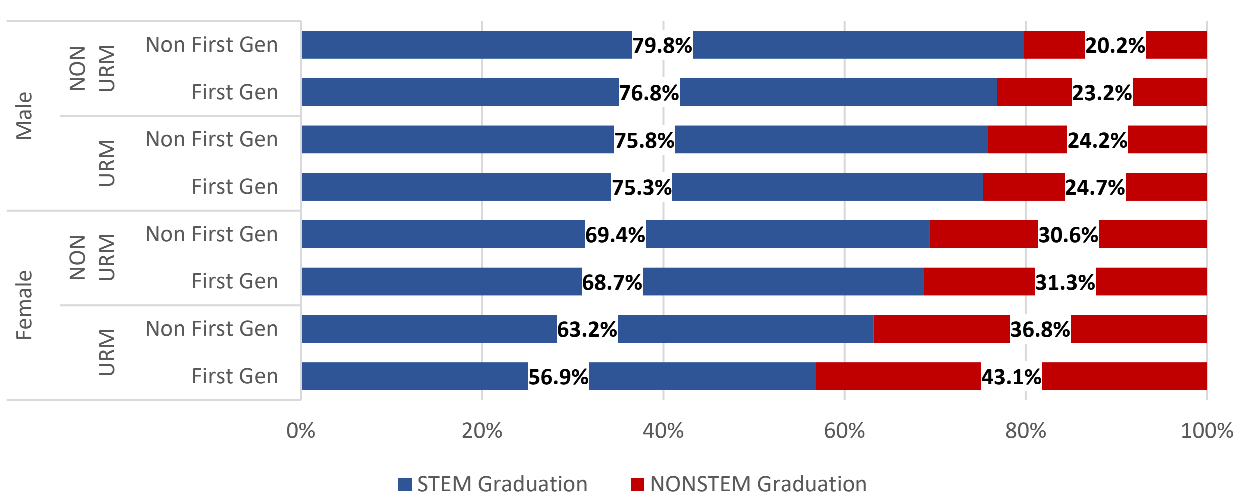


Figure 6 documents the STEM and non-STEM graduation rates of students who entered in STEM in the College of Science and graduated. In the College of Science, across all demographic categories, STEM entry students tend to persist and graduate in STEM at high rates. However, female students graduate in non-STEM at higher rates than their male peers. Non-first generation non-URM males experienced the highest STEM graduation rate across all groups (80%), whereas first generation URM female students saw the lowest STEM graduation rate (57%).

Figure 6. UA STEM and NONSTEM Graduation Rates of STEM Enterers by Demographic Groups, COS Entry Cohorts 2014-2016



College of Engineering

Figure 7 below documents UA graduation and attrition rates among students who entered in STEM in the College of Engineering. Non-first generation URM females saw the highest graduation rate (84%) across all groups followed by non-first generation non-URM females (83%). In general, females experienced graduation rates almost 10% higher than males from their same demographic groups. However, one exception to this pattern is seen in the first-generation URM group, where males (65%) and females (64%) experience very similar graduation rates. With respect to UA attrition, first generation non-URM males experienced the highest withdrawal rate (29%) followed closely by non-first generation URM males (28%). First generation URM males (12%) and females (11%) saw the highest in-progress rates, signaling that on average these students may take longer to graduate.

Figure 7. UA Graduation and Attrition Rates of STEM Entry Majors by Demographic Groups, COE Entry Cohorts 2014-2016

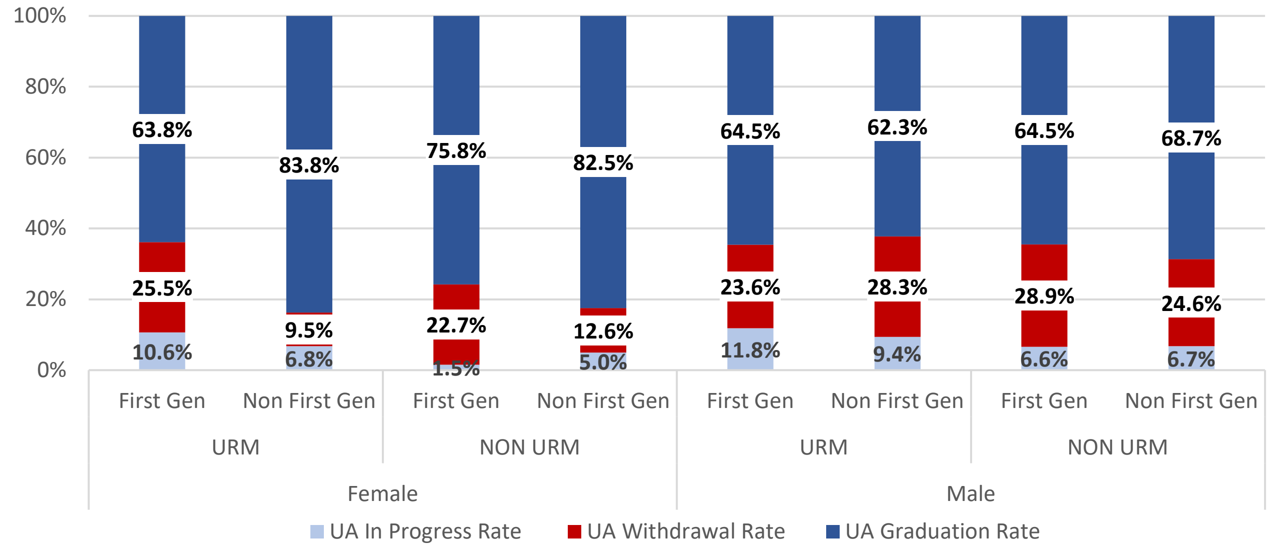
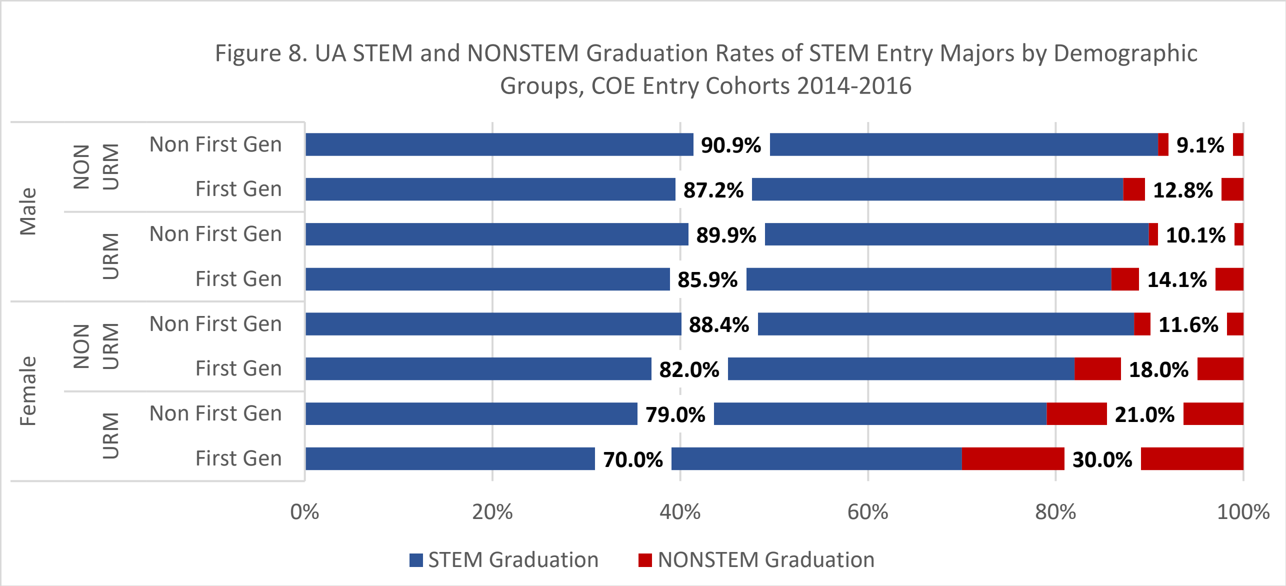


