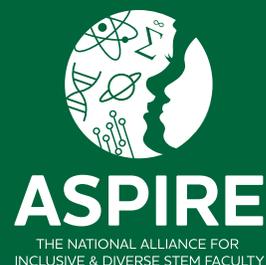




Strengthening Pathways to Faculty Careers in STEM: Recommendations for Systemic Change to Support Underrepresented Groups

Lessons from the APLU INCLUDES Project



Strengthening Pathways to Faculty Careers in STEM: Recommendations for Systemic Change to Support Underrepresented Groups

Lessons from the **APLU INCLUDES** Project

Jessica Bennett, Lisa Lattuca, Kacy Redd, and Travis York

CREATIVE COMMONS LICENSING & CITATION

Copyright statement (for use by others)

From “Strengthening Pathways to Faculty Careers in STEM: Recommendations for Systemic Change to Support Underrepresented Groups” by J. C. Bennett, L. Lattuca, K. Redd, and T. York (2020). [CC BY-NC-SA](#).

Suggested Reference Citation

Bennett, J.C., Lattuca, L, Redd, K., and York, T. (2020). Strengthening pathways to faculty careers in STEM: Recommendations for systemic change to support underrepresented groups. Washington, DC: Association of Public and Land-grant Universities.



This material is based upon work supported by the National Science Foundation under Grant No. (1649199, 1834518, 1834522, 1834510, 1834513, 1834526, 1834521). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

CONTENTS

Executive Summary	5
Introduction	6
The APLU INCLUDES Project	6
Project Activities	6
Report Objectives	7
From Pipeline to Pathways: Mapping the Routes and Terrain to the STEM Professoriate	8
Understanding the Topographical Features of the Pathways	9
Special Equipment: Essential Features for Supporting the Journey	9
Travelers' Assistance: Understanding the Support Infrastructure for URG STEM Participation	10
Strong Support for Student Travelers: Undergraduate and Graduate Programs	13
Rougher Roads for Post-Doctoral Fellows and Early Career Faculty	14
Missing or Weak On-Ramps, Special Occupancy Lanes, and Infrastructure Supports	14
Glitchy GPS: The Impact of Limited Data Availability on Designing Better Roads	15
Signal Weak Spots in the Current Data Universe	15
Pixelated Images While Navigating	16
Considerations for Reinforcing the Pathways: Broadening Participation through Connected and Networked Activities	16
Widening the Road Ahead	17
Call to Action	18
Our Next Journey: Aspire, The Future of APLU's INCLUDES Work	19
Aspire Activities	19
Broader Scholarly Impact	20
Getting Involved in Aspire	20
References	21

Front cover photo courtesy of University of Maryland, Baltimore County



Photo courtesy of Virginia Commonwealth University

EXECUTIVE SUMMARY

Broadening participation of underrepresented groups (URG) in the science, technology, engineering, and mathematics (STEM) fields is critical to maintaining and growing U.S. competitiveness in innovation, the knowledge and science economy, and broadly equipping the 21st century workforce. As the U.S. population grows increasingly diverse, failure to engage and retain URG individuals in STEM education will likely result in a declining STEM workforce, hampering the U.S.'s ability to remain at the forefront of science and discovery.

As part of a national initiative to recruit, hire, and retain STEM faculty from underrepresented groups, the Association of Public and Land-grant Universities (APLU) INCLUDES project, funded by the National Science Foundation, examined university efforts supporting access to, retention in, and progress to the professoriate for URG STEM faculty aspirants. In addition to convening academic experts and institutional leaders, APLU surveyed member institutions about their practices to promote diversity in these areas. Findings from APLU INCLUDES Activities included:

- ◆ There are a wide variety of pathways to the STEM professoriate, including many non-traditional routes.

- ◆ Many universities have robust programs to support URG students during their undergraduate and graduate careers, but that support appears to diminish at the post-doctoral and early career faculty stages.

- ◆ While existing programs are serving immediate needs of individual students, the localistic and targeted focus of these programs display a limited impact on the most intractable challenges to diversifying the faculty.

- ◆ The lack of federal unit-level data frustrates efforts to follow aspirants to the STEM professoriate through the career pathways.

This report details the findings of APLU INCLUDES work and calls on higher education leaders, current STEM faculty, researchers, and policy makers to help shift the conversation from focusing on addressing individuals' needs to create systemic and cultural changes in the STEM ecosystem to promote diversity and inclusion across the career pipeline.



INTRODUCTION

Broadening the participation of underrepresented groups (URG) in the science, technology, engineering, and mathematics (STEM) fields is critical to maintaining and growing the United States' competitiveness in innovation, the knowledge and science economy, and ensuring an adequate STEM workforce (1) (2). STEM fields remain a prominent and growing sector of the world economy, and discoveries in STEM will be essential to tackling the world's most challenging problems, including climate change, disease, famine, and drought. Technology is increasingly embedded across all work sectors, as reliance on computers, networks, and data shape all areas of the human experience — from medicine to social service delivery to entertainment.

Engaging diverse perspectives and approaches to these challenges and opportunities is vital to ensuring the best solutions to meet the broadest set of needs are developed (2). In addition, as the U.S. population grows increasingly diverse, failure to engage and retain URG individuals in STEM education will likely result in a declining STEM workforce, further hampering the U.S.'s ability to remain

competitive in an increasingly STEM-focused global economy (2). Graduating a diverse STEM-educated workforce, then, is vital to national interests.

One key lever for enhancing the participation in STEM at all levels of education is cultivating diverse and inclusive STEM faculties at research universities. Students from underrepresented groups have been found to be more academically successful when taught and mentored by those with similar backgrounds (3) (4) (5) or by those who are successful in implementing inclusive practices (4) (6) (7). Recent data from the National Science Foundation shows that while underrepresented minority (URM) students earn 21 percent of STEM Bachelor's degrees, only 10.1 percent of STEM faculty at 4-year institutions are from URM backgrounds (8). For women, who earn 58.4 percent of Bachelor's degrees in STEM, the STEM faculty at 4-year institutions is only 34.6 percent (8). By the numbers, it is clear we do not currently have a national STEM faculty that reflects the demographics of the students they are educating.

THE APLU INCLUDES PROJECT

In February of 2016, APLU launched a multi-pronged effort to address the underrepresentation of minority racial and ethnic groups, women, and persons with disabilities in faculty positions in U.S. colleges and universities. The APLU INCLUDES Project, funded by the National Science Foundation (NSF #1649214), engaged administrators and faculty members from APLU member institutions and eight national partners in two convenings and data collection efforts. The project identified critical junctures in the pathways to STEM faculty careers — from undergraduate to graduate to post-doctoral and finally to the early career years — and how this progression can be aligned and connected to develop inclusive and effective pathways.

