2018 CoNECD - The Collaborative Network for Engineering and Computing
Diversity Conference: Crystal City, Virginia Apr 29

STEM Success Stories: Strategies for women and minorities to thrive, not just survive, in engineering

Dr. Carlotta A Berry, Rose-Hulman Institute of Technology

Dr. Carlotta A. Berry is an associate professor in the department of Electrical and Computer Engineering at Rose-Hulman Institute of Technology. She is the director of the multidisciplinary minor in robotics and co-director of the Rose building undergraduate diversity scholarship and professional development program. She has been the President of the Technical Editor Board for the ASEE Computers in Education Journal since 2012. She is a member of ASEE, IEEE, NSBE, and Eta Kappa Nu.

Ms. Janice Fenn, Rose-Hulman Institute of Technology

Janice Fenn is Director of the Center for Diversity at Rose-Hulman Institute of Technology, and founder of the Professional Resources Organization, Inc., a consulting firm that provides innovative seminars and training tools to enhance Diversity & Inclusion, Employee Development. Inclusive Leadership and Mentoring. Ms. Fenn's corporate experience includes Senior Director of Global Diversity for Kraft Foods, and positions in human resources and diversity at Sara Lee Corporation and Quaker Oats. Ms. Fenn is co–author of the book Do You See What I See?; creator of the Development Ladder Game™ and the Diversity Fairy Tale Series. Ms. Fenn has been featured in Ebony, Jet, DiversityInc, Wal–Mart's Profiles in Pride, the Black Success Guide. Ms. Fenn holds both BS and MS degrees in Biology from Tuskegee University, and an MBA from Purdue University's Krannert School of Business.

STEM Success Stories:

Strategies for women and minorities to thrive, not just survive, in engineering

Abstract

There are many research studies on women and minorities in STEM focusing on increasing the pipeline, including increasing interest at a young age, diversifying pathways, and identifying success and retention strategies. This paper attempts to add to that body of work by exploring what these students need to be successful upon entering their college study. We present a unique perspective based on interviews with 10 recent STEM graduates from a top-rated engineering program in the Midwest, Rose-Hulman Institute of Technology. This paper focuses on their success stories, and their pathways to surviving and thriving in a campus environment with limited diversity.

This study was completed at a small private engineering institution in the Midwest with an approximate enrollment of 2300 students, 25% of which are women and less than 8% underrepresented students of color. Such a small diverse population presents special challenges for students from diverse backgrounds. With limited opportunities to see or connect with others like themselves, it is challenging to experience a sense of belonging, community, support or mentorship. This may be exacerbated by inadequate academic preparation and minimal information on what to expect once on campus. These ten recent graduates shared information on their background, experiences and their advice to other aspiring students from diverse backgrounds.

The students were diverse based upon their gender, race, ethnicity, socioeconomic background and/or first generation college status. The interviews revealed the critical resources, and survival strategies embraced by these students. This paper will present the results of these interviews, lessons learned, and helpful insights useful for stakeholders to recruit, develop and retain diverse students, and advice for diverse students entering their STEM field of study.

Introduction

This paper presents the results of one-on-one interviews with 10 recent graduates of a small engineering school with limited diversity. The students were diverse with respect to race, ethnicity, socioeconomic background and/or first generation status. The purpose was to identify the methods and techniques that enabled these students to not only survive, but to thrive in a rigorous engineering program, and provide these strategies and resources for future minority students to be successful in a STEM course of study.

Literature Review

To put the results of the study in context, the authors conducted a literature review of related work on the study of women and URM students in STEM programs. The primary focus was on the challenges and the causes for success and failure. Allen-Ramdial & Campbell [1] state that

isolation is one of the biggest challenges faced by URM students in STEM fields. One way to solve this challenge and promote diversity in education is to achieve a critical mass. Unfortunately, this may not be quickly remedied in most environments, thus other intermediary options must be embraced. Isolation may diminish self-efficacy and re-affirm the negative stereotype of the lack of suitability of URM students for STEM study. The presence of peers has been shown to have a positive impact on a student's identity and self-efficacy. Institutional leadership who support practices that create a culture of inclusion and eliminate negative cultural practices that undermine a diverse learning environment and community are also critical in making advances in STEM diversity.