Figure 8 documents the STEM and non-STEM graduation rates of students who entered in STEM in the College of Engineering and graduated. Expectedly, these students saw high rates of STEM graduation in part due to the fact that all engineering disciplines are considered STEM fields. However, a portion of these STEM enterers who graduated did leave STEM to graduate in a non-STEM field. All female groups experienced lower rates than their corollary male groups. Non-first generation non-URM females experienced 88% STEM graduation rate while their male peers saw 91% STEM graduation rate. URM and first generation females experienced further disparity in comparison to their peers. For example, 86% of first generation URM males graduated in STEM but only 70% of first generation URM females graduated in STEM.



College of Medicine

Figure 9 below documents UA graduation and attrition rates among students who entered in STEM in the College of Medicine. Non-first generation non-URM females saw the highest graduation rate (79%) across all groups, while first generation URM males saw the lowest graduation rate (52%). In general, females experienced higher graduation rates than males from their same groups, with the exception that first generation non-URM males (62%) saw a slightly higher graduation rate than first generation non-URM females (58%). With respect to attrition, first generation URM males and females experienced the highest withdrawal rates (44% for males, 41% for females).

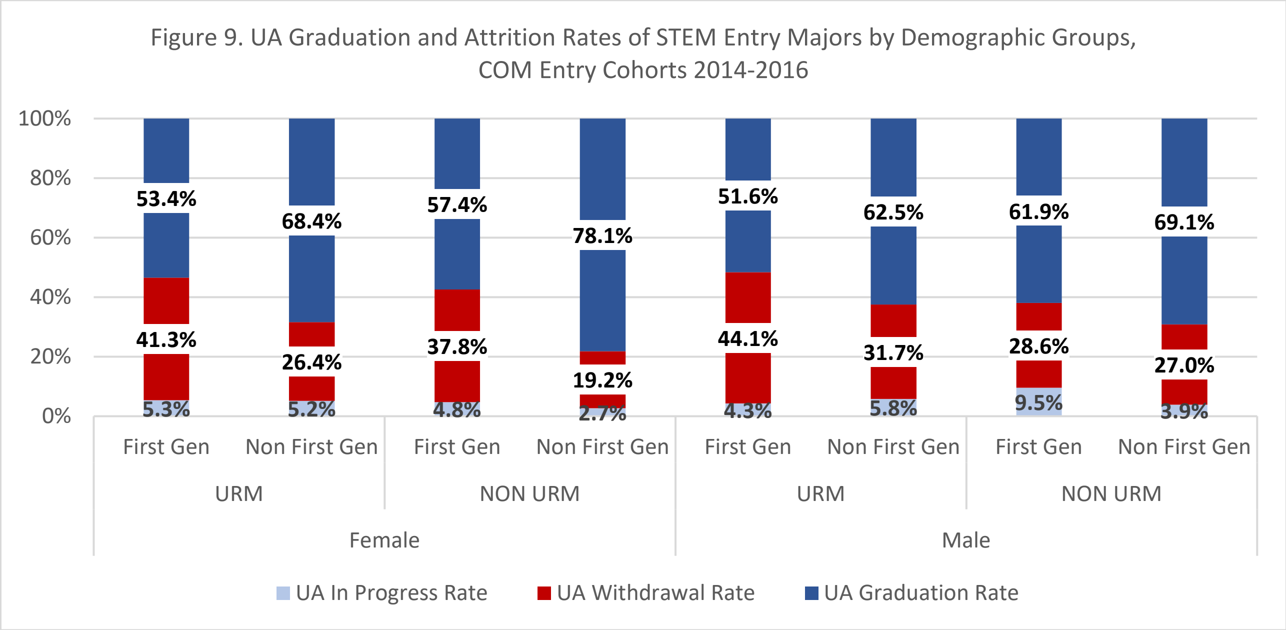
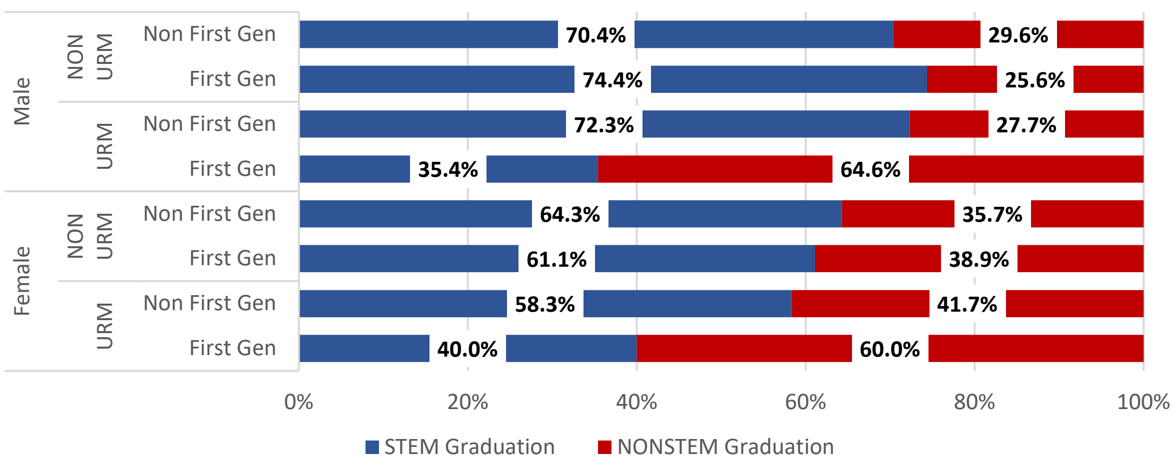