Project Activities

The APLU INCLUDES Project is premised on the belief that gaps in the pathways can be bridged through the collective action of faculty, administrators, and professional staff at APLU institutions committed to the success of marginalized and underrepresented students and the diversification of the U.S. STEM professoriate. APLU INCLUDES leveraged the expertise of subject-matter experts, institutional leaders, and practitioners to identify gaps in university efforts to support access

to, retention in, and progress to the professoriate for underrepresented STEM faculty aspirants through a [series of summits](#) held in 2017 and 2018 (9) (10). In addition, APLU convened three core working groups — the Faculty Diversity Task Force, the STEM Pathway Task Force, and the Technical Advisory Committee — to examine challenges in diversifying the STEM professoriate.

10.1%
of STEM faculty at four-year institutions are from underrepresented minority backgrounds.

The Faculty Diversity Task Force focused on how institutions can better understand their approach to attracting, hiring, and retaining URG STEM faculty through a self-assessment process. They developed an institutional model of faculty diversity and accompanying data template and narrative (11) (12) (13).

The STEM Pathways Task Force was charged with identifying a suite of transformative institutional activities currently in use to increase participation along the STEM pathways. They shaped the development and administration plan of the online [STEM-OP: Survey to Expand and Maximize Opportunities to the](#)

[Professoriate](#), which collected information about existing APLU member programs and initiatives that support underrepresented students, postdocs, and early-career faculty in STEM. The STEM-OP was co-constructed by project staff and the STEM Pathways Task Force. The survey was then vetted and revised at the 2017 APLU INCLUDES Summit before being administered online and made publicly available through [APLU's website](#).

“

By the numbers, it is clear we do not currently have a national STEM faculty that reflects the demographics of the students they are educating.

Since the survey was intended to capture as much information about current practices as possible, APLU recruited participation in the survey from across its membership via network newsletters, targeted emails to provosts, and APLU INCLUDES contacts as well as among NSF networks including Principal Investigators of targeted programs (e.g., NSF's INCLUDES DDLPs, NSF AGEPS, NSF LSAMPS). The survey was open for six weeks. To lighten the burden of the survey's comprehensive nature, participants had multiple options for uploading documents (e.g., project reports, informational items, reports, etc.) and providing web links to more easily communicate information. A broad summary of the nature and focus of submitted programs is included below, including a table detailing specific initiatives that survey respondents agreed to be highlighted as part of this report.

The APLU INCLUDES Technical Advisory Committee was tasked with evaluating the adequacy and coverage of current data sources and metrics available along the STEM pathways. The task force also developed the conceptual model of the pathways in STEM at 2-year and 4-year institutions from undergraduate matriculation to faculty appointments. They scanned the nationally available data sources that might illuminate the success of transition through these pathways, with a focus on underrepresented groups and made recommendations where additional data may be needed.

During the work of the Technical Advisory Committee, the National Academies released a complementary report, [Indicators for Monitoring Undergraduate STEM Education](#), which offers a framework for addressing

the quality and impact of undergraduate education (14). Goal two of that report outlines indicators needed to assess progress on equity, diversity, and inclusion of STEM students and instructors. Chapter six of the report provides a summary of existing data sources and monitoring systems for undergraduate education.

Report Objectives

This report synthesizes what we learned about the state of university STEM pathways through our APLU INCLUDES activities to address questions around three critical areas:

- 1. What are the common and emergent pathways to the STEM professoriate currently in place? Within these pathways, where does support for underrepresented groups exist and where is that support lacking?**
- 2. What are the opportunities for alignment between and among programs and institutions to strengthen pathways for underrepresented groups seeking to enter STEM faculty positions?**
- 3. What publicly accessible data is available to aid institutions and national organizations in understanding student, particularly URG students', movement and attrition throughout STEM pathways and to inform decision-making? Where do we need additional or better data?**

This report calls on APLU member institutions to take action by partnering with colleagues within and beyond their own institutions to strengthen existing connections and build new alignments within the network of pathways that underrepresented STEM students and postdocs could follow to faculty careers. This report also calls on policy makers and researchers to consider how they can improve the data landscape to better illuminate both the persistent and systemic challenges preventing broadening participation. Finally, this report provides institutional leaders with a systems perspective of promising intervention programs and practices being used across APLU's network to address the challenges of broadening participation.

FROM PIPELINE TO PATHWAYS: MAPPING THE ROUTES AND TERRAIN TO THE STEM PROFESSORiate

Ongoing efforts to ensure that the U.S. remains competitive in the STEM enterprise through the creation of a steady stream of STEM-educated graduates has resulted in a persistent metaphor of a “pipeline.” This pipeline, or single educational trajectory from primary and secondary education into an eventual career in the sciences, has been described as leaky for those from underrepresented backgrounds. The leaks represent loss points when individuals leave the pipeline to study other fields or enter other careers. The work of APLU INCLUDES joins others in questioning the validity of this metaphor to accurately capture the complexity of the STEM education and career ecosystem, and the challenges that colleges and universities, in particular, face when attempting to change who become faculty in STEM fields (5).

The journey to the professoriate is long and complex. Without a clear map and an excellent guide, travelers are apt to be confused by unfamiliar academic territory with extensive emotional hills and valleys and poorly marked trails as well as wide open spaces of potential. Difficulties arise when one’s guide is temporarily, or perhaps completely, out of sight. Figure 1 below represents the pathways to the STEM professoriate that are familiar to those who have completed the journey, as well as the points at which individuals might leave the most common pathways. These are the academic and non-academic spaces that individuals on the way to the STEM professoriate inhabit at different time points, and the transitions among those spaces that they must successfully navigate.