Although strong leadership commitment to diversity in STEM is critical, the authors suggest that the support of faculty is even more critical to the success of diverse students in STEM, as faculty have significantly more one-to-one contact with the students on a daily basis, and over a longer period of time. Thus, it is critical to more adequately prepare faculty for this role through diversity and inclusion training, in order that they may engage and support diverse students appropriately. Faculty should be engaged in supporting these diverse students beyond their teaching role, including academic advising, coaching and mentoring, social status checks, and more. Furthermore, faculty involved in these roles should be supported and rewarded, as they would be for other important campus initiatives. Nonetheless, there are some challenges with this approach since research has shown that women and minority faculty typically already have a heavier service load and more diversity responsibilities than do their peers.

Berry & Walter [2] describe an NSF S-STEM a mentoring and professional skills program developed to increase the recruitment, retention and development of URM in STEM fields. They posit that in order to retain underrepresented populations in STEM, it is necessary to support the emotional as well as the academic needs of these students. Thus, the primary goal of this program is to promote inclusion and support, thereby eliminating the sense of isolation that diverse students in STEM often describe. A complete program ideally includes workshops, mentoring and professional development. However, it is frequent that some or all of these components may be missing in a traditional STEM curriculum. Another critical component of supporting the success of URMs in STEM is special outreach to secure internship, co-op or research experiences for these students. These experiences are the lynchpin to students understanding how their technical education relates to their future career goals. In addition, students who receive and are successful in these experiences are better able to overcome the marginalization and isolation that is inherent in current STEM programs, and are better positioned to mentor and support other URMs to successfully complete their course of study. Roper [3] states that students that attend a Historically Black College (HBCU) are more likely to earn a STEM degree because of these pre-existing structures of community and support.

Gandara, et al. [4] also found that minority engineering programs and/or universities that are more highly effective were typically smaller. However, because of their smaller size, these programs may not be able to create a critical mass of students. Particularly excluded from some of these smaller programs with limited funding are students who are financially needy. This limited funding might also impact the breadth of course work and diversity of the faculty, which

correspondingly impacts the quality of the students' total education. Thus, many small recruitment and retention programs must determine whether their ultimate goal is to create survivors or to produce leaders as they seek to focus their efforts. This is where the stakeholders must make tradeoffs regarding what they want their primary goal to be. Female engineering alumnae at the University of Missouri-Rolla report that their success was partially based upon the small school environment, which allowed them to develop relationships who shared common goals and interests. Additionally, this small environment provided the opportunity for them to take on leadership roles in student organizations.

Hurtado et. al, Hurtado et. al, Chang et. al, Garcia and Hurtado, Herrera et al., and Egan et. al performed several studies to identify conditions and practices that increase retention in STEM and prepare students for graduate study and STEM field careers [5], [6], [7], [8], [9], [10]. They performed a longitudinal study for seven years to track a cohort of students from a wide array of institutions including predominantly white (PWI) and minority service institutions (MSI). One finding was that science course work based upon application to one's life experiences had a significantly positive impact on academic performance and social adjustment for URMs in STEM.

Another impact on the success of URMs is the resources that they receive from upperclassmen and peer networks. This includes practical study tips and resources, recommendations and inclusion in social circles. In fact, research shows that joining a club during the first year of college appeared to affect persistence in a major. These organizations allow students to engage in a peer group that shares their academic and career interests, which may reinforce their identity, and academic and career goals. One finding showed that participation of URMs in undergraduate research, which is linked to their pursuit of advanced STEM degrees, is heavily dependent upon the feedback and recommendations these students receive from their peer networks. When there is not a critical mass of URM students to provide this support, URM students are significantly adversely affected.

