Increasing Retention Rates of Undergraduates in STEM

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APMA 1910: Race and Gender in the Scientific Community

ABSTRACT

This research focuses on understanding why there exists a large discrepancy in the STEM concentrator student body-- specifically, the disproportionate amount of underrepresented minorities (URMs) who leave their intended STEM concentrations sometimes in favor of another STEM concentration, many times in favor of a non-STEM concentration. We analyze faculty and student interviews to understand the disconnect between the two and create an actionable items for the University, departments, professors, and students to help increase the retention of students studying STEM, particularly URMs.

KEYWORDS

Minorities in science, Minorities in technology, Minorities in mathematics, Minorities in engineering, Academia, Race, Undergraduate Attrition, Undergraduate Retention, Diversity, Inclusion

NOTES

Research project prepared during the 2017 spring semester at Brown University for course APMA 1910: Race & Gender in the Scientific Community

I. INTRODUCTION

Motivation behind this research project began during the Spring 2017 semester at Brown University in a course called APMA 1910: Race & Gender in the Scientific Community. This course sought to understand the inner workings of how different scientists, who identify with a variety of different ethnicities, cultures, races, genders, and groups, experience traversing through higher education and beyond, specifically within science, technology, engineering and mathematics (STEM) fields. We decided to focus our research on understanding why there exists a large discrepancy in the STEM concentrator student body-- specifically, the disproportionate amount of underrepresented minorities[1] (URMs) who leave their intended STEM concentrations sometimes in favor of another STEM concentration, many times in favor of a non-STEM concentration.

It is necessary to first acknowledge that although the scope of this paper focuses on anecdotes, conversations, and perspectives from students, faculty, and administration from the high school and college levels, it is recognized that the contributing factors to the leaky pipeline[2] often start long before high school. A combination of oppressive systems, familial conditions, and other variable situations all lead to students being disinterested, discouraged, or disengaged from pursuing careers in STEM. Our research relied heavily on personal experiences, one-on-one interviews, and qualitative and quantitative research-- similar to that of an ethnography.

II. HIGH SCHOOL STUDENTS AND STEM

Issues of retention are not unique to higher education alone-- according to Mary Lewis Siversten, students lose interest in science as early as fourth grade. While in middle school, many students are interested in math and science, however, by the time they are in high school, many of them have come to the conclusion that scientific fields are not for them. According to Snyder & Dillow, 48% of Black eighth graders and 43% of Latinx eighth graders reported that they "often" or "always/almost always" found their math work engaging and interesting, yet “[m]ore than three out of four high school students who test in the top mathematics quartile do not pursue a STEM major in college. Additionally, of those who pursue STEM majors, only 50% actually complete their degree in a STEM area” (Faber et. al.). There are several factors that contribute to students’ loss of interest for the field, including the lack of representation of women and minorities in STEM, media’s portrayals of scientists and mathematicians, and poor STEM education in schools, among others (“Generation STEM”).

We created a survey for high school students to gauge their feelings about STEM and education. The survey was shared on Facebook, a popular social media platform, and we received 229 responses over the course of about two weeks. The survey consisted of 17 anonymous and optional questions, of which 16 were open ended with text based responses. All four years were represented, with 29.69% of respondents identifying as freshmen or first years, 10.92% as sophomores or second years, 25.33% as juniors or third years, 32.31% as seniors or fourth years, and 1.31% as super seniors (students in their fifth or more year of high school). Three countries, over ten states across the United States, and an online school were represented

[1] The National Action Council for Minorities in Engineering defines URMs as “African Americans, American Indians/Alaska Natives, and Latinos” (Underrepresented Minorities In STEM).

[2] The leaky pipeline is a metaphor for the way that historically underrepresented groups disappear from pursuing STEM educations and careers.

in the responses. 63.32% of respondents identified as "woman" or "female". 69.43% of respondents attended Northside College Prep (NCP)[3], a selective enrollment high school in the northwest side of Chicago.