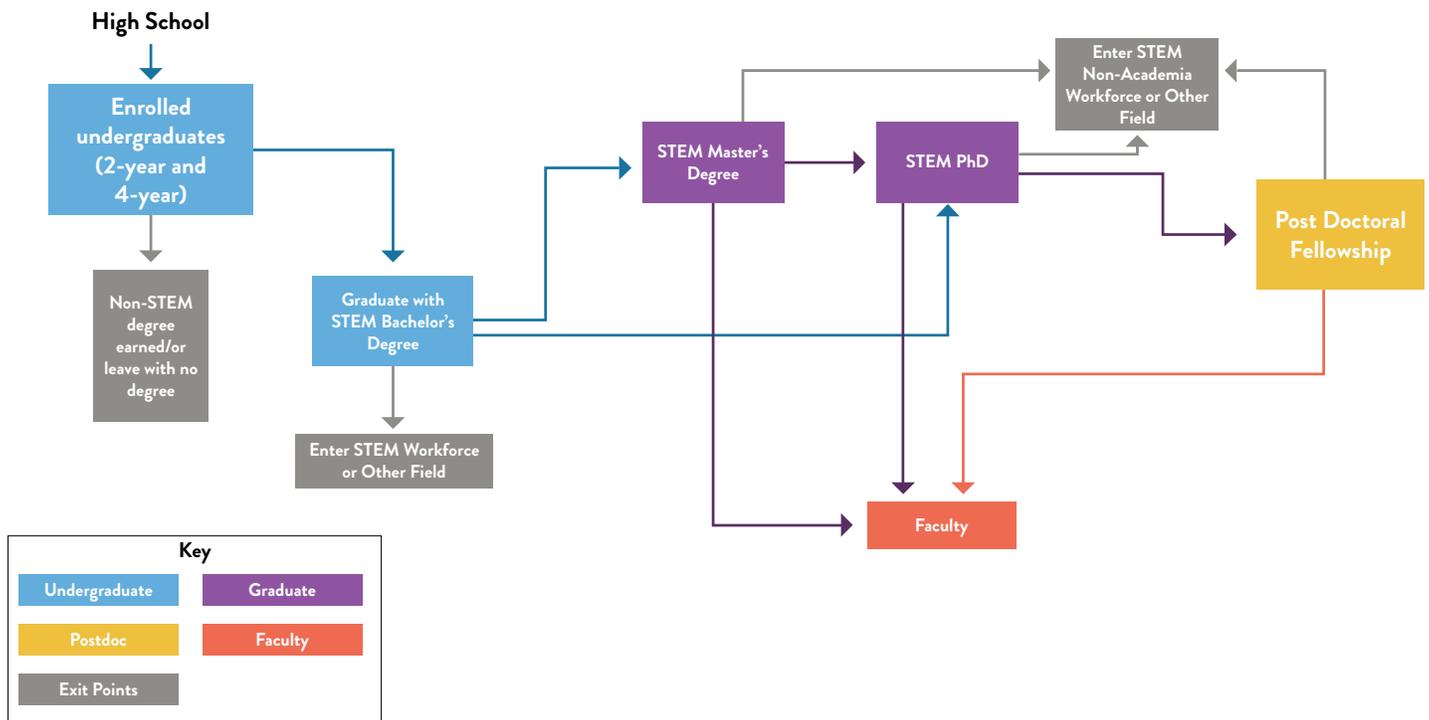


Figure 1. Postsecondary STEM Pathways to Academic Career

This view of the map is simplified. Clicking on the map will take you to an interactive version that allows you to zoom in. These zoomed-in sections attempt to capture the multiple stops and stop-outs along these pathways. The most well-worn pathway to the STEM professoriate begins with matriculation to undergraduate education, declaration of a STEM major, and graduation. An individual on this well-worn pathway then moves to a STEM research position or immediate application to

a STEM graduate degree program. Some students will pursue a master’s degree, with employment between the master’s and a doctoral degree. Others will earn a master’s on the way to a Ph.D. Following the doctorate, professoriate hopefuls may enter a post-doctoral fellowship or go directly into a faculty role. The preferred itineraries vary by discipline, but individuals’ needs, experiences in institutions, and self-discovery may dictate how direct a route is taken.

Understanding the Topographical Features of the Pathways

Our map is a bit deceptive because it obscures the topographical features along the pathways to faculty work: the hills and valleys are flattened, broken bridges appear intact, and the timeframe for the journey is unclear. A more serious limitation is that the map primarily reflects the paths of those who have succeeded. As such, it likely represents the least adverse routes and is unlikely to accurately and comprehensively reflect the experiences of those who exited the pathways or capture reasons for their departures.

In particular, this map offers no connections between the points where individuals enter non-STEM degrees and jobs or non-research roles, and potential re-entry points on the way towards a STEM professoriate position. This map can also offer little in the way of explanations for why individuals might exit the major pathways or get stuck in what may be viewed as cul-de-sacs or byways, such as extended post-doc appointments or non-tenure-track roles.

“

Our map is a bit deceptive because it obscures the topographical features along the pathways to faculty work: the hills and valleys are flattened, broken bridges appear intact, and the timeframe for the journey is unclear. A more serious limitation is that the map primarily reflects the paths of those who have succeeded.

While the map cannot elucidate these challenges, participants at the [APLU INCLUDES 2017](#) Summit identified common critical challenges to broadening participation along the journey to the professoriate (10). These challenges, as generally understood by researchers, policy-makers, and institutional leaders, were identified as A) a lack of role models, mentors, and quality advising stymieing advancement and retention at points all along the pathways to the professoriate; B) the critical nature of transition points such as between undergraduate degree completion and entry to graduate school or from graduate school to postdoctoral or faculty positions; and, C) the continued undermining of diversity efforts by pervasive and unexamined implicit bias in admissions, hiring, and promotion and tenure.

Special Equipment: Essential Features for Supporting the Journey

The STEM Pathways Task Force, alongside summit participants, identified the most common strategies to improve the success of URG STEM students along the career pathways to the professoriate: communities of support, institutional investment and structures, and career socialization. The task force identified the qualities that make efforts in each category the most successful, while acknowledging that for many areas, there may not be enough data to know which particular iterations of these programs warrant further investment. These findings align with conclusions and recommendations in the National Academies' report, [Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students Diverse Pathways](#) (5).

A community of support is a key mechanism for advancing URG STEM students and faculty due to the small numbers of individuals from these backgrounds. Such communities offer culturally responsive and tailored support addressing the unique challenges that URG participants may encounter. High-quality communities of support feature person-to-person connections, including peer support programs, mentoring, quality advising, learning cohorts, and family support programs. Ideally, communities of support are collaborative, spanning institutions within academia, or across academia, business, and industry.

In addition to the creation of community, institutions must make deep investment—financial and symbolic—in transforming their policy and educational structures to spur lasting change. This includes cultivating increased responsibility for student success by investing in high-impact practices to support student engagement via quality, culturally sensitive educational staff development. High-impact practices include undergraduate research mentoring, team and cohort peer support groups, and faculty-led learning communities. Staff who support student learning and engagement, including faculty, instructors, and academic advisors, should be trained to have a deeper understanding of potential cultural differences and adapt their approaches to student support accordingly.

Finally, many cultural myths and assumptions pervade our understanding of who and what a scientist is. Enhanced career socialization includes clarifying and sometimes challenging these assumptions for students

and faculty, as well as developing deeper understanding of the norms, conventions, and beliefs inherent to science research careers. High-quality programs in this area would educate students early and clearly about the role of research, including opportunities to engage in research;

demystify the graduate school application process; enhance the mentoring skills of faculty; and explicitly discuss the positive value of faculty jobs and their contributions to changing communities through research, collaboration, engagement, and problem solving.

