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A Case Study: Undergraduate Research and Resilience in 3D

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Abstract

It is well documented that undergraduate research enhances the educational experience of STEM undergraduates, and attracts and retains students by providing a pathway into their fields. The purpose of this study is to analyze the impact of being involved in an undergraduate environmental engineering research program, in this case provided by the NASA Space Grant. The student is living minority status in three dimensions (3D) as being a woman, a first-generation college student, and a Native American studying engineering.

It is fascinating to analyze how one's environment and experiences influence their resiliency. Data will be collected on her readiness for an academic career along measures including but not limited to understanding of the research process, skills in academic writing, self-efficacy, and competence in oral presentation. The case study will explore her story. What experiences shaped her determination and brought her to this level, and what benefit did she gain from NASA Space grant? The goal is that sharing her story will encourage others to believe that they can do it, too.

Additionally, the student has chosen a faculty member who also lives diversity in 4D. Does this match offer different opportunities for student growth than would be available within a more conventional mentor-mentee pairing?

Introduction

As presented by the U.S. Department of Education in *The Nation's Report Card*, the report showed that girls earned more credits in high school science and mathematics courses between 1998-2005, a trend which continued until male graduates closed the gap in 2009. At 63%, a majority of female graduates completed a midlevel or rigorous curriculum in 2009, compared to 55% of male graduates. One might argue, then, that the issue is not that girls are less interested in STEM; rather, it seems that girls do not perform well on tests. In 2009, male high school graduates had higher National Assessment of Educational Process (NAEP) mathematics and science scores than their female counterparts, completing the same curriculum level [1]. This might be correlated with the Arizona State University's finding that "the average male student thinks he is smarter than 66 percent of the class, while the average female student thinks she is smarter than 54 percent of the class" [2]. Stoeger et al. reported that STEM interest is almost three times higher for boys than girls. The same study reported that female students think that STEM is not appropriate for them due to a perceived disconnect between the "real world" and their assignments; therefore, the girls prefer social studies [3].

Based on the National Science Foundation's (NSF) latest report on bachelor's degrees awarded in Science and Engineering—by citizenship, ethnicity, race and sex—in 2014 among US citizens or permanent residents, White graduates constituted 61.5% of the degrees. The Hispanic/Latino, Asian, Black/African American, American Indian/Alaska Native, two/more races, and other/unknown races/ethnicities earned 12.1%, 9.5%, 8.7%, 0.5%, 2.8%, and 7.6%, respectively, of the bachelor's degrees in Science and Engineering [4].

According to the National Action Council for Minorities in Engineering (NACME), "*The solution to America's competitiveness problem is to activate the hidden workforce of young men and women who have traditionally been underrepresented in STEM* [Science, Technology, Engineering, and Mathematics] *careers—African Americans, American Indians, and Latinos*" [5]. The number of underrepresented minority (URM) bachelor degree recipients in engineering was 12,903 in 2014, a 10% increase from 2013. "This number represents 13.7 percent of the total number of engineering degrees (93,950) conferred that year" [5]. While ethnic minorities are consistently underrepresented in STEM [6], Native Americans are especially unlikely to pursue and complete an engineering degree.

The 2014 growth was "mainly concentrated with the Latino population, who earned 8,984 baccalaureate degrees, while African Americans earned 3,599, and American Indian/Alaska Natives earned 320" [5]. Only 42% of Native Americans pursue any form of higher education, and of those, just 13% attain bachelor's degree. "American Indian/Alaska Natives constituted 0.9 percent of the college-age population, yet earned only 0.3 percent of engineering degrees" [5]. Native American women constitute 0.07% (1 out of 13,000) of the US Engineering workforce. These numbers suggest that "support is especially crucial for Native Americans, who trail other underrepresented minorities in STEM education and account for less than 0.2 percent of engineering doctorates" [7].

Furthermore, first-generation students are at risk for failing to successfully complete programs in engineering. Though the pursuit of engineering or STEM degrees by first-generation students remain understudied, reports suggest that as a group, first-generation students are less likely to complete their degree than continuing-generation students [8]. Given the existing underrepresentation of Native Americans in higher education, and in light of the impediments faced by first-generation students and the high numbers of students leaving STEM fields [9], it follows that first-generation Native American students living at the intersection of these conditions might experience a specific set of challenges.