Figure 10 below documents STEM and non-STEM graduation rates of students who entered in STEM in College of Medicine and graduated. 74% of first generation non-URM males graduated in STEM and this was the highest rate across all groups. However, only 35% of first generation URM males graduated in STEM. A similar disparity in STEM graduation rate is evident among first generation non-URM females (61%) in comparison to first generation URM females (40%). This indicates a significant disparity along race/ethnicity status among first generation students in the college. With the exception of the first generation URM group, females saw lower STEM graduation rates than their male peers in each group, reiterating the general pattern of higher STEM attrition rates for females across colleges.

Figure 10. UA STEM and NONSTEM Graduation Rates of STEM Entry Majors by Demographic Groups, COM Entry Cohorts 2014-2016



College of Social and Behavioral Science

Figure 11 below documents UA graduation and attrition rates among students who entered in STEM in the College of Social and Behavioral Science. Because SBS offers only a few STEM majors, the sample size of this group (particularly male students) are much smaller than the other colleges. For example, only 2 first generation URM males entered in STEM in SBS between 2014 and 2016 and both of them withdrew, leading to a 100% UA withdrawal rate. Females saw much lower rates of withdrawal than males from their same groups except among non-first generation URM students. Female URM students saw the highest in-progress rates, and within this larger group 10% of first generation URM females who entered in STEM in SBS were still in progress after year 6. This perhaps indicates that while first generation URM females continued to persist, they may take longer to graduate than some of their peers.

Figure 11. UA Graduation and Attrition Rates of STEM Entry Majors by Demographic Groups, SBS Entry Cohorts 2014-2016

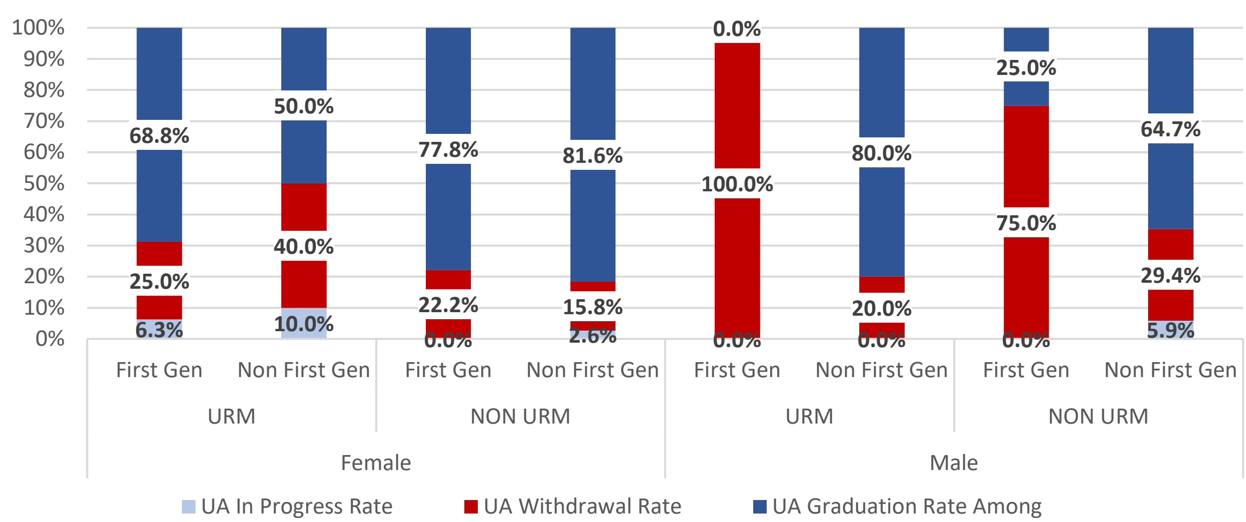
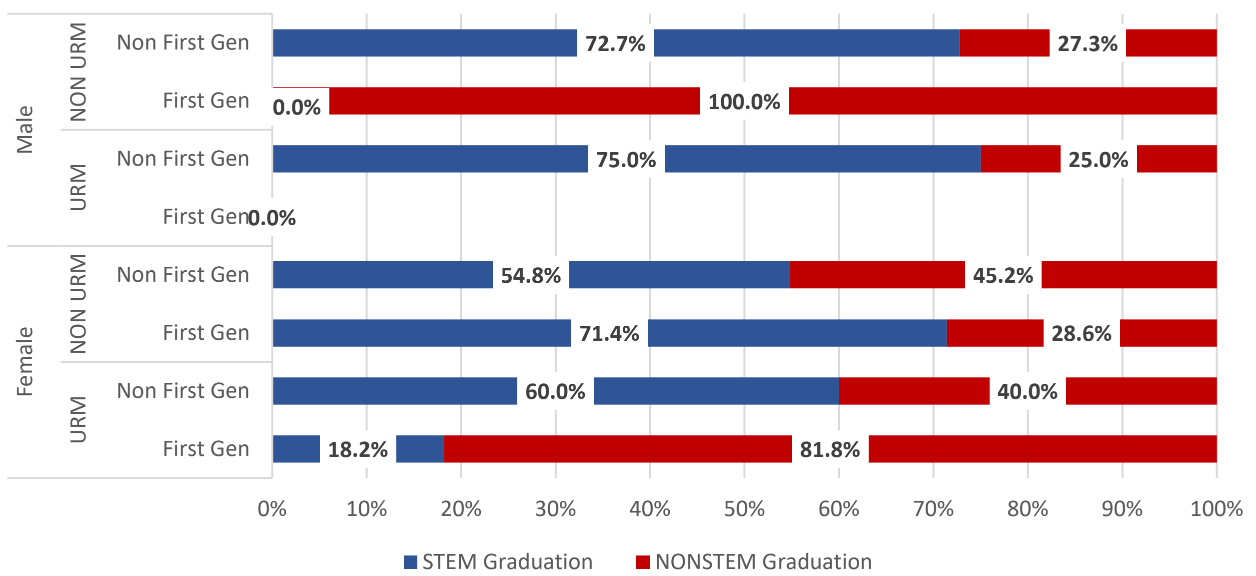