TRAVELERS’ ASSISTANCE: UNDERSTANDING THE SUPPORT INFRASTRUCTURE FOR URG STEM PARTICIPATION

These strategies improve the experience along all parts of the pathways. While some programs may focus predominantly on one strategy, other programs engage a combination of strategies. One common example of a multi-pronged strategy is undergraduate research experience programs. These programs may use cohort learning as a community of support, provide evidence of institutional investment in a high-impact practice, and expose students early to a key element of the faculty STEM research career.

The results of the STEM-OP survey allow us to see examples of how APLU institutions have promoted the success of underrepresented STEM students in

undergraduate and graduate studies, new STEM doctorates in postdoctoral positions, and new STEM faculty.

Table 1 provides details of submitted programs that chose to be named and featured, including which locations along the pathways to the STEM professoriate they engage, how well they address the challenges identified by the APLU INCLUDES summit participants, and whether they engage in the necessary elements for programmatic intervention identified by summit participants. Learn more about these programs by clicking the program name.

Table 1. Selected Results of the [STEM-OP: Survey to Expand and Maximize Opportunities to the Professoriate](#)

Program	Description	Challenges for URG Students & Faculty Addressed			Necessary Elements for URG STEM Student & Faculty Success Deployed		
		Lack of Role Models, Mentors & Advisors	Rocky Transition Points	Implicit Bias in Admissions, Hiring & Advancement	Communities of Support	Institutional Structures	Faculty Career Socialization
Secondary							
Health Sciences and Technology Academy (HSTA)	The Health Sciences and Technology Academy is a high school mentorship program that uses a framework of rewarding student success and addressing individual needs to prepare students for health care and STEM-based undergraduate and graduate programs.	●	●		●		

Program	Description	Challenges for URG Students & Faculty Addressed			Necessary Elements for URG STEM Student & Faculty Success Deployed		
		Lack of Role Models, Mentors & Advisors	Rocky Transition Points	Implicit Bias in Admissions, Hiring & Advancement	Communities of Support	Institutional Structures	Faculty Career Socialization
Water Network for Team STEM (WaNTS)	The Water Network for Team STEM project's goal is to broaden participation of Indigenous Pacific Islanders in STEM fields by teaching and empowering them to learn how to maintain and manage clean water using an interdisciplinary lens.	●			●		●
Undergraduate							
Emory/CCHF Chemistry Summer Undergraduate Research Program (CSURP)	The Chemistry Summer Undergraduate Research Program (CSURP) program provides research experience for chemistry and chemical engineering undergraduate students across institutions in the United States.	●				●	●
University of Arkansas Engineering Career Awareness Program	The Engineering Career Awareness Program provides academic, financial, and social supports for underrepresented and disadvantaged students in preparation for graduating and beginning their careers in the field.		●		●	●	
LAUNCH: Undergraduate Learning Communities	LAUNCH: Learning Communities provides a network for undergraduate students to build relationships and interact with their fellow peers and mentors as a support system.	●			●		
LAUNCH: Undergraduate Research Communities	LAUNCH: Undergraduate Research provides introductory research opportunities for first-generation, low-income, underrepresented students in all academic disciplines with the hope that they continue their education on to graduate school.	●				●	●

Program	Description	Challenges for URG Students & Faculty Addressed			Necessary Elements for URG STEM Student & Faculty Success Deployed		
		Lack of Role Models, Mentors & Advisors	Rocky Transition Points	Implicit Bias in Admissions, Hiring & Advancement	Communities of Support	Institutional Structures	Faculty Career Socialization
<u>Learning To Build STEM Research Communities- A Proposal To Strengthen, Expand, And Disseminate A Successful Retention Model</u>	L.E.A.R.N. is a learning community for incoming students from high school (F-L.E.A.R.N.) and community college (T-L.E.A.R.N.) that is dedicated to building a supportive environment and providing opportunities for research in STEM disciplines.		●		●		●
<u>Purpose + Reach = Individuals Measured for Excellence (PRIME) STEM Project</u>	PRIME STEM provides support to 120 first-generation, low-income and/or documented disability STEM students through skill-building activities and mentorship.	●			●		
<u>STEM-R: Modeling STEM Retention and Departure across Physics, Mathematics, and Engineering</u>	The STEM-R project is researching and developing a framework to determine the reasons and possible solutions as to why undergraduate STEM majors leave their disciplines but remain enrolled in college.		●			●	
Graduate							
<u>UC Davis Bridge to Doctorate Program</u>	Through learning communities, workshops, and other activities, the UC Davis Bridge to the Doctorate Program guides underrepresented groups in STEM to pursue graduate degrees.		●			●	●
Post Doctoral							
<u>Early Career Leadership Workshop</u>	The NM EPSCoR Early Career Leadership Workshop is a 3-day program of interactive sessions designed to enhance the professional skills of post-doctoral scholars and early career faculty in STEM disciplines.		●				●



Program	Description	Challenges for URG Students & Faculty Addressed			Necessary Elements for URG STEM Student & Faculty Success Deployed		
		Lack of Role Models, Mentors & Advisors	Rocky Transition Points	Implicit Bias in Admissions, Hiring & Advancement	Communities of Support	Institutional Structures	Faculty Career Socialization
Faculty							
Unconscious Bias Faculty training	Cornell's Unconscious Bias Faculty Training is a resource for faculty search committee members to recognize biases in hiring and to develop their skills in how to become a proactive recruiter.			●		●	

The programs highlighted in Table 1 constitute just a portion of the contributions that APLU institutions are making to diversify the U.S. STEM professoriate, and suggest where support is strongest and where additional support is required. The strongest focus appears to be in the earliest sections of the postsecondary pathway. Many institutions have instituted programs of academic and social support to enhance retention of underrepresented students in STEM fields. We found programs are more numerous at the graduate and undergraduate levels, and many of these benefit from financial support from federal agencies and foundations.

Strong Support for Student Travelers: Undergraduate and Graduate Programs

Many of the undergraduate-focused programs are comprehensive in nature, providing academic and social support, sometimes beginning in the summer prior to the first year of college and into the early years of the students' undergraduate experience. These kinds of programs are also the subject of numerous research studies seeking to evaluate their success in retaining students in STEM majors, maintaining their interests in STEM careers, and encouraging research interests through supervised experiences with STEM faculty members either on their home campus or on other university campuses during summer breaks. It is worth noting, however, that many of these programs are ecumenical in their support of STEM careers; they encourage broad interests with the primary goal of keeping students in the STEM workforce. A few seek to advance students to careers in research and traditional faculty positions.