Aggregate High School Survey Results

- 17.11% of White-identifying respondents feel that they do not "belong in math and/or science" compared to 17.65% of Black or African American identifying respondents and 33% of Hispanic or Latinx identifying respondents.
- 11.86% of White-identifying respondents remembered a time when they "really liked math and/or science" but no longer like it compared to 11.76% of Black or African American identifying respondents and 31.11% of Hispanic or Latinx identifying respondents.
- 13.16% and 5.26% of White-identifying respondents feel that school has negatively or somewhat negatively "changed the way they see [themselves]", respectively, compared to 0% and 25% of Pacific Islander-identifying respondents, 11.76% and 23.53% of Black or African American identifying respondents and 13.33% and 22.22% of Hispanic or Latinx identifying respondents.
- 14.47% and 22.37% of White-identifying respondents do not "feel in charge of [their] education and/or future" or only slightly in charge, respectively, compared to 11.76% and 29.41% of Black or African American identifying respondents and 20% and 22.22% of Hispanic or Latinx identifying respondents.

The aggregate high school survey results shown above, show that the demographics and perceptions of incoming students interested in STEM are already skewed. Therefore, it is important to address students' concerns early in their Brown/college careers and even more important to set the proper systems of support in place such that STEM attrition rates are minimized. Students who decide to not pursue their intended STEM concentrations should make the decision not because they feel inferior or unsupported in their departments, but because they have found another concentration that best suits their needs:

> Intelligence can only be led by desire. For there to be desire, there must be pleasure and joy in the work. The intelligence only grows and bears fruit in joy. The joy of learning is as indispensable in study as breathing is in running. Where it is lacking there are no real students, but only poor caricatures of apprentices who, at the end of their apprenticeship, will never have a trade (Weil 120).

III: BROWN STATE OF AFFAIRS

Numbers in STEM

Recently, Brown departments were required to create Departmental Diversity and Inclusion Action Plans, also known as DDIAPs, and submit them to Brown's Office of

[3] NCP is ranked among the best schools in the nation (U.S. News), has an average ACT score of 30 (out of 36) and a graduation rate 99%, according to the Illinois State Board of Education. Many graduating seniors at NCP attend elite universities such as Brown, Columbia, Northwestern, Stanford, and Yale, among others (Northside Prep).

Institutional Diversity & Inclusion. This initiative was part of the University's overall action plan to "create a more diverse and inclusive academic community and to address issues of racism and various forms of discrimination" (Action Plans).

URMs make up roughly 30% of the United States population (U.S. Census). Members of historically underrepresented groups[4] (HUGs) comprise 19% of Brown's undergraduate population and 9% of all faculty members. In the 'Life and Medical Sciences' and 'Physical Sciences' URMs make up only 7% and 5% of faculty, respectively. According to their DDIAPs, of the seven STEM departments researched, only one has the same or a higher ratio of HUG concentrators and none have the same or higher ratio of faculty. In the Applied Mathematics department, 5% of concentrators and 4% of faculty members are URMs. In Biology, 20% of concentrators and 7% of faculty members belong to an HUG. In Chemistry, 10% of concentrators identify as students of color[5]. No data regarding faculty diversity is present in the Chemistry DDIAP. In Computer Science, 6% of undergraduates who completed their computer science degree in 2016 were members of HUGs. According the DDIAP, the department currently has no data on the ethnic/racial makeup of their faculty, but they 'are working with the Dean of the Faculty's office' to collect it. In Engineering, 13% of concentrators and 4% of faculty members are URMs. No information regarding student or faculty demographics was found in the Mathematics DDIAP. Lastly, in Physics, 7% of undergraduates and 3.5% of faculty members belong to a HUG.

STEM Department Concerns

We interviewed faculty and staff members in the seven departments mentioned above to learn more about what problems different departments face and what best practices are needed to foster a diverse and inclusive community.

Faculty and Staff Interview Questions

- What do you think an ideal <<department>> student looks like?
- In what ways do you try to make your courses or department more inclusive?
- What do you think are some best practices for teaching a diverse group of students?
- Have you noticed any disparities among different groups of students, either by race, class, background, geographic location, or other?
- Do you have any thoughts or opinions as to what contributes to these disparities?