High-status and selective non-MSI universities have a negative effect on STEM persistence because of the educational climate fostered. The peer environment at such schools may be highly competitive, and faculty members may be more focused on research than teaching. Furthermore, limited minority faculty results in a limited number of role models for URM students. Additional challenges that URMS majoring in STEM have to overcome are cultural value differences, disparate socialization processes, internalization of stereotypes, isolation, perception of racism, and inadequate program support. Due to the statistically significant results that predicted that URM students were less likely to complete an undergraduate STEM degree, this presents a unique challenge for institutions to implement programs that specifically target retaining these populations. Results indicate that there is an increased chance of retention of URMs at HBCUs and Hispanic Serving Institutions (HSI) due to stronger connections between students and faculty. However, it appears that student persistence to completion increases as the level of selectivity increases, which would be a result at majority institutions as well.

This same research indicated that financial concerns affect the rate of URM applications to STEM fields of study as well as their persistence in the program. URM students were more likely to have worked more hours in high school reducing their availability to participate in STEM

courses and enrichment programs, thereby affecting their application rate. Furthermore, participation in such a research-oriented program prior to college has also been shown to change these results to improve persistence. Once in college, URMs express more financial concerns than majority students, which reduce the likelihood of majoring in sciences and affect their academic and social adjustment.

Espinosa [11] examined data from several freshman surveys to identify the self-concept of African American and Latino men and women in STEM majors. The author found that some predictors of success for women were related to frequency of working on group projects while for men it had to do with satisfaction with math and science coursework and the opportunity to conduct research. It appeared that the college environment was a greater predictor of success compared to background characteristics or precollege experiences. The study also indicated that the college environment makes students less sure of their motivation to achieve. This may indicate that despite lack of academic preparation, these students can achieve success if the college climate is supportive and conducive to success.

Strayhorn [12] summarized his study on the social barriers and supports for URM students in STEM fields based upon individual and group interviews of 39 URM students majoring in STEM. The measure of success was based upon persistence in a STEM major and maintaining a 3.0 GPA. The barriers were categorized into three major themes including negative perceptions/stereotypes, lack of same-race peers, and negative classroom interactions. The themes for the supports were URM faculty mentors and sociocultural and spiritual resources. The results indicated that students who belong to one more cultural groups such as NSBE, honor societies, student government, or gospel choir that value education, achievement and persistence were more likely to persist in STEM fields. This is consistent with some of the earlier findings but may be one of only many needed supports to ensure success.

Estrada also examined methods to improve URM student persistence in STEM [13]. The study found that students who participate in co-curricular programs pursue STEM careers at a higher rate than those who do not participate in intervention programs. These programs typically included research experiences, mentorship, or both, and were used to build efficacy, identity, and values to improve student persistence and retention. These supports may be enhanced even more with the addition of a bridge program from high school to the university.

Lastly, Kendricks and Arment [14] presented the adoption of a K-12 family model to enhance STEM persistence and achievement for URM students. Their work indicated that students perform better in a multicultural learning environment with some emphasis on social and academic needs. The program has six activities including research, professional development workshops, graduate school visits, honors programs, mentoring, academic learning community and a living, learning community. It was not necessary to modify the academic rigor of the STEM program but rather to make significant changes to the campus environment. Since these authors have presented a K-12 model, the framework to create a K-16 model for a seamless integration from high school to college already exists.

Method

During the 2016 and 2017 school year, ten STEM graduates were interviewed by the authors to identify strategies for success as well as the resources they identified as being critical to enabling them to persist and successfully graduate. The questions posed are available in the Appendix.

Results

The students interviewed included five women and five men with the ethnicities shown in Figure 1. It should be noted that due to the low numbers at the university, it was not possible to get any students with Latino/Hispanic or Native American ethnicity. Some of the students were born in the US; some were not citizens and some came to the United States solely to go to college. The students were asked about their high school diversity profile in order to gauge their experience with diverse populations before entering the university. Of the 8 students who responded to this question, 50% attended predominantly white high schools similar to the institution. Of the remaining high schools, one went to a predominantly Asian high school and the other 3 went to a racially mixed high school. Figure 2 provides a summary of the degrees obtained by the students.