Graduate education in STEM fields also receives considerable attention, although programming and scope may not be as robust as at the undergraduate level. Programming to support STEM graduate students can be highly targeted or open to underrepresented students generally (i.e., people of color, veterans, people with disabilities). Federally funded efforts such as the Department of Education's [McNair Scholars](#) and the [NSF's Alliances for Graduate Education and the Professoriate \(AGEP\)](#) programs provide support for some of the institutional efforts at APLU institutions (and beyond).

APLU campus efforts to support underrepresented students, however, are not limited to academic support programs. Many campuses have deployed faculty development programs promoting inclusive teaching and course transformation to ensure an inclusive and equitable educational experience for diverse students of all kinds. Such programs are increasingly offered through teaching and learning centers on college and university campuses, but they tend to attract a small subset of faculty in STEM and across academic fields. To strengthen these efforts, in 2013 APLU began building a national network of STEM Education Centers to connect campus-based centers that focus on improving the learning experiences of undergraduate students in STEM fields. This community of individuals engaged in STEM education transformation share ideas and effective approaches through conferences and digital forums such as the [STEM Education Center Toolkit](#) to provide guidance by sharing expertise on assessment and evaluation practices, partnerships, and communication strategies.

Some universities have also instituted efforts to prepare existing faculty for the complex task of completing holistic admissions review for graduate students. While great strides have been made in understanding the accomplishments of undergraduate applicants in the context of their diverse backgrounds and life experiences, similar efforts have been slower to take hold in graduate admissions. At the level of graduate education, the approach is two-pronged, with efforts to support graduate student success through academic support programs and through programs to sensitize faculty to the hidden biases they bring to their reviews and thus to improve the ability of admissions committees both to see the talent in their applicant pools and to seek it out.

Rougher Roads for Post-Doctoral Fellows and Early Career Faculty

We know the least about, and provide the least support for, the transitions from graduate study to postdoctoral appointments or the transition into faculty positions from graduate study or the postdoc role. While postdoctoral appointments are a common practice in the science and engineering fields, programs intentionally designed to support postdocs are hardly universal. [NSF's recent requirement](#) for “mentoring plans” for all postdoctoral fellows supported by NSF funds is evidence of this need, and is an approach to meeting it (see the National Science Foundation's Grant Proposal Guide [Section II.C.2.g](#)). An exemplar of university- and system-wide approaches, the President's Postdoctoral Fellows programs bring highly qualified Ph.D.s to a campus and connect them to their prospective department and mentors. Such programs, however, are broad in their reach across disciplines and consequently provide limited opportunities for talented underrepresented STEM graduate students to move into carefully crafted and supervised postdoctoral positions.

Finally, another subset of programs focuses on the experiences of early-career faculty. Many of these initiatives have been sponsored by the [NSF ADVANCE](#) program, seeking to support women's progress in STEM faculty careers. Some programs are focused on training faculty search committees on implicit bias to ensure fairer consideration of women and other underrepresented groups during the recruitment, hiring, and merit review processes. Other programs focus on the experiences of faculty once on campus.

While women faculty continue to be underrepresented in many STEM fields, they are many other demographics that remain URGs in the STEM faculty ranks. Faculty support programs focused on enhancing the success and experience of faculty with other URG identities are less

well documented and funded, though many institutions have expanded and institutionalized changes from their NSF ADVANCE efforts to include URG faculty generally.

Missing or Weak On-Ramps, Special Occupancy Lanes, and Infrastructure Supports

In examining current initiatives and programs aimed at broadening participation in STEM, we found numerous programs at the graduate and undergraduate levels, and many of these benefit from financial support from federal agencies and philanthropic foundations. The vast majority of these programs focus on broadening participation for women and underrepresented minorities (URM). While a handful provide highly targeted interventions for particular URM students, such as the Water Network for Team STEM (WaNTS), which focuses particularly on engaging Indigenous Pacific Islanders, many identify potential beneficiaries more broadly. These broadly conceived programs serve a larger proportion of potential students, but they may not broaden or reinforce pathways to the professoriate for those who rarely find themselves receiving targeted STEM support.

Few programs are designed to specifically address the needs of individuals who have disabilities, are veterans, or have other marginalized identities. The focus on women's and URM success in STEM is likely a direct result of institutional reliance on federal funding from the National Science Foundation, National Institutes of Health, and other federal agencies to support these efforts as well as the siloed domains of federal appropriations and focus (i.e., support for veterans coming from Departments of Defense or Veterans Affairs or individuals with disabilities from Departments of Education or Health and Human Services).

The emphasis on implementing undergraduate and graduate student programs strengthens the early stages of a STEM faculty career path, but presumes, in alignment with the pipeline metaphor, that ensuring a supply early in the process will adequately address the challenges to diversifying the STEM professoriate. The lack of focus on transition support into post-doctoral fellowships or early career faculty roles ignores the barriers facing individuals at these stages and fails to illuminate and make easier potential routes into the academy from doctorate holders working in industry, government, or other sectors.

Existing academic and social support programs at the undergraduate and graduate levels buffer underrepresented students from the effects of intended or unintended bias, including microaggressions, in the programs and on their campuses. Direct support to underrepresented students in STEM is undoubtedly a

necessary part of the solution to the underrepresentation of diverse people in the STEM faculty, but it is not enough.

Only a few efforts seek to build awareness among faculty members about the effects of implicit bias and microaggressions on URG students and colleagues; many faculty are not attuned to the experiences underrepresented groups in higher education encounter, inadvertently contributing to unfriendly climates. This lack of awareness contributes to a persistent and substantial challenge in addressing the unfounded beliefs and discriminatory behaviors of some faculty who teach and advise URG students, who encourage or discourage applications and applicants, who determine who is admitted to graduate study, and who recruit and hire faculty colleagues.

GLITCHY GPS: THE IMPACT OF LIMITED DATA AVAILABILITY ON DESIGNING BETTER ROADS

One of the outstanding challenges for understanding the varying pathways to the STEM professoriate is a lack of data allowing us to better map the alternative routes, departure and re-entry points, and challenging barriers for underrepresented and underserved individuals. Since students are likely to be educated at multiple institutions, perhaps in multiple states, along the way to a doctorate and eventual faculty career, understanding these pathways requires robust data at the national level.

Signal Weak Spots in the Current Data Universe

The United States federal government provides a limited number of data sets that give us information about the STEM pathways from undergraduate education to a faculty position. The data we have capture single points in time along this STEM pathway for broad categories of people. We have no information collected federally tracking individuals along the pathways.

Available data on points along the pathways, to varying degrees, include demographic information of interest (see National Science Board's Science and Engineering Indicators and the National Center for Science and Engineering Statistics' [Women, Minorities, and Persons with Disabilities in Science and Engineering](#) report and [associated tables](#)) (8).

Even less of the federal data and analyses by federal agencies provide insight on the intersecting identities (overlapping characteristics of gender, race, and

“

Bias in many elements of the higher education system must be addressed to provide diverse, inclusive, and equitable educational environments that serve the needs of students, postdocs and faculty alike.