A common issue many departments face, according to to several faculty members, is the lack of a sense of community among concentrators. The Computer Science department however, seems to not have an issue of competitiveness or lack of community, according to several professors and students in the department. Some attribute the department's long-standing Undergraduate Teaching Assistant (UTA) program, introduced by Professor Andy van Dam since

[4] Brown defines HUGs as "people who self-identify as Hispanic or Latinx, American Indian or Alaska Native, Black or African American, or Native Hawaiian or Other Pacific Islander" (Pathways to Diversity and Inclusion). We use the terms HUG and URM interchangeably throughout this paper.

[5] Although the DDIAP does not clarify what races or ethnicities constitute 'students of color,' White, Asian, 'students of color,' and 'other' are all classified disjointly.

the department's inception in 1965 (van Dam) as an important factor in the feeling of unity among students.

Another source of concern is the lack of data departments have regarding the demographics of their student body. After making initial contact with the professors interviewed, many of them were hesitant about talking about their departments either because they did not have any data to support their claims, or because talking about student demographics requires caution, due to privacy regulations. For a lot of departments, working on DDIAPs was the first and only opportunity they have had to see concrete numbers regarding their student populations. Without the proper statistics, departments have a difficult time gauging the success of their initiatives and understanding the issues their departments face.

The biggest concern mentioned by several staff and faculty is the lack of training provided to professors. Best put by Dean Katherine Smith,

> Faculty pursue a career as a scholar and an academic where they're diving very deeply into their one particular field and that's where their focus is: the content in their area of study and advancing it. And never along the way really, have many of us been given the training that we need to do the things we're being asked now [...] Nowhere in my Ph.D. or post-doc training did anyone ever sit down and say, 'You know what, one day, you're going to be teaching a room of diverse students. How do you think you might go about that to do it effectively and recognize that you have a room where people are coming from different backgrounds and different learning needs?'

Although Brown has the Sheridan Center, "a place where faculty, graduate students and postdocs come together from across the disciplines to inquire about, explore, and reflect upon teaching and learning as ongoing and collaborative processes" (Sheridan Center for Teaching & Learning), not many professors know about it nor the resources available through it. Furthermore, some professors seem to believe that an inclusive classroom is 'one-size fits all,' and they fear losing their individuality in the name of inclusion (Smith). The professors who indeed try to be more inclusive in their classroom do not always use best practices. As stated by a professor in the Computer Science department,

> We do a lot and a lot of it is not grounded in research; we're not aware of the literature or we don't care to read it or whatnot and I think that's a bad thing because good intentions don't always lead to good outcomes.

Non-STEM Experts

In an effort to fully understand the leaky pipeline phenomenon, we felt it necessary to speak with faculty and staff outside of STEM, in departments such as Education, Sociology, and Ethnic Studies. Those interviewed have done research in or are involved in studies of discrimination, income inequality, minority education, and systemic racism, to name a few.

The first of these conversations was with Dr. Andrea Flores, an Education lecturer at Brown. Dr. Flores focuses primarily on Latinx youth education as well as immigrant education, but often looks into the realm of studying how race, class, geography, and community play into educational attainment due to intersectionality. In speaking with Professor Flores, it was understood that there are very prominent structural, historical, and cultural issues at hand, ones that affect many URM students in higher education, especially those within STEM. "How do we prepare URM students for the struggles they are going to face in STEM; how are we going to

prep them with a challenge they might not have ever had before?" says Dr. Flores, alluding to the fact that often times, students who go to prestigious high schools or colleges are not as academically prepared as their wealthier counterparts. Because there tend to be such few numbers of URM students in STEM, many carry the added pressure of feeling that they must represent their families, cultures, and identities in the classroom. For students of low-income backgrounds, there is an added pressure to not only provide for themselves, but also provide for family members. Financial responsibilities can therefore be a determining factor for students debating whether to endure in a discipline they may not feel prepared for.