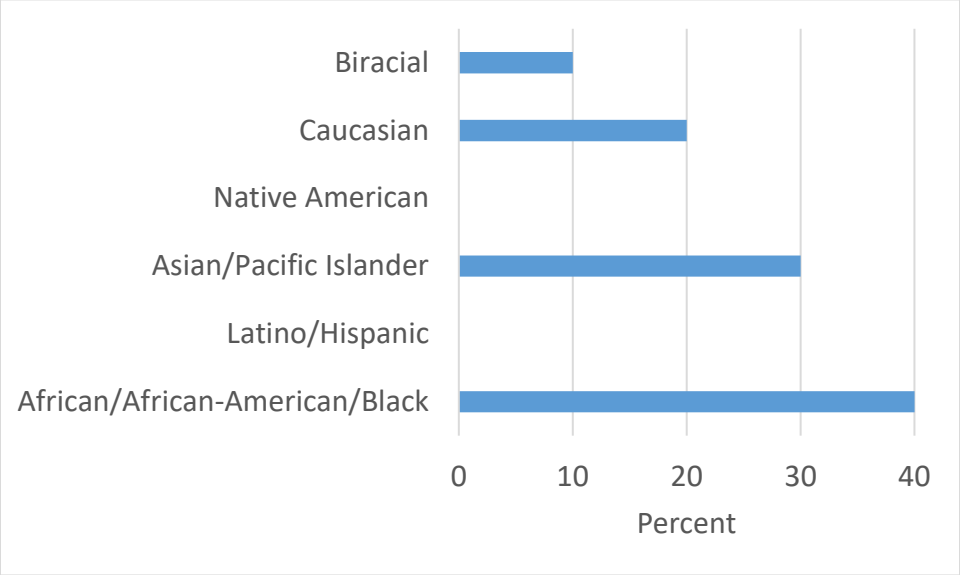

Figure 1: Student Ethnicity

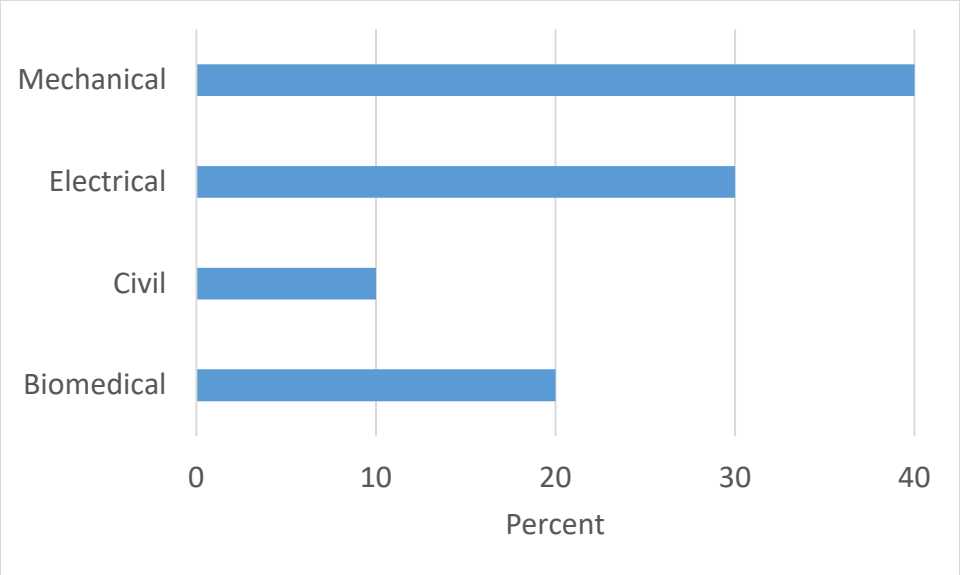

Figure 2: Engineering Degrees

Students were asked about their high school class rank in order to gauge their academic preparedness for engineering school and these responses are presented in Table 1. This group included at least one valedictorian and it should be noted that this institute is a selective and academically rigorous, competitive school so it would be expected that most students were in the top of their class. The institute has an approximate 60% admission rate with most students having an A average in high school, ACT scores of 25 or higher and combined SAT scores of 1200 or higher. Table 2 provides a summary of the self-reported ACT and SAT college test scores.