Bias in many elements of the higher education system must be addressed to provide diverse, inclusive, and equitable educational environments that serve the needs of students, postdocs and faculty alike. Our attempts to move from a pipeline mode of thinking to a pathways approach requires creative engagement with varying points in the pathways and addressing the core foundations of this network of roads, highways, and rest areas.

disability, for example) of individuals within this STEM pathway.

For the following points along the pathway, we have demographic information on race, ethnicity, and sex for at least broad fields in STEM, with some intersectional data as well:

- ◆ Number of enrolled undergraduates in 2- and 4-year institutions;
- ◆ Intentions of freshmen to major in science and engineering fields;
- ◆ STEM associate degrees conferred;
- ◆ STEM bachelor's degrees conferred;
- ◆ Master's degree conferred; and
- ◆ Doctorate degree conferred.

We have a subset of this demographic data for:

- ◆ Employment status of STEM bachelors, masters, and doctoral degree recipients;
- ◆ Science, engineering, and health doctorate holders employed in universities and 4-year colleges, by faculty rank;

- ◇ Science, engineering, and health doctorate holders employed in universities and 4-year colleges, by tenure status.

We have little to no demographic information for the employment status of individuals with a postdoc experience.

There is also a lack of data collected nationally that illuminates the use of high-impact institutional practices to support URG undergraduates, graduates, postdocs, and faculty; success outcomes other than degrees conferred and employment status; or information on why individuals transition out of a professoriate pathway.

We invite the reader to explore the APLU INCLUDES [Inventory of STEM Demographic Data Sources](#), which is a table of available data on STEM indicators as well as a visualization of the pathways to the professoriate, with an indication of the amount of available data associated with points along this pathway. The inventory includes available data beyond that collected by federal agencies. The inventory provides the data source, a link to available data tables, and coding on what demographic elements of interest the table/data source addresses.

Pixelated Images While Navigating

The Inventory of STEM Demographic Data Sources makes clear that we lack information about transition points such as demographic information about who leaves graduate programs, postdoc positions, and

faculty positions and why. We also lack demographic information about re-entrants from less traditional points along the pathway. There is currently a prohibition against federal agencies collecting data at the individual level, making it difficult to follow individuals through their academic careers as they move across institutions, state systems, depart educational institutions entirely, and return as students or faculty members.

Having a single unit-level record system would enable us to follow individuals along their STEM education and faculty career trajectories. The lack of comprehensive unit-level data that takes into account the varying and intersectional identities of STEM learners and educators also makes it difficult to identify where the persistent, systemic challenges to broadening participation exist. Policy makers, funders, institutional administrators and educators, and researchers are forced to extrapolate how and where and of what nature the most effective programmatic interventions might be.

It is daunting and nearly impossible for individual programs to track the long-term impacts of these activities — especially those sited in the early undergraduate years — on eventual faculty or research careers. As policy makers and federal funders wrestle with the return on investment of broadening participation portfolios, the lack of systemic data prevents strategic and meaningful investments in programs that have the broadest and most lasting impact.

CONSIDERATIONS FOR REINFORCING THE PATHWAYS: BROADENING PARTICIPATION THROUGH CONNECTED AND NETWORKED ACTIVITIES

As we considered how institutions within the higher education ecosystem might begin to address the pathways challenges of broadening participation in a systemic way to create a more diverse STEM faculty, three overlapping and reinforcing funnels emerged as shaping the available pathways and our understanding about them: academic filtering, program distribution, and data gaps.

Academic filtering is a result of the increasing standards and fewer opportunities as students and academics move along the academic pathway from high school through undergraduate education to graduate school to faculty positions. At each stage, selection practices and decreasing space in the ecosystem converge to create fewer opportunities.

Program distribution is the clustering of interventions along academic pathways; this funnel mirrors the shape of the academic filter, offering the most interventions early in the academic experience.

The **data availability** funnel is a similar shape, with the most information available about undergraduate students, and decreasing along the academic pathways; the lack of data makes it difficult to identify where interventions may be most valuable. The siloing of data across different agencies that share a stake in the STEM enterprise makes it difficult to account for systemic challenges.

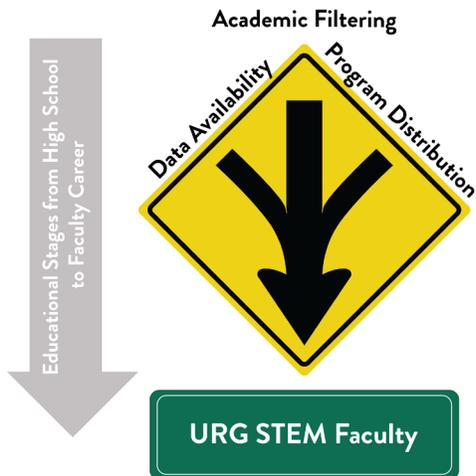


Figure 2. STEM Ecosystem Funnels

These three funnels combine and overlap to restrict underrepresented STEM student, postdoc, and early career faculty progress on the pathways, and our understanding of how best to increase URG progress along the pathways (see Figure 2).

Widening the Road Ahead

In response to these ecosystem-wide funnels, strengthening the pathways to the STEM professoriate is not the responsibility of single institutions or even a small number of well-resourced universities. Rather, more progress will be made if institutions purposefully partner to widen the funnels for STEM students, postdocs, and early career faculty. This will involve bolstering disciplinary and institutional definitions of inclusive excellence in admissions and hiring processes, expanding and connecting programs and initiatives across pathways and institutions, and shining the light of data on the least understood portions of the pathways to the professoriate.

This report provides evidence that APLU member institutions are working diligently to address the needs of the STEM workforce and preparing students and postdoctoral fellows to enter faculty ranks.

There is, however, more work to be done to clarify and align pathways to the professoriate for those who want to pursue it, and to support underrepresented individuals who make it

**CAUTION:
THIS IS COMPLICATED!**



to postdoctoral and faculty positions in STEM getting the guidance and support they need to thrive in academia. The current approach, in which institutions implement singular intervention programs at particular points in the pathways, provides some benefits. First, programs can be focused on the particular needs of institutions, their local context, and the populations of students and faculty they are serving, such as the WaNTS program’s focus on serving indigenous Pacific Islander communities. As a result of this tailored approach, APLU institutions and their state legislatures may be more interested in investing in and sustaining these programs beyond the levels of resources flowing from external funders. In addition, these immediately implemented programs do help to mitigate known current challenges for students matriculating right now, and do not require waiting for sweeping changes to the STEM educational ecosystem.



Programs aimed at eliminating bias may not be doing enough to create truly inclusive teaching, mentoring, and advising cultures.