Figure 12 below documents STEM and non-STEM graduation rates of students who entered in STEM in the College of Social and Behavioral Science and graduated. Non-first generation URM (75%) and non-URM (73%) males saw the highest STEM graduation rates while first generation URM females experienced the lowest by far. While 69% of first generation URM females who entered in STEM in SBS graduated from the UA, only 18% of that group graduated with a STEM degree. The great majority left STEM to graduate in a non-STEM field.

Figure 12. UA STEM and NONSTEM Graduation Rates of STEM Entry Majors by Demographic Groups, SBS Entry Cohorts 2014-2016



INFERENTIAL ANALYSIS FINDINGS

For each model we tested, we report which, if any, variables were found to be statistically significant and their odds ratios. We evaluate each model's performance in terms of its explanatory power (using Nagelkerke's R^2). For the final model, predicted probabilities for each demographic sub-group are reported.

Baseline Model Findings: UA Wide Cohorts

First, we ran these models for the UA-wide STEM outcomes. Table 10 details each model's performance and conditional predictions of likelihood. Under each outcome scenario, only the variables that were found to be statistically significant predictors are reported here with odds ratios framed as statements of likelihood. Because odds ratios under 2.0 are unintuitive, here these findings are mostly reported as "group A % more or less likelihood compared to Group B" not as "group A times more or less likely than group B."

Across all UA-wide outcomes including STEM Entry (Outcome A), STEM graduation (Outcome B and C), non-STEM graduation (Outcome D), and UA withdrawal (Outcome E), sex was found to be a statistically significant variable. Among the four types of underrepresented status, sex consistently saw the highest odds ratios. In Outcomes C, D, and E, all four demographic variables were found to be statistically significant predictors of the outcome.

Table 10. Significant Results of Logistical Regression Model Tests for UA-Wide Outcomes

Included Cohorts	Sample Size	Outcomes	r^2
2014-2020	42443	Outcome A: Enter UA as a STEM Major	0.004
Among all students:		Females 20% less likely compared to Males** Pell 9% more likely compared to non-Pell**	
2014-2016	12501	Outcome B: Graduate UA with a STEM Degree	0.031
Among all graduators:		Females 45% less likely compared to Males** URM 15% less likely compared to non-URM** First generation 10% less likely compared to non-First generation*	
2014-2016	7241	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.039
Among STEM entry students:		Females 12% less likely compared to Males* URM 30% less likely compared to non-URM** First generation 34% less likely compared to non-First generation** Pell 21% less likely compared to non-Pell**	
2014-2016	4822	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.058
Among STEM entry students who graduated:		Females 2x more likely compared to Males** URM 34% more likely compared to NONURM** First generation 32% more likely compared to non-First generation** Pell 20% more likely compared to non-Pell*	
2014-2019	14829	Outcome E: Withdraw from UA after entering as a STEM major	0.027
Among STEM entry students:		Females 25% less likely compared to Males** URM 23% more likely compared to non-URM** First generation 63% more likely compared to non-First generation** Pell 13% more likely compared to non-Pell*	

* indicates p value < .05

** indicates p value < .001

The problem of STEM attrition, or a student's transition from a STEM field to a non-NONSTEM degree, was modelled in Outcome D. Here, it is important to note that females were found to be twice as likely as men to graduate with a non-STEM degree after entering in a STEM major. The problem of UA attrition by STEM students, or a student's transition from a STEM field to UA withdrawal, was modelled in Outcome E. Here, it is important to note that first generation students were found to be 63% more likely to graduate with a non-STEM degree after entering in a STEM major. compared to students who were not first-generation students. Interestingly, among STEM entry students, being female was associated with lower odds of STEM graduation, but also lower odds of UA withdrawal as compared to males.

Baseline Model Findings: College Entry Cohorts

After establishing some UA-wide trends, we tested the model separately by college. In many instances sex remains uniformly statistically significant throughout. The model's performance varied in different contexts.

College of Agriculture and Life Sciences

Among those students who entered in CALS, being female was associated with 42% less chance of entering as a STEM major and 47% less chance of STEM graduation as compared to males. Among only those CALS students who entered in STEM, being female was associated with being almost twice as likely (1.8x or 88%) to graduate in a non-STEM field as compared to males, but also associated with 27% less chance of withdrawal. URM students experienced 25% less chance of STEM entry as compared to their non-URM peers while first generation students were 40% less likely to graduate with a STEM degree.