Table 1: High School Graduation Placement

Rank	Number
Top 10%	6
Top 20%	0
Top 30%	1
Top 50%	1
Not Sure	2

Table 2: College Test Scores

SAT	#	ACT	#
>30	2	>2000	2
>25	2	>1600	2
>20	1	>1200	0
Don’t recall or did not take	3	Don’t recall or did not take	3

Math and Science Preparation

The students were asked about their math and science preparation before attending college. One student stated that their parents were in math and science and encouraged them to do many science-based summer programs. All of the students participated in at least one middle school or high school STEM summer program. At least four of the students took AP math and science courses and two students were in Project Lead The Way in high school. In addition, at least three students earned some college credit in math and science before formally enrolling in college. Most students learned of this small engineering school in the Midwest through a mentor or family friend or a flyer in the email and at least two students were recruited to play sports for the school.

Financial Support

Since financial concerns are a major influence on college performance, students were also asked about how they were funding their education. Most students had a combination of scholarships, loans, parental assistance, work-study and/or other jobs. Some students were on full-tuition minority scholarships. One student was completely supported by his parents.

Academic Experience

The students were asked about their transition from high school to college and the freshman academic experience. Five students stated that their freshman year went fine due to summer transition programs or because they were used to studying from high school. Five students stated that because they did not have to study in high school, thus the rigor of the university was difficult. It was about a year before they learned how to balance their time between personal and academics pursuits. Students stated that they overcame these challenges by going to see professors, learning to ask for help from peers and seeking tutoring. One female student recounted that the academic challenges were exacerbated by male students proclaiming that she was only here because she was female. Some minority students also addressed that majority students were resentful and felt they earned more scholarship or were only admitted because of their race or ethnicity.

With respect to the overall academic experience, several students indicated that the school was challenging; nonetheless, it is possible to get through with a strong work ethic and dedication. One reason this is possible is the strong connection between the students, faculty, and staff. One student stated that they had been dismissed from the university twice due to academic issues but was determined not to fail nor to return home. They were able to overcome these challenges with long nights, working hard, prayer and speaking to professors and mentors. They understood that the overall goal was graduation even if the overall GPA was below a 3.0. One student stated that work-life balance is key with respect to extracurricular activities. Two students stated that their fraternity and sorority as well as access to the old files provided by their club networks was key to improving their academic performance. One also stated that engagement in NSBE was critical in creating a balance between work and personal time, and invaluable in helping them to feel a part of the campus community.

Support Services

In general, most students had a positive experience at the university. A few stated that they had negative experiences trying to do group work or being stigmatized for being different. In addition, one stated that the counseling services could be improved to help students deal with the stress of the rigorous environment. One student stated that there are some negative and positive aspects of a small university environment, For example, professors are there to support you but they also talk to each other, which may create pre-conceived notions within the faculty community about your performance or potential.

Students were asked about the support they needed, sought out or received. Many of them stated that they needed relationships with student, faculty, and staff and most times, they were able to have these. They also sought out and received emotional support through clubs, fraternities, and sororities. Some students stated that they were too shy to seek out the necessary personal relationships but they were still able to develop them when others reached out. One student stated that she was also able to manage her stress through the counseling center. She acknowledged that she sought out tutors, but did not always find them very helpful. One student stated that he needed more advice on what to do after the job interview or at the beginning of his professional career. Another student also stated more resources on how to navigate corporate America and work with people from multiple disciplines would have been invaluable. Two students stated that the mandatory orientation to college course taught during their freshman year was not very helpful in exposing students to university resources success strategies. This feedback presents an opportunity for the campus to make this course a more relevant, meaningful introduction to the university.

Some students expanded on the supports that they felt were missing. One felt that the school did not completely value diversity, which meant there were not always supports for organizations such as NSBE, SHPE, SASE or SWE. One student felt that some clubs or organizations were a clique and it was difficult for an outsider to break into them. One of the international students also felt that there were not many resources for first generation international college students. Another expressed that there were not enough resources for students who did not have a strong calculus foundation upon entering the college.