On the other hand, this current program-by-program approach has limited effect on changing the broader landscape of STEM participation and faculty diversity. First, directing resources to one location along the pathways does not resolve challenges or barriers that individuals from URG backgrounds may face at another point in their career. They also have a minimal impact beyond the limited number of students who engage these programs — with limited capacity within the programs and sharp focus on the STEM teaching and learning space rather than broader institutional and disciplinary environments, cultures, and values. Few programs provide broader interventions to address the prevalence of instructional bias in the classroom and other learning spaces for undergraduate and graduate students. And programs aimed at eliminating bias may not be doing enough to create truly inclusive teaching, mentoring, and advising cultures.

The prevalence of bias and lack of inclusion extends beyond the instructional space to affect collegial relationships and decision-making, including the recruitment, hiring, and retention of faculty from diverse, underrepresented backgrounds. In addition, individual institutional interventions do little to shift the disciplinary cultures that span institutions and sectors, shaping the STEM ecosystem.

CALL TO ACTION

For Higher Education Leaders

- ◆ Develop more robust programs to strengthen later parts of pathway, especially focusing on the transitions from graduate student to faculty or post-doc roles, and early career supports for faculty.
- ◆ Shift your thinking about the recruitment and retention of students and faculty from a competition mindset to one that considers how your efforts might have a positive impact on the broader STEM ecosystem by aligning activities with other institutions. The [APLU INCLUDES Guidebook for Campus Self-Assessment](#) is a great resource.
- ◆ Invest in sustaining programs and practices launched via external funding. Many positive initiatives to address challenges of URG students and faculty only exist for the duration of funding.
- ◆ Prioritize a lens for diversity, equity and inclusion into a broad range of core institutional activities and investments; Diversity, equity, and inclusion should become the lens with which you do your work, not another initiative or separate activity.

For STEM Faculty

- ◆ Bring a spirit of curiosity and discovery to learning about and from URG students and colleagues in order to improve your teaching, research, service, and collegueship to those facing the most insurmountable barriers.
- ◆ Push institutional leadership to support and reward investment in faculty learning about inclusive practices through sponsoring faculty training, course buy-outs, and recognition in tenure and promotion review.
- ◆ Take advantage of opportunities to learn about implicit bias and microaggressions, and how they manifest in decisions about URG students and colleagues. This includes acknowledging how conceptions of merit, skill, and ability have been shaped by historical legacies of access and power.
- ◆ Be an ally to URG individuals in institutional, departmental, and disciplinary spaces, especially when they are not present or in a position to speak for themselves.

For Researchers

- ◆ The challenges facing URG faculty aspirants are well documented; more research is needed on the short- and long-term benefits of particular interventions along the pathways to inform institutional and funder efforts to implement the most promising practices.
- ◆ Little is known about the needs and experiences of those who depart and re-enter the pathways to the STEM professoriate, and more research could help shape potential programs or interventions.

For Policy-Makers

- ◆ Support efforts to capture and track student-level unit record data to better understand the progress of individuals through the STEM ecosystem; the lack of a unified, unit-level data system makes understanding the varying pathways more difficult.
- ◆ Create incentives via appropriations to reduce agency and disciplinary siloes regarding broadening participation in the STEM ecosystem, particularly for those with disabilities and who have served in the armed forces.

OUR NEXT JOURNEY: ASPIRE, THE FUTURE OF APLU'S INCLUDES WORK

In order to move beyond the individual programs approach to create systemic change at scale, APLU, in partnership with the Center for the Integration of Research, Teaching and Learning (CIRTL) housed at the University of Wisconsin and colleagues at the University of Georgia; Iowa State University; University of California, Los Angeles; and University of Texas at El Paso, have launched an NSF-funded INCLUDES Alliance: Grant No. (1834518, 1834522, 1834510, 1834513, 1834526, 1834521) [Aspire: The National Alliance for an Inclusive and Diverse STEM Faculty](#). The vision of Aspire is to increase the learning, persistence, and completion of students from underrepresented groups in colleges and universities in STEM to increase their contributions to the U.S. STEM enterprise through creating a more diverse and inclusive faculty.

Aspire focuses on faculty because they play a central role in the success of URG students. When URG students are taught by URG faculty, they achieve at significantly higher rates (3) (4) (15). Research also reveals that inclusive teaching, mentoring, and advising improves performance, self-efficacy, and STEM identity, which foster persistence (16) (7) (6). Aspire is pursuing three mutually reinforcing strategic goals:

- ◆ Deepening the preparation of all STEM faculty to be inclusive and effective in their teaching, research mentoring, and advising;
- ◆ Diversifying the faculty through effective recruitment, hiring, and retention of URG STEM faculty via institutional transformation in practices, policies, and resources;
- ◆ Fostering institutional cultures that recognize and value inclusivity and diversity broadly, and in the context of STEM faculty work specifically.

Aspire's work toward its goals is undertaken through three reinforcing change initiatives -- Institutional Change, National Change, and Regional Change. These initiatives seek to address some of the weaknesses of the institution-by-institution approach to broadening participation by: encouraging institutions to approach change holistically; developing a framework for inclusion to be adopted by individuals, institutions and disciplines; and leveraging local partnerships of 2-year and 4-year institutions to improve the STEM teaching and learning enterprise. These efforts are supported and enhanced by teams of researchers, evaluators, and centralized coordination, support, and strategic leadership.

Aspire Activities

Aspire's Institutional Change (IChange) initiative aims to develop a more inclusive and diverse STEM faculty through working at the institutional level of the STEM ecosystem with two primary programs: the IChange Network and the IAspire Leadership Academy. The IChange Network (ICN) engages institutions committed to advancing Aspire's three strategic goals as a community of transformation. ICN institutions begin with a self-assessment process to identify areas of strength and growth around recruiting, hiring, and retaining a diverse and inclusive STEM faculty. They use the results of the self-assessment, in consultation with network peers, to develop robust action plans to identify, implement, assess, and scale promising practices across STEM colleges and departments. A team of consultants and technical advisors help to provide concierge-style service to support campus change efforts, while a competitive grants process helps to fund innovation and cross-network learning.

The IAspire Leadership Academy elevates the preparedness of academic leaders from underrepresented groups so they can aspire to and succeed in academic senior leadership roles. Fellows gain critical leadership skills across numerous competencies and learn how to lead institutional change in the increasingly complex environments in which STEM faculty operate. They apply their learning on leadership and change management at their home institutions through institutional action projects.