Table 11. Significant Results of Logistical Regression Model Tests for CALS Entry Outcomes

Included Cohorts	Sample Size	College of Agriculture and Life Sciences Entry Outcomes	r^2
2014-2020	2300	Outcome A: Enter UA as a STEM Major	0.025
Among those who entered in CALS:		Females 42 % less likely compared to Males** URM 25% less likely compared to non-URM*	
2014-2016	1053	Outcome B: Graduate UA with a STEM Degree	0.02
Among those who entered in CALS and graduated:		First generation 39% less likely compared to non-First generation*	
2014-2016	354	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.042
Among those who entered in CALS in STEM:		Females 47% less likely compared to Males*	
2014-2016	354	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.042
Among those who entered CALS in STEM and graduated:		Females 1.8x (88%) more likely compared to Males*	
2014-2019	1008	Outcome E: Withdraw from UA after entering as a STEM major	0.013
Among those who entered in CALS in STEM:		Females 27% less likely compared to Males**	

* indicates p value < .05
** indicates p value < .001

College of Engineering

Among students who entered in COE (all of whom were STEM entry), female membership was also found to be statistically significant across outcomes. Again, females were 41% less likely to graduate in STEM in general when compared to males. Among graduating students who entered COE, females were more than 1.5 times (59%) more likely to graduate with a non-STEM degree relative to males. However, female membership did appear to be protective of UA withdrawal (41% less likely when compared to males). However, first generation students who entered in COE seemed to be at particular risk for withdrawal, 63% more likely to drop out than non-first generation students who entered in COE.

Table 12. Significant Results of Logistical Regression Model Tests for COE Entry Outcomes

Included Cohorts	Sample Size	College of Engineering Entry Outcomes	r^2
2014-2016	1696	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.02
Among those who entered in COE:		Females 37% less likely compared to Males*	
2014-2016	1200	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.027
Among those who entered in COE and graduated:		Females 59% more likely compared to Males*	
2014-2019	3312	Outcome E: Withdraw from UA after entering as a STEM major	0.02
Among those who entered in COE:		Females 41% less likely compared to Males** First generation 46% more likely compared to non-First generation**	

* indicates p value < .05
** indicates p value < .001

College of Science

The model performed the best in scenarios modeled for COS enterers. In COS, underrepresented status was found to be significant across a majority of the outcomes. Most notably, females who entered COS were 70% less likely to enter in STEM and 35% less likely to graduate with a STEM degree as compared to their male peers. Among students who entered COS in STEM, females were 43% less likely to graduate in STEM but 34% less likely than males to withdraw from the UA. Among those students who entered COS in STEM and graduated, females were 1.7 times more likely to graduate with a non-STEM degree as compared to their male peers.

URM students who entered COS were found to be 27% less likely to graduate with a STEM degree than non-URM students who entered COS. Among students who entered COS as STEM majors, they were 23% more likely to withdraw from the UA when compared to non-URM COS STEM majors.

First generation students were similarly less likely to graduate with a STEM degree and 48% more likely to withdraw than their non-first generation peers. Pell status was determined to be a significant predictor variable in modelled outcomes in COS, which is an important difference from other college contexts.

Table 13. Significant Results of Logistical Regression Model Tests for COS Entry Outcomes

Included Cohorts	Sample Size	College of Science Outcomes	r^2
2014-2020	9496	Outcome A: Enter UA as a STEM Major	0.076
Among those who entered in COS:		Females 70% less likely compared to Males**	
2014-2016	3911	Outcome B: Graduate UA with a STEM Degree	0.04
Among those who entered in COS:		Females 35% less likely compared to Males** URM 27% less likely compared to non-URM** First generation 20% less likely compared to non First generation* Pell 26% less likely compared to non-Pell**	
2014-2016	1904	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.033
Among those who entered in COS in STEM and graduated:		Females 43% less likely compared to Males** Pell 23% less likely compared to non-Pell*	
2014-2016	1904	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.033
Among those who entered COS in STEM and graduated:		Females 1.7x (75%) more likely compared to Males** Pell 30% more likely compared to non-Pell*	
2014-2019	6613	Outcome E: Withdraw from UA after entering as a STEM major	0.033
Among those who entered in COS in STEM:		Females 34% less likely compared to Males** URM 23% more likely compared to non-URM** First generation 48% more likely compared to non First generation** Pell 26% more likely compared to non-Pell*	

* indicates p value < .05
** indicates p value < .001

College of Medicine

Among students who entered in COM (all of whom were STEM entry), URM and first generation membership was also found to be statistically significant across all tested outcomes(see Table 14). URM students were 40% less likely to graduate in STEM among enterers and among graduators, 62% more likely to graduate in a non-STEM field compared to non URM students. URM students were also 26% more likely than their counterparts to withdraw from UA. Similarly, first generation students were 50% less likely to graduate in STEM among enterers and among graduators, 63% more likely to graduate in a non-STEM field when compared to non-first generation students. Alarmingly, first generation students also appeared to be at particular risk of UA withdrawal; over twice as likely as their counterparts. In addition, females were found to be 18 % less likely to withdraw but among those who graduated, they were 35% more likely to graduate in a non-STEM field than males.

Table 14. Significant Results of Logistical Regression Model Tests for COM Entry Outcomes

Included Cohorts	Sample Size	College of Medicine Entry Outcomes	r^2
2014-2016	1586	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.063
Among those who entered in COM:		URM 40% less likely compared to non-URM** First gen 50% less likely compared to non-First generation**	
2014-2016	1056	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.044
Among those who entered in COM and graduated:		Females 35% more likely compared to Males* URM 62% more likely compared to non-URM** First generation 63% more likely compared to non-First generation**	
2014-2019	2478	Outcome E: Withdraw from UA after entering as a STEM major	0.049
Among those who entered in COM:		Females 18% less likely compared to Males* URM 26% more likely compared to non-URM** First generation 2.25x more likely compared to non-First generation**	

* indicates p value < .05
** indicates p value < .001

College of Social and Behavioral Sciences

While SBS had small sample sizes when compared to other colleges, we ran the model in this setting too (see Table 15). No predictor variables were determined to be statistically significant with regard to the likelihood of STEM entry but females were 47% less likely to graduate with a STEM major and almost 2x more likely to graduate with a non-STEM major when compared to their male peers. URM students were 53% less likely than their non-URM peers to graduate with a STEM degree. Importantly, first generation students who entered SBS in STEM were found to be 2x more likely to withdraw from the UA when compared to their non-first generation peers.