Dr. Flores reflected on her own experience as half Guatemalan, as well as in the experiences of many of her URM students: "There's a crisis of low expectations that begins very early-- lack of resources and/or lack of funds… although high-income does not mean you'll necessarily make it through!" Being transparent, humanizing education, and making material relevant to students' lives were all practices mentioned to improve higher education. Furthermore, educators must bear in mind that for students from underrepresented backgrounds, the obstacles and pitfalls are much greater, and therefore the pressure is often heavier and more detrimental to their psyche.

Primarily interested in the ways that science perpetuates and even exacerbates many of the societal injustices and implicit discriminations of everyday life, professor of Biology and Africana Studies, Lundy Braun, was a Science and Society undergraduate who eventually joined the world of academia. In contrast with Dr. Flores' account of cultural factors that affect the retention of URM students in higher education, Dr. Braun was critical of the systems and institutions in place that dramatically affect the perceptions of scientists, lecturers, and students alike. Professor Braun "studies science and how it has produced our ideas of race-- how science perpetuates racial inequality through research saying that the DNA is different." According to Dr. Braun, "current scientific practices are rooted in racist assumptions and ways of thinking" which undoubtedly makes for difficult classroom experiences, especially when placed in the context of institutions that were historically reserved for White male students only.

According to Dr. Braun, scientific teaching is not personable, nor does it contextualize what exactly it is that is being learned. Having experience in teaching and understanding both traditional scientific fields and social sciences, she notes that "everything in social sciences and humanities is contextualized and at least perceived as relevant," unlike in the 'hard' (physical) sciences. The teaching, she adds, is "caught up in theory" and ceases to make science relevant in the lives of the students who are attempting to learn. One must highlight that as important as theory is, it is also important to contextualize it. One of the largest discrepancies we were able to point out in our conversation with Dr. Braun was that it is harder for students in the sciences to recognize that their work is truly important, and not just a way to achieve financial stability. If educators ensure material is presented in a culturally relevant manner, students will be more likely to not become disinterested in their scientific pursuits.

From a sociological perspective, Professor John Logan argues that "it's all about exposure." A researcher of race relations and inequalities, he alludes to some people's socialization at a very young age to think mathematically and scientifically. Unfortunately, that is precisely one of the major problems in STEM-- because most STEM classes assume that every student is starting with the same background knowledge, students who fall behind are presumed to not be 'cut out' for the field. According to Professor Logan, the Sociology department at Brown starts with students where they are and seeks to develop their skills from there--

depending on what each student wants to research and their area of expertise, among others. On the other hand, STEM fields often require foundational prerequisite knowledge that leaves certain students behind or even incentivizes them to quit early.

"It's a combination of racial and class inequalities," says Professor Logan. To help reduce the effects of said inequalities, Dr. Logan suggests making science more subjective, adding a humanizing science, and understanding that every student has a different background and pre-acquired knowledge. As summarized by Professor Logan, "there's a whole category of lower-income people where they encounter challenges all the time and either have to grind through them for make their own way around them… sometimes school is not a priority in some people's chaotic lives and the easiest way to move on is to quit, seen as just another barrier." While convincing students that science is relevant, making the playing field more equitable by acknowledging students' different backgrounds will help increase retention rates for URM students overall, not just within the STEM fields.

Undergraduate students

We spoke with a variety of different undergraduates, in departments including Economics, Engineering, Computer Science, and Biology. The conversations sought to understand different factors involved in choosing and eventually declaring a concentration.

Undergraduate Interview Questions

- What have been some of the obstacles you've faced in your department or concentration?
- If you switched concentrations, why did you switch? If you haven't switched concentrations, have you ever considered switching concentrations?
- Are you happy with your department, including professors, advisors, courses, and fellow concentrators?
- Are you happy with the concentration you're pursuing?
- What, if anything, do you find to be the biggest differentiating factor between choosing to whether or not to study STEM for students of color and the rest of the student body?
- What, if anything, do you find to be the biggest difference in actually studying/pursuing STEM for students of color?
- Have you ever faced either implicit or explicit discrimination in studying your field, either from your professors or your peers?