Keys to Success

Students were asked about their key to thriving in a STEM field. One student stated that there must be a willingness to learn everything. Students have to learn how to ask for help, how to rely on other people, and how not allow pride or the stigma of needing assistance to deter you. One student stated that his strong Christian faith along with great classmates and friends were integral to his success. Another student stated that tenacity as well as faith was a big part of persistence. One student felt that identifying the necessary resources for each class and understanding that they are all different is key. Furthermore, it is necessary to become more personable, outgoing, and engaging and learn how to speak with passion, sincerity and confidence to make necessary connections. Along these lines, one student said it was important to make personal connections and eliminate the isolation created by high engagement with social media, computers and video games. It is necessary to be social in order to manage the high level of stress. It it is important to

get out, explore campus opportunities, and engage in professional organization activities. Several students emphasized that it is important to use time management to plan study, class and relaxation time in order to maintain yourself physically, mentally, and emotionally. Some students encourage expanding your horizon beyond your major to learn about other areas and talking to a wide array of people across campus. One student encouraged finding a study group with a mixture of peers, not just the ones that provide the most comfort. It is also helpful to identify an upperclassmen mentor in your department to help with course work.

Finally, all students were asked about their plans after graduation, 6 are going to work in a STEM field, 3 are going to graduate school in a STEM field, and 1 is going to graduate school in engineering management.

Conclusions

In conclusion, this paper has presented a summary of one-on-one interviews with 10 recent STEM graduates at a small engineering school in the Midwest. The purpose of the exit interviews was to identify strategies and resources that enabled them to persist and successfully graduate with a STEM degree. They were not only asked about their academic background including preparation but how they handled the rigor of an engineering program and what resources and support services they recommend to those that will come behind them.

Sense of Belonging

One common theme among most students was that they needed a sense of belonging that is provided through participation in a mentorship, professional organization or cultural organization such as NSBE, SHPE, AISES, SWE, SASE, honor society, fraternity, or sorority. Although some students waited a couple of years before joining these organizations, they came to regret this decision because the experience was so invaluable and gave them a sense of shared experiences, understanding, and a strong desire to support each other. As stated earlier, research has shown that this sense of comfort on a college campus can eliminate isolation, marginalization and give them the needed confidence to excel in their studies.

Confidence

Another observation was that students must have the self-awareness to recognize when they need help. They may not realize that their failure to recognize this need may not be due to a lack of aptitude but rather limited exposure, performance in pre-requisite courses, or inadequate high school curriculum. This deficiency requires students to have the confidence to ask for help and get beyond the sense of embarrassment or pride. When these concerns are not addressed, it may translate into the students feeling they are not suitable for STEM due to initial challenges with foundational courses such as physics and calculus. The students also have to overcome the intimidation of speaking with faculty or asking for tutoring. These concerns are sometimes amplified when they realize they are one of only a few students of color. They have this overwhelming need not to stand out from the group anymore than they feel that they already do.

Enrichment Programs

An important resource for STEM success is summer enrichment programs to introduce students to STEM as well as transitional programs to prepare them for the rigor of college courses. Many times these programs must provide financial support or college credit incentives to draw the target population. The authors propose that these programs must be sufficiently marketed so that first generation students of color are aware of these programs and the resources available.

Financial Concerns

For many students of color or first generation students, there are financial concerns that affect their academic performance and sense of belonging. It is difficult for students to work full-time while also managing a full-time course load and making connections with faculty, staff, and students to seek out help when needed. In some cases, students may not have enough money for books, to travel home, or incidentals. Many times their student loans may be as much money as their parents make, which can be overwhelming for a college student. Furthermore, these students sometimes have to deal with envy from majority students who feel that the scholarships received by underrepresented students are not fair or deserved.

Mentoring

Students have stated that lack of mentors or role models in high school to steer them to STEM and encourage them is a needed resource. In addition, a great support system in college such as faculty can help them to persist and remain in a STEM major. The difference between these students and others may be that it was not a topic of dinner conversation when they were small. Students may not have any close friends, colleagues or parents who laid out STEM career expectations or even knew anyone in these professions. Therefore, students gravitate toward faculty and staff to receive this affirmation, encouragement, and guidance for support.