Table 15. Significant Results of Logistical Regression Model Tests for SBS Entry Outcomes

Included Cohorts	Sample Size	College of Social and Behavioral Sciences Entry Outcomes	r^2
2014-2016	1053	Outcome B: Graduate UA with a STEM Degree	0.02
Among those who entered in SBS and graduated:		URM 53% less likely compared to non-URM**	
2014-2016	354	Outcome C: Graduate UA with a STEM degree after entering as a STEM major	0.042
Among those who entered in SBS in STEM and graduated:		Females 47% less likely compared to Males*	
2014-2016	354	Outcome D: Graduate UA with a NONSTEM degree after entering as a STEM major	0.042
Among those who entered SBS in STEM and graduated:		Females 1.8x (88%) more likely compared to Males*	
2014-2019	277	Outcome E: Withdraw from UA after entering as a STEM major	0.013
Among those who entered in SBS in STEM:		First generation 2x more likely compared to non-First generation*	

* indicates p value < .05
** indicates p value < .001

Improved Model Findings: UA Wide Cohorts

In many instances, the initial models were able to explain only 2-4% of the variation in the sample. After testing the initial models in various STEM outcome scenarios, we became interested to see how STEM Entry, whether a student entered as a STEM major, might provide some insight into differential graduation outcomes.

In the initial modelling of Outcome A, STEM Entry was treated as a dependent variable. In the initial modelling of Outcome C, STEM Entry is treated as a condition for sample inclusion. However, for the additional round of modelling we chose to add STEM Entry as an independent variable and to test this model for Outcome B (Graduate UA with a STEM Degree). We hypothesized that if students entered in STEM, they would be much more likely to graduate in STEM. We also wanted to see how adding an additional STEM Entry variable would affect the influence of the other demographic predictors.

This addition created a 5-variable model which performed quite well at modelling the scenario of STEM graduation among graduators. It correctly predicted 80% of UA-wide cases and was able to explain 42% of the variability in outcome B. We also ran the same 5 variable model to model the scenario of STEM graduator among enterers. It correctly predicted 77% of UA wide cases and was able to explain 28% of the variability in outcome B.

This is a subtle but important difference in the sampled group. Running the model for enterers includes all students who withdrew whereas running the model for STEM graduators only includes students who graduated. Here, by including both students who graduated and students who did not, we get a better sample of the range of students who entered the UA not only those students who were successful in graduating.

Table 16. Significant Results of Improved Logistical Regression Model Tests for UA-Wide Outcomes

Included Cohorts	Sample Size	UA-Wide Outcomes	r^2
2014-2016	12501	**Outcome B: Graduate UA with a STEM Degree**	0.422
Among all graduators:		STEM Entry 15.8x more likely compared to non-STEM Entry** Females 48% less likely compared to Males** URM 24% less likely compared to non-URM** First gen 17% less likely compared to non-First generation**	
2014-2016	19615	**Outcome B: Graduate UA with a STEM Degree**	0.284
Among all enterers:		STEM Entry 9.6x more likely compared to non-STEM Entry** Females 17% less likely compared to Males** URM 30% less likely compared to non-URM** First gen 31% less likely compared to non-First generation** Pell 14% less likely compared to non-Pell**	

* indicates p value < .05
** indicates p value < .001

As expected, having entered in STEM at the UA drastically increases one's chances of achieving a STEM degree. However, being female, URM, or first generation also remain statistically significant predictors in this model. In lieu of a secondary analysis of the model's interaction effects, we present the predicted probabilities of STEM graduation by student sub-group in Table 17 and Table 18. This gives a better sense as to how students who occupy more than one underrepresented status may or may not experience compounded effects.

Table 17 below presents the predicted probabilities that a student who graduates will graduate in STEM based on their inclusion or exclusion in the demographic groups. A graduating student who enters in STEM and occupies all the dominant statuses (male, non-URM, non-first generation, non-Pell Eligible) has almost an 81% chance of graduating in STEM whereas a student who enters in STEM and occupies all the underrepresented statuses (female, URM, first generation, Pell eligible) has only a 57% chance of achieving a STEM graduation. A graduating student who entered in STEM and is female, URM, first generation, and Pell eligible is almost 12% lower chance of a STEM graduation than a female student who enters in STEM but is not URM, first generation or Pell eligible (69%).

Table 17. Predicted Probability of STEM Graduation Among Those Who Graduate UA

Demographic Group				Non-STEM Entry	STEM Entry
Female	URM	First Gen	Pell	8%	57%
			Non-Pell	8%	59%
		Non-First Gen	Pell	9%	62%
			Non-Pell	10%	63%
	Non-URM	First Gen	Pell	10%	64%
			Non-Pell	11%	65%
		Non-First Gen	Pell	12%	68%
			Non-Pell	12%	69%
Male	URM	First Gen	Pell	14%	72%
			Non-Pell	15%	73%
		Non-First Gen	Pell	16%	75%
			Non-Pell	17%	76%
	Non-URM	First Gen	Pell	17%	77%
			Non-Pell	18%	78%
		Non-First Gen	Pell	20%	80%
			Non-Pell	21%	81%

With regard to NONSTEM entry, it makes sense that a student who does not enter in STEM would have a much lower probability of STEM graduation. These low rates reiterate the importance of engaging students before they enter the university in order to increase the likelihood that students from groups underrepresented in STEM enter as STEM majors. Yet, even among the NONSTEM entry group some disparity is still apparent. For example, a student who enters as a non-STEM student and occupies all of the underrepresented statuses (I.e., female, URM, first generation, Pell eligible) has only an 8% chance of graduating with a STEM degree whereas a student who enters as a non-STEM major but occupies all of the dominant statuses (I.e., male, non-URM, non-first generation, non-Pell eligible) has a 21% chance of graduating with a STEM degree.