Aspire's National Change initiative focuses on creating and disseminating professional development for future and current faculty about inclusive teaching, research mentoring, and faculty advising. National Change's Aspire Summer Institute (ASI), launching in summer 2020, is a Train-the-Trainer, week-long intensive institute that provides participants with the knowledge, strategies, and skills for inclusive practices using a holistic framework that develops transferable skills across multiple faculty roles. Undergirding ASI's conceptual framework is a focus on the development of three foundational domains for inclusive practices: knowledge of identity, both of oneself and student, and the impact of identity on learning; intercultural understanding to move beyond passive acceptance of different cultures and cultural identities to actively addressing issues of equity; and, relational skills to more effectively connect and communicate with students and colleagues. In order to align and reinforce professional development practices simultaneously

at institutional, regional and national levels, the National Change team partners with institutions, as well as disciplinary research societies and professional organizations. In addition, National Change is working with disciplinary societies and other stakeholders to expand and raise awareness of the national pool of URG STEM faculty through a national database.

Aspire's Regional Change initiative comprises Regional Collaboratives (RCs) or networks of geographically related 2- and 4-year institutions. Currently, there are Aspire RCs in California, Iowa, and Texas. Three more will be added by 2022, expanding the reach and impact across the United States. In this model, institutions work together to share and develop programs and experiences that work towards increasing the number and diversity of the pool of graduate students and qualified professionals pursuing a teaching career in STEM at 2-year colleges; and expanding and strengthening the skills of future, early-career, and current STEM faculty to teach the diverse 2-year student population.

Broader Scholarly Impact

In addition to attempting to create change by supporting institutions, individuals, and regions in becoming more diverse and inclusive, Aspire's research projects focus on deepening understanding around the strategies and conditions that support increasing inclusivity and diversity in STEM departments and programs. The resulting findings should identify the factors that propel or impede efforts to foster diversity and inclusion in institutions of higher education, how successful networks and collaboratives of institutions are at creating significant change, and how a multi-faceted effort such as Aspire might serve as a model for further systemic change initiatives.

Getting Involved in Aspire

APLU member institutions can engage Aspire through several different avenues. They can apply to become a member of the IChange Network and engage in a deep self-assessment and action planning process. They can nominate and support faculty in the IAspire Leadership Academy, and its accompanying action project, to promote STEM leaders from diverse backgrounds.

Members can enhance their approach to inclusion on campus by attending a research mentor training co-hosted by Aspire and CIMER, sending interested faculty and faculty development professionals to attend the Aspire Summer Institute, or hosting a training on their own campus.

Finally, institutions can join an existing or establish their own regional collaborative. With Aspire, we hope to create lasting, far-reaching changes to the STEM ecosystem and begin to affect the multiple pathways to the STEM professoriate by creating a more diverse and inclusive STEM faculty.

REFERENCES

1. **National Academies of Sciences, Engineering, and Medicine.** *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5.* Washington, DC : The National Academies Press, 2010. <https://doi.org/10.17226/12999>.
2. —. *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads.* Washington, DC : The National Academies Press, 2011. <https://doi.org/10.17226/12984>.
3. **Palmer, R T, Maramba, D. C. and Gasman, M.** *Fostering success of Ethnic and Racial Minorities in STEM: The role of minority-serving institutions.* New York, NY : Routledge, 2013. <https://www.routledge.com/Fostering-Success-of-Ethnic-and-Racial-Minorities-in-STEM-The-Role-of-Palmer-Maramba-Gasman/p/book/9780415899475>.
4. **Rodriguez, C, et al.** *Broadening participation in STEM: A call to action.* Washington, DC : American Institutes for Research, 2012. <https://www.air.org/sites/default/files/downloads/report/Broadening-Participation-in-STEM-Feb-14-2013-0.pdf>.
5. **National Academies of Sciences, Engineering, and Medicine.** *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways.* Washington, DC : National Academies Press, 2016. <https://doi.org/10.17226/21739>.
6. **Mayhew, M J, et al.** *How college affects students: 21st century evidence that higher education works (Vol. 3).* San Francisco, CA: Jossey-Bass, 2016. <https://www.wiley.com/en-us/How+College+Affects+Students%3A+21st+Century+Evidence+that+Higher+Education+Works%2C+Volume+3+-p-9781118462683>.
7. **Kuh, G D, et al.** *Student success in college: Creating conditions that matter.* San Francisco, CA : John Wiley & Sons, 2011. <https://www.wiley.com/en-us/Student+Success+in+College%3A+Creating+Conditions+That+Matter%2C+%28Includes+New+Preface+and+Epilogue%29-p-9780470599099>.
8. **National Center for Science and Engineering Statistics.** *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019.* Alexandria, VA : Special Report NSF 19-304, 2019. Available at www.nsf.gov/statistics/wmpd.
9. **York, Travis T, et al.** *2018 APLU INCLUDES Summit Report: Developing a diverse STEM professoriate through collective impact.* Washington, DC : Association of Public & Land-grant Universities, 2018. <https://www.aplu.org/projects-and-initiatives/stem-education/aplu-aspire/aplu-includes.html>.
10. **York, Travis T, et al.** *2017 APLU INCLUDES Summit Report.* Washington, DC : Association of Public & Land-grant Universities, 2017. <https://www.aplu.org/projects-and-initiatives/stem-education/aplu-aspire/aplu-includes.html>.
11. **York, Travis T and Griffin, Kimberly.** *Diversifying the STEM Professoriate: Defining the Issue at Hand.* s.l. : CAHSI's INCLUDES Conference, 2017. <http://par.nsf.gov/biblio/10041363>.
12. **Griffin, Kimberly, Mabe, Alan and APLU INCLUDES Faculty Diversity Taskforce.** *"A Guidebook for a Campus Self-Assessment of Successes and Challenges in STEM Faculty Diversity.* Washington, DC : Association of Public and Land-grant Universities, 2018. <https://www.aplu.org/projects-and-initiatives/stem-education/aplu-aspire/aplu-includes.html>.
13. —. *APLU INCLUDES institutional self-assessment for inclusive recruitment, hiring, and retention of STEM faculty -- Draft.* Washington, DC : Association of Public and Land-grant Universities, 2018. <https://www.aplu.org/projects-and-initiatives/stem-education/aplu-aspire/aplu-includes.html>.
14. **National Academies of Sciences, Engineering, and Medicine.** *Indicators for Monitoring Undergraduate STEM Education.* Washington, DC : The National Academies Press, 2018. <https://doi.org/10.17226/24943>.
15. **Tovar, E.** *The role of faculty, counselors, and support programs on Latino/a community college students' success and intent to persist.* Community College Review. 2015, Vol. 43, 1.
16. **Center for Community College Student Engagement.** *Show me the way: The power of advising in community colleges.* Austin, TX : The University of Texas at Austin, College of Education, Department of Educational Leadership and Policy, Program in Higher Education Leadership, 2018. https://www.ccsse.org/nr2018/Show_Me_The_Way.pdf.