For the most part, a lot of the responses were similar. Alex, Sara, and Kendal identify as women of color in Computer Science-- notoriously one of the most rigorous and time-demanding concentrations at Brown. Each of them recalled the Computer Science curriculum as frustrating and often times even demoralizing, noting that the primary things that got them through their struggles were having friends, peer advisors, TAs, and mentors, as well as keeping a very determined mindset of refusing to give up at all times. The former point about peers, mentors, and human elements that played vital roles in achieving their respective educations, is one of the reasons many of the students we have spoken to switched to Computer Science from other science fields such as engineering. At Brown, the Computer Science department makes a valiant

effort to recruit, train and even pay an array[6] of teaching assistants, mentors, advisors, and counselors of diverse identities to create the inclusive environment students need. “Other departments really should take notes,” one of the students said, noting that similar to the opinion that many of the interviewed non-STEM professors had, the humanizing is key to making sure students learn as safely and effectively as possible.

However, it is not to be interpreted that the Computer Science Department, unlike other departments, does not have flaws-- a common theme among STEM students we spoke with was the idea of the objectivity of science and subjectivity in their other social sciences or humanities courses, as put by one student “in my ethnic studies classes, I am not afraid to raise my hand and contribute because I feel like what I have to say is relevant and is going to be heard.” The very nature of STEM curricula creates a binary of right and wrong, due to the ‘objectivity’ of numbers, data, and statistics. It is important to acknowledge that STEM fields can indeed be subjective-- the understanding of theorems and facts varies between students and can be very different from that of faculty. More discussions in classroom and more individual time with professors were among some of the ways to help create a more transparent and empathetic dialogue-- both within the student body and between faculty and undergraduates.

Aside from the pedagogical reasons causing issues of STEM retention, there also exists a cultural and socio-economic element to be recognized among many URM students and students from low-income backgrounds. Statements such as “I have to represent my family” and “I have to make the migration worth it” were common during interviews. Understanding that students, especially at a diverse and prestigious institution like Brown, come from varying backgrounds, is simply the beginning-- many of these students, particularly those who identify as URM, are first generation college students and/or come from families where they might be expected to become the primary financial provider upon graduation. This external pressure, away from grades or personal aspirations, but rather deeply rooted in familial ties and responsibilities, can have lasting mental and emotional effects on students of different ethnicities and socio-economic backgrounds. Often times, these effects are even more prominent in STEM due to the assumed financial security upon entering STEM careers. Students in these situations have a completely different approach to their college studies and a completely different motivation for how, why, and even what they want to achieve. The external pressure combined with the already alienating, isolating nature of STEM fields makes it much harder for some URM students to continue with challenging, non-personable majors due to the lack of support, guidance and overall uncertainty of success. Adding roles of support, advice, guidance, and mentorship can go a very long way in helping some students simply ‘get through it.’

IV. DISCONNECT

All of the information gathered leads us to one question: where is the disconnect? Students are trying their very best and have aspirations to do incredible things and faculty have goals of shaping the next generations of scientists and mathematicians. The goal is to be transparent and create incentives and solutions to make sure each student can receive a quality educational experience.

As mentioned earlier, faculty does not receive training on best educational practices. Makine training in understanding diversity, leadership, and empathy is necessary for helping

[6] Pun intended

increase student retention in STEM. Another area of disconnect regards course expectations for student prerequisite knowledge. The "if you fail you didn't belong in the course" mentality has been noted by many members of the student body and even some professors, and it is something that needs to be addressed. Lack of communication between students and faculty leaves students unsure of how to discuss important topics and situations, while professors are left uncertain as to which of their students are on the same page; STEM discussion traditionally 'flies under the radar' and such silence can have drastic effects on how effective education actually is.

The idea of transparency and discussion leads to the third and final area of disconnect: the subjective nature of science. The biggest and most impactful difference in the perspectives of faculty and undergraduates is indeed the idea that science is objective for many administrators: there is a right and a wrong, the numbers do not lie and if you do not get it, then you simply do not get it. Many students, however, are advocating for a more subjective view of science that involves actual discussion and debate for why certain things make sense or are the way they are. Getting a more transparent view and getting everyone on the same page with regard to whether or not STEM is subjective will be the basis for solving many of the other issues that have been brought up. The more humanity and connection that STEM adopts, the better off STEM departments will be.