Table 18 presents the predicted probabilities that a student who enters the UA will graduate in STEM based on their inclusion or exclusion in the demographic groups. Here, all entering students are included in the sample and thus, it represents a wider swath of types of students (not only graduators, but also students who withdrew). Importantly, female status among graduators lowered the likelihood of STEM graduation by about 48% compared to males, but among only enterers female status lowered the likelihood of STEM graduation by only 17%. This is perhaps due to the association of female status as a protective against UA drop out at the same time female status associated with a much higher likelihood of NONSTEM graduation.

With respect to the outcome of STEM graduation for all enterers, all four demographic statuses were found to be statistically significant indicators and expectedly, STEM entry was still found to be a large influence (almost 10x) on the likelihood of STEM graduation. Somewhat counterintuitively, in this scenario Pell status correlated to a slight increase in likelihood of STEM graduation.

As is evident in Table 18 below, differential predicted probabilities calculated by the model give some insight into how these chances might map onto real student groups. In looking at the STEM entry group only (right side), it is apparent that odds of graduation are quite varied based on one's membership in all four types of groups. At the high end, a STEM entry student who occupies all the dominant statuses (male, non-URM, non-first generation, non-Pell Eligible) has almost a 57% chance of graduating in STEM whereas a STEM entry student who occupies all the underrepresented statuses (female, URM, first generation, Pell eligible) has only a 31% chance of achieving a STEM graduation.

Table 18. Predicted Probability of STEM Graduation Among Those Who Enter UA

Demographic Group				Non-STEM Entry	STEM Entry
Female	URM	First Gen	Pell	4%	31%
			Non-Pell	5%	34%
		Non-First Gen	Pell	6%	39%
			Non-Pell	7%	43%
	Non-URM	First Gen	Pell	6%	39%
			Non-Pell	7%	43%
		Non-First Gen	Pell	9%	48%
			Non-Pell	10%	52%
Male	URM	First Gen	Pell	5%	35%
			Non-Pell	6%	39%
		Non-First Gen	Pell	8%	44%
			Non-Pell	9%	48%
	Non-URM	First Gen	Pell	7%	44%
			Non-Pell	9%	47%
		Non-First Gen	Pell	10%	53%
			Non-Pell	12%	57%

RECOMMENDATIONS

As this analysis illustrates, sex, underrepresented minority status, first generation status, and Pell eligible status all shape STEM student outcomes, with students from historically underrepresented groups having lower chances of success than students from dominant groups. While there is variation in the degree to which these factors impact the likelihood that a student will enter, persist, and graduate in STEM, taken collectively the data indicates that strategic efforts should be taken to reduce disparities that continue to result in lower rates of participation and success among students from groups traditionally underrepresented in these fields. Based on the findings in this report, existing research on effective ways to support the entry and success of students from underrepresented groups in STEM, and insider knowledge of the University of Arizona, we have developed the following 7 recommendations. These recommendations focus on creating more robust and coordinated efforts to engage and support students from marginalized groups, strengthening research and evaluation practices in order to ensure that programs are having their intended impact, and pushing STEM units to be reflective and proactive in examining departmental and unit-level cultures, policies, and practices that lead to disparities in STEM student outcomes.

1. **Greater Coordination and Strategic Vision Around STEM Outreach:** One of the factors most influential in predicting the likelihood that a student will graduate with a STEM degree is if they entered the University of Arizona as a STEM student. While this may not be surprising, this points to the continued importance of investing in efforts to build robust pathways into STEM in order to reduce disparities in STEM enrollment at entry to the university. While there are numerous UA STEM outreach programs focused on engaging and supporting students from underrepresented groups, these programs tend to operate in silos and lack a coordinated strategy or approach. Efforts should be made to coordinate outreach activities in order to promote greater impact and efficiency. At the same time, coordinated mechanisms for evaluating program impact and longitudinally tracking student outcomes should be developed in order to assess which programs are the most impactful at driving students from underrepresented groups to pursue STEM at the university-level. This would allow for strategic investment in the most high-impact programs while also providing data necessary for programs to address shortcomings as they emerge.

2. **Strengthening STEM Student Support Pathways:** Due to institutional organization and culture, STEM outreach programs often function separate from student support programs for newly enrolled students. This results in a lack of continuity between engaging K-12 students from groups under-represented in STEM and supporting them once they arrive on campus. Better coordination between diversity-focused outreach programs and on-campus STEM student support programs could help support students from under-represented groups as they transition into the University, helping to address STEM retention disparities.

3. **Investment in Programs to Support First Generation Female URM STEM Students:** A consistent finding in this report is the degree to which sex, URM, and first generation status combine to shape STEM student experiences. While female URM STEM students are engaged through various STEM student support programs across campus (e.g., WISE, ASEMS), we currently lack programming specifically targeted at supporting female URM STEM students. The significant disparities experienced by female URM STEM students suggest that strategic investment should be made in developing female-centered and culturally responsive programming and support structures.

4. **Follow-up Analysis:** This report should serve as a baseline from which to longitudinally track progress towards reducing disparities in STEM student outcomes. Repeating this analysis every 3-5 years would provide stakeholders across campus with critical information on if initiatives are working to reduce disparities or

not. Moreover, creating flags within the UAnalytics system to identify student involvement in STEM student support would allow for centralized analysis of the degree to which involvement in different programs affects STEM student outcomes in a way that is methodologically robust, comparable across programs, and intersectional. It would also reduce burdens associated with individual student data tracking that impact the degree to which programs are able to evaluate their impacts, increasingly the availability of evaluation data. This would provide decision-makers with additional information necessary for allocating resources in a way that is most impactful.