Intersectionality theory, as articulated by Crenshaw [10], posits that approaches to ameliorating inequities must account for multiple, intersecting identities in order to have a meaningful impact. Women in STEM face certain challenges on the basis of gendered impacts of the field, as do Native Americans on the basis of the severe underrepresentation of their ethnic group. The intersectionality theory would suggest that programs solely focusing on gender discrimination or ethnic underrepresentation would be inadequate. Rather, it is crucial to understand the ways that these two factors intersect to impact Native American women in STEM so that appropriate measures can be undertaken to work toward reversing historical inequities in the field.

In addition to the disproportionately low participation of Native Americans and first-generation college students in STEM, the gender gap has emerged as an area of concern for many institutions working toward advancements in the STEM fields. Women remain consistently underrepresented in STEM. While efforts have been made to study the root causes of the disproportionately low numbers of students from these groups, many such studies focus on approaches to the retention of women in STEM fields; this is a necessary step but ultimately insufficient to adequately address the persistent gap between men's and women's pursuit of study in STEM. This paper aims to support a more comprehensive agenda for ameliorating the underrepresentation of women and minority groups in STEM by offering a review of the structural, cultural, and institutional impediments to progress toward gender parity, specifically focusing on the underrepresentation of women in engineering. The paper also explores the impact of the mentor-mentee relationship and engagement in undergraduate research on the pursuit of STEM study.

In order to help illustrate the influence of cultural structures and institutions, materialized in students' lived realities, this paper concludes by drawing on the experiences of an undergraduate engineering student living minority status in three dimensions; the student is a woman, a Native American, and a first-generation college student. She lives at the intersection of these dimensions of her identity in an environment in which people who look like her are not well represented; all three of these identities are notoriously underrepresented in the academy, and STEM in particular. Her mentor lives minority status in four dimensions as a woman, first-generation college student, an immigrant from Turkey, and a Muslim woman who observes hijab. Not only do each of these individuals' stories help to shed light on the ways in which broad, often unseen structures impact the decisions students make, their experience of the 4D/3D pairing between mentor and mentee offers a lens through which to approach the very issues of retention with which conventional studies of the gender gap are concerned. Just as intersectionality helps scholars to understand how legal institutions are ill-equipped to account for the lived experiences of minorities [10], the concept can shed light on how relationships and representation can influence outcomes in the pursuit of engineering among underrepresented student populations.

Factors that Play a Role for Minority Resilience in Engineering

Almost from birth, girls and boys are socialized into different sets of gendered cultural norms [11]. Over time, children are taught that boys are more predisposed to technical, scientific, and mathematical activities, while girls are more emotionally oriented and less innately capable than boys in technical activities [12]. Before they reach college and are asked to choose a field of study, students have been influenced by social norms that may remain unseen and unchallenged. While broad social inequities persist, and as "women and racial/ethnic minorities continue to earn less and hold less powerful positions in the workforce than white men" [13], these gaps are particularly pronounced in STEM. The disparity is especially clear in engineering, where only one in seven engineers is a woman. Though "women earn about half the doctorates in science and engineering in the United States [they] comprise only 21% of full science professors and 5% of full engineering professors" [14]. A comprehensive study of multiple processes playing a role in these disparities showed that there was a cumulative effect of advantages for men and disadvantages for women that built over time to produce highly gendered outcomes by the time they reached the advanced stages of the education pipeline [15].Thus, the solution to the gender gap in STEM must reach deeper than retention efforts aiming at the college population.

Also, a significant gap exists in pay among men and women, even when controlling for intervening variables, estimated at an average of $13,000 annually or about 16% [13]. Women are frequently perceived to be secondary earners by their employers without regard for their financial realities, which over time produces conditions in which hiring decisions relating to earnings normalize the gender pay gap [13]. Women with STEM degrees are less likely to work in STEM fields than men, and more likely to work in education or healthcare, in which the pay tends to be less than in STEM. Despite the "STEM premium" that leads to higher earnings in STEM than in other fields, a gender wage gap persists even when controlling for other variables such as time in the workforce, level of training/education, etc. [16]. Another well-documented factor influencing the persistent gender gap in engineering is a disciplinary culture that is sometimes inhospitable to women, ranging from family leave and productivity norms, that do not account for the physical requirements of childbirth and child rearing, to sexual harassment and casual or overt sexism. In fact, many of the nearly 40% of women who leave STEM cite persistent sexism as one factor influencing their decision [9], [15], [17].