V. ACTIONABLE STEPS

Keeping in mind the issues different departments face and the disconnect found between faculty and their students, it is important to discuss ways to solve said disconnect and thus help increase the retention of students, particularly URM students, in scientific fields.

The University

Although issues of retention are at a departmental level, the University needs to provide certain tools and resources, as well as have certain expectations for departments to continuously work on improving their inclusivity.

University Level Action Items

- Provide resources to professors and lecturers for educational training.
- Require and provide diversity and inclusion training for faculty and staff.
- Make demographic data more accessible to administrators.
- Hold departments accountable for gathering and retaining data to help guide new initiatives.
- Require departments to publish outreach and hiring practices.

Departments

By using the tools and resources the University provides, as well as creating their own tools and means of measuring success, departments can help improve their retention rates.

Departmental Level Action Items

- Provide resources for mentorship.
- Include students in conversations regarding new initiatives.

- Conduct surveys to understand community concerns such as: annual climate surveys and exit surveys for students switching concentrations, dropping courses, graduating, or otherwise leaving the department.
- Require and facilitate training for staff and faculty.

Professors

Professors play a large role in making their own fields more diverse and inclusive to students of all backgrounds. By making small changes in their courses, professors can have a large impact in helping students succeed in their courses.

Faculty Level Action Items

- Provide students with clear work and prerequisite knowledge expectations.
- Help every student start with the same foundation by providing resources to gain or review prerequisite knowledge.
- Be open and receptive to student feedback and adjust teaching style accordingly.
- Make course material relevant to students and their everyday lives.
- Use inclusive examples in class-- for example, rather than using names in homework problems or examples in class, use pronouns like “you.”
- Read and learn about best teaching practices as well as systems of oppression.

Undergraduates

While making an inclusive environment is in many ways the responsibility of administration, students know themselves best and are responsible for their own education and success. Undergraduates must help shape the community they are a part of.

Undergraduate Level Action Items

- Work toward creating a collaborative, rather than competitive, community in their departments.
- Ask about and make use of resources available, especially early in their college careers.
- Hold faculty and other concentrators accountable by providing honest and critical feedback.
- Talk to professors early if they feel unprepared for their courses.

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REFERENCES

"Action Plans." Office of Institutional Diversity & Inclusion. Brown University, n.d. Web. 10 May 2017. <https://www.brown.edu/about/administration/institutional-diversity/action-plans>.

"Applied Mathematics Department Diversity & Inclusion Plan." Applied Mathematics Department at Brown University(2015): n. pag. Web. 2 May 2017. <https://www.brown.edu/web/documents/ddiap/AppliedMathematics.DIAP.Sept2016.pdf>.

"Biology Department Diversity & Inclusion Plan." Biology Department at Brown University(2015): n. pag. Web. 1 May 2017. <https://www.brown.edu/web/documents/ddiap/BiologyDivision.DIAP.Sept2016.pdf>.

Braun, Lundy. Personal interview. 24 April 2017.

"Brown: A Timeline." Brown's History: A Timeline. Brown University, n.d. Web. 2 May 2017. <https://www.brown.edu/about/history/timeline/>.

"Brown University." Faculty | Office of Institutional Research. N.p., n.d. Web. 2 May 2017.

"Brown University." Enrollment | Office of Institutional Research. N.p., n.d. Web. 2 May 2017. <https://www.brown.edu/about/administration/institutional-research/factbook/enrollment>.

"Chemistry Department Diversity & Inclusion Plan." Chemistry Department at Brown University (2015): n. pag. Web. 10 May 2017. <https://www.brown.edu/web/documents/ddiap/Chemistry.DIAP.Sept2016.pdf>.

Chen, Xianglei. "STEM Attrition among High-performing College Students: Scope and Potential Causes." Journal of Technology and Science Education 5.1. National Center for Education Statistics.