5. **Improve Student Data Definitions:** As with all equity work, it is imperative to create data models that account for the complexity and diversity within our student body. Care should be taken with respect to definitions used for sex, race and ethnicity, and socio-economic status proxies. The currently available IPEDS race/ethnicity nomenclature should be supplemented with the inclusive ethnicity fields newly made available this year by Analytics. The traditional URM designation must be further disaggregated to better understand the differing experiences of Hispanic, Native, Black, and multiracial STEM students. We also anticipate that in years to come, the normative ways we have institutionally tracked sex and gender may undergo some transformation. Student outliers within a binary sex classification will continue to grow. Currently, the "Unknown" category for gender is insufficiently vague and could perhaps also be supplemented with an additional inclusive field. Pell eligibility, linked to FAFSA, was used as a proxy for socio-economic status, but also has limits (i.e. citizenship requirements) so additional metrics could and should be used to account for socioeconomic status.

6. **Centralized Mechanism for Tracking Impact of STEM Outreach and Student Success Programs:** Efforts should be made to create flags for involvement in STEM outreach and support programs within the UAIR system. This would allow for centralized analysis of the degree to which involvement in different programs affects STEM student outcomes in a way that is methodologically robust and comparable across programs and reduces burdens on individual programs. This would provide decision-makers with additional information necessary for allocating resources in a way that is most impactful.

7. **Assess and Address STEM Unit Practices, Policies, and Culture:** Though the methods utilized here were not designed to identify the causal factors leading to disparities in entry, retention, and graduation among STEM students, existing research on STEM student experiences points to a variety of factors including curricular structure, course content, departmental and course cultures, and inequitable teaching practices. STEM units should consult with diversity and inclusion experts to evaluate existing practices and create action plans for creating more equitable and inclusive practices, policies, and cultures within and across STEM units.

Reference List

Anderson, E., & Kim, D. (2006). Increasing the success of minority students in science and technology [4th in a Series: The Unfinished Agenda: Ensuring success for students of color]. Washington, DC: American Council on Education.

Blackburn, H. (2017). The status of women in STEM in higher education: A review of the literature 2007–2017. Science & Technology Libraries, 36(3), 235-273

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. Journal of Research in Science Teaching, 51, 555–580.

Chen, X. (2005). First generation students in postsecondary education: A look at their college transcripts (NCES 2005-171). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Christoffersen, A. (2017). Intersectional approaches to equality research and data. Equality Challenge Unit. http://www.ecu.ac.uk/wp-content/uploads/2017/04/Research_and_data_briefing_2_Intersectional_approaches_to_equality_research_and_data.pdf

Conrad, S., Canetto, S. S., MacPhee, D., & Farro, S. (2009). What attracts high-achieving socioeconomically disadvantaged students to the physical sciences and engineering? College Student Journal, 43, 1359–1369.

Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. American Educational Research Journal, 46, 924–942. doi: 10.3102/0002831209349460

Hurtado, S., Han, J. C., Sáenz, V. B., Espinosa, L. L., Cabrera, N. L., & Cerna, O. S. (2007). Predicting transition and adjustment to college: Biomedical and behavioral science aspirants' and minority students' first year of college. Research in Higher Education, 48, 841–887. doi: 10.1007/s11162-007-9051-x

National Science Board. (2014). Science and engineering indicators 2014 (NSB 14-01). Arlington, VA: Author. Retrieved from: http://www.nsf.gov/statistics/seind14/

National Student Clearinghouse Research Center. (2015). Science and engineering degree attainment: 2000–2014. Herndon, VA: Author. Retrieved from: http://nscresearchcenter.org/snapshotreport-degreeattainment15/

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. Harvard Educational Review, 81(2), 172-209.

Shaw, E. J., & Barbuti, S. (2010). Patters of persistence in intended college major with a focus on STEM majors. NACADA Journal, 30(2), 19–34.

Appendix A. UA STEM Major List

Advanced Transportation Engr
Aerospace Engineering
Agricultural & Biosystems Engr
Agricultural Engineering
Agronomy
Animal & Biomedical Industries
Animal Health Science
Animal Sciences
Applied Computing
Applied Physics
Applied Science
Architectural Engineering
Architecture
Astronomy
Atmospheric Sciences
Biochemistry
Bioinformatics
Biology
Biomedical Engineering
Biosystems Analytics & Tech
Biosystems Engineering
Chemical Engineering
Chemistry
Civil Engineering
Computer Engineering
Computer Science
Crop Production
Cyber Operations
Cybersecurity
Data Science and Visualization
Ecology & Evolutionary Biology
Electrical & Computer Engineer
Electrical Engineering
Engineering
Engineering Management
Engineering Mathematics
Engineering Physics
Entomology
Entomology and Insect Science
Environ Hydrology & Water Res
Environmental Engineering
Environmental Science
Environmental Studies
eSociety
Food Safety
Food Studies
General Biology
Geographic Info Sys Tech
Geographic Information Sci
Geological Engineering
Geosciences
Groundwater
Hydrology
Hydrology and Atmospheric Sci
Industrial Engineering
Information Science & Arts
Information Science & eSociety
Information Science & Tech
Integrated Science
Intelligence & Info Ops
International Env Conservation
Management Information Systems
Materials Science & Engr
Mathematics
Mechanical Engineering
Medical Technology
Metallurgical Engineering
Microbiology
Mining Engineering
Molecular & Cellular Biology
Natural Resources
Neuroscience & Cognitive Sci
No Major Selected Architecture
No Major Selected Engineering
Nuclear Engineering
Nutritional Sciences
Optical Sciences & Engineering
Pharmaceutical Sciences
Physics
Physiological Sciences
Physiology
Physiology & Medical Sciences
Plant Pathology
Plant Sciences
Pre-Computer Science, BA
Pre-Computer Science, BS
Pre-Engineering
Pre-Neurosci & Cognitive Sci
Pre-Nutritional Sciences
Pre-Pharmaceutical Sciences
Pre-Physiology
Pre-Psychological Science
Psychological Science
Rangeland Management
Statistics and Data Science
Sustainable Plant Systems
Systems Engineering
Wildlife, Watershed, Range Res
Zoo and Aquarium Conservation