Future Work

In the next phase of this work, the authors will interview more women and URM STEM graduates and use their feedback to create a database of resources and design a formal support program for incoming freshmen. Some possible programs and resources could include formal faculty and staff mentoring, peer mentoring, academic support services, college bridge program, and community building activities.

Acknowledgment

The authors would like to thank all the students interviewed and Rose-Hulman Institute of Technology for providing resources supporting this work.

References

[1] Allen-Ramdial, S. A. A., & Campbell, A. G. (2014). Reimagining the pipeline: advancing STEM diversity, persistence, and success. BioScience, 64(7), 612-618.

[2] Berry, C.A. & Walter, D.J., "ROSE-BUD (Rose Building Undergraduate Diversity) MAPS (Mentoring and Professional Skills)", *Proceedings of the 2013 American Society of Engineering Education (ASEE) 120th Annual Conference and Exposition*, Atlanta, GA, June 23 - 26, 2013.

[3] Roper, C. (2011). Developing talent in science and technology: Institutional factors and minorities in the STEM disciplines.

[4] Gandara, P. and Maxwell-Jolly, J. (1999). Priming the Pump: Strategies for increasing the underrepresented minority undergraduates, The College Board, New York.

[5] Chang, M. J., Sharkness, J., Newman, C., & Hurtado, S. (2010, May). What matters in college for retaining aspiring scientists and engineers. In annual meeting of the American Educational Research Association, Denver, CO.

[6] Hurtado, Sylvia, et al. "Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project." New Directions for Institutional Research 2010.148 (2010): 5-15.

[7] Hurtado, S., Eagan, M. K., Tran, M. C., Newman, C. B., Chang, M. J., & Velasco, P. (2011). "We do science here": Underrepresented students' interactions with faculty in different college contexts. Journal of Social Issues, 67(3), 553-579.

[8] Eagan, M. K., Hurtado, S., & Chang, M. J. (2010, October). What matters in STEM: Institutional contexts that influence STEM bachelor's degree completion rates. In annual meeting of the Association for the Study of Higher Education, Indianapolis, IN.

[9] Garcia, G. A., & Hurtado, S. (2011). Predicting Latina/o STEM persistence at HSIs and non-HSIs. University of California, Los Angeles.

[10] Herrera, F. A., Hurtado, S., & Chang, M. (2012). Maintaining career aspirations in science, technology, engineering, and mathematics (STEM) among college students. In annual conference of the Association for the Study of Higher Education, Charlotte, NC.

[11] Espinosa, L. L. (2008). The academic self-concept of African American and Latina (o) men and women in STEM majors. Journal of Women and Minorities in Science and Engineering, 14(2).

[12] Strayhorn, T. L. (2010, October). Work in progress—Social barriers and supports to underrepresented minorities' success in STEM fields. In Frontiers in Education Conference (FIE), 2010 IEEE (pp. S1H-1). IEEE.

[13] Estrada, M. (2014). Ingredients for improving the culture of STEM degree attainment with co-curricular supports for underrepresented minority students, Commissioned paper for National Academies of Science, Engineering and Medicine. National Academies of Sciences White Paper.

[14] Kendricks, K. D., & Arment, A. R. (2010). Adopting a K-12 family model with undergraduate research to enhance STEM persistence and achievement in underrepresented minority students.

Appendix

Student Interview Questions

1. Name

2. Student Age
3. Gender
4. Ethnicity
5. Members in Household
6. High School Name
7. High School Student Diversity Profile
8. Math & Science preparation before college
9. How student learned about school
10. Financial support at college (parents paid, scholarships, loans, combination, work-study, etc.)
11. Freshman year academic experiences
12. Overall academic experience at college
13. Overall student experience at college
14. What support needed, support sought, support received
15. What support was still missing
16. The key to success for you in college
17. What you recommend for others to be successful at college
18. Graduating with a degree in
19. Long-term goals