"Computer Science Department Diversity & Inclusion Plan." Computer Science Department at Brown University(2015): n. pag. Web. 12 May 2017. <https://www.brown.edu/web/documents/ddiap/ComputerScience.DIAP.Sept2016.pdf>.

Crockel, Kendal. Personal interview. 25 April 2017.

"Engineering Department Diversity & Inclusion Plan." Engineering Department at Brown University (2015): n. pag. Web. 10 May 2017. <https://www.brown.edu/web/documents/ddiap/EngineeringSchool.DIAP.Sept2016.pdf>.

Faber, M., & Unfried, A., & Wiebe, E. N., & Corn, J., & Townsend, L. W., & Collins, T. L. (2013, June), Student Attitudes toward STEM: The Development of Upper Elementary School and Middle/High School Student Surveys Paper presented at 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia. https://peer.asee.org/22479

Flores, Andrea. Personal interview. 25 April 2017.

Heck, Isobel. "Lacking Foundation, Minorities Struggle in STEM Fields." Brown Daily Herald.

Karim, Alex. Personal interview. 26 April 2017.

Lo, Uloma. Personal interview. 25 April 2017.

Logan, John. Personal interview. 26 April 2017.

"Mathematics Department Diversity & Inclusion Plan." Mathematics Department at Brown University(2015): n. pag. Web. 11 May 2017. <https://www.brown.edu/web/documents/ddiap/Mathematics.DIAP.Sept2016.pdf>.

"Northside College Preparatory Hs (9-12) - City Of Chicago Sd 299." Northside College Preparatory Hs | School Snapshot. N.p., n.d. Web. 2 May 2017.

"Northside College Prep Brochure." Northside College Prep (n.d.): n. pag. Web. 2 May 2017. <http://www.northsideprep.org/pdf/AboutNCP%20Brochure.pdf>.

"Physics Department Diversity & Inclusion Plan." Physics Department at Brown University(2015): n. pag. Web. 11 May 2017. <https://www.brown.edu/web/documents/ddiap/Physics.DIAP.Sept2016.pdf>.

Pathways to Diversity and Inclusion. Brown University, 19 Nov. 2015. Web. 5 May 2017.

“Generation STEM - Full Report” (n.d.): n. pag. Girl Scouts. Girl Scouts. Web. 5 May 2017.

"Secretary Arne Duncan's Remarks to the President's Council of Advisors on Science and Technology." U.S. Department of Education.

Sivertsen, Mary Lewis. "Archived - State of the Art: Science - Transforming Idea 1." Science is for all students. US Department of Education (ED), n.d. Web. 5 May 2017.

Smith, Katherine. Personal interview. 25 April 2017.

Snyder, T. D., & Dillow, S. A. (2013). Digest of Education Statistics 2012 (NCES 2014-015). National Center for Education Statistics, Institute of Education Sciences, U.S.

Department of Education. Washington, DC. 5 May 2017.

Solano, Sara. Personal interview. 25 April 2017.

"Underrepresented Minorities in STEM." Underrepresented Minorities in STEM | NACME - NACME. N.p., n.d. Web. 5 May 2017. <http://www.nacme.org/underrepresented-minorities>.

US Census Bureau Public Information Office. "Newsroom Archive." 2010 Census Shows America's Diversity - 2010 Census - Newsroom - U.S. Census Bureau. N.p., 19 May 2016. Web. 5 May 2017.

US News, and National Rankings. "How Does Northside College Preparatory High School Rank Among America's Best High Schools?" U.S. News & World Report. U.S. News & World Report, n.d. Web. 10 May 2017.

van Dam, Andries. Personal interview. 26 April 2017.

Website. "How Does Northside College Preparatory High School Rank Among America's Best High Schools?" U.S. News & World Report. U.S. News & World Report, n.d. Web. 12 May 2017.

Weil, Simone. "Weil, Simone - Reflections on the Right Use of School Studies With a View to the Love of God." Scribd. N.p., n.d. Web. 12 May 2017.