Research Experiences for Undergraduates (REU)

The overwhelming evidence provided in the literature has proven the impact of undergraduate research experience on students' decision to pursue and persist in a graduate degree and a career in the STEM workforce [18] - [22]. Students learn not only research competencies but also other skills such as teamwork, communication, and presentation [23].

Laurila et al. [24] studied Native Americans participating in mentor-based research at the Native American Cancer Prevention (NACP) program at Northern Arizona University. According to Laurila et. al., because many Native American students have responsibilities that typical non-Native students may not have, Native American students start, stop, and change college institutions at a range of different stages of their lives. The students enter and exit at various points in their academic career. In their model, Laurila et. al. demonstrated that when a "web of support and opportunities" exist, as opposed to the pipeline system, Native Americans can achieve a higher degree of success, where "63% of Native American students in NACP received bachelor's degrees compared to the national average of 38%" [24].

As in the present study, other empirical studies of the impact of undergraduate research on the pursuit of STEM have utilized practical case studies to illustrate how to achieve the intended benefits within various disciplines. The influence of REU has been studied for chemical sciences [25], for engineering [26], [27], for computer science [28], and for engineering technology [29]. Upon reviewing the literature, it is our best understanding that the present study is the first to investigate the REU experience through the lens of minority status at various levels for environmental engineering.

Mentor-Mentee Relationship

Many studies have been conducted to demonstrate the significance of the mentor-mentee relationship. The mentor-mentee partnership is encouraged to help advance people within their career path and personal growth. With regard to STEM, the relationship has been encouraged to help students, especially those who are underrepresented, to persist in their objective to become scientists, engineers, and mathematicians. Mentored undergraduate research programs, focusing on the underrepresented, have demonstrated effective outcomes [24], [30]- [33]. The idea of the relationship is to help students identify themselves in STEM fields by increasing their competence, performance, and recognition [34], [35].

Based on previous studies, underrepresented racial/ethnic minorities and females "report a lower sense of belonging" [34] in comparison to their white and male counterparts [35] – [37]. Belonging to STEM fields is dependent on self-efficacy, which is the "confidence in one's ability to successfully perform a given task" [34]. For a mentee to feel positive about their field, the mentee's perception of the relationship with the mentor is significant. Prunuske et. al. [30] determined that mentees' confidence improved when they actively participated in research projects and acquired "the skills necessary for professional socialization." They also determined that the personality of the mentor was more significant than the research project. In addition, the mentees wanted mentors who would communicate and engage with them. When studying the mentors, Prunuske et al. [38] determined that mentors need to understand the cultural differences between themselves and the mentees. For instance, a Native American may not be comfortable sacrificing an animal due to their religious beliefs; hence, a mentor should be able to respect that belief system and help the mentee find a way to fit into the lab.

In another study, Dennehy and Dasgupta [31] studied the impact of gender on the mentor and mentee relationship in retaining female engineering students. They determined that "same-gender peer mentoring during the transition to college appears to be an effective intervention to increase belonging, confidence, motivation, and ultimately retentions of women in engineering" [31]. They suggest that female mentors "protect women's feelings of belonging and connection to other peers in engineering" [31]. Additionally, they found that better performance (e.g., GPA) is not correlated with women's pursuit of a degree or career in engineering.

"In 2013, URMs constituted 12.1 percent of employed engineers, which paled in comparison to their representation in the overall population (31.5%). They also constituted only 6.6 percent of engineering faculty, which continued a troubling trend of minute minority representation in academic settings. Minority youth pursuing engineering degrees lack mentors from similar backgrounds who can encourage and support them in their journey" [5]. We are here to argue against the prevailing notion that to help students, any minority would be able to help any other minority. If, as the empirical records suggest, having meaningful relationships and being role models for one another are most important for successful outcomes, this paper argues that it is more important to have similar struggles than to have the same race/ethnicity.

Focus of the Study: Case

Melissa has strong desire to lead and be a good role model. She has been involved in AISES (American Indian Science and Engineering Society) Northern Arizona University (NAU) Chapter and she became the president of the club in November 2017. She is also involved with Thau Beta Pi (co-educational Engineering Honor Society). She came to the meetings with her mentor, sometimes, self-doubting and worried about whether she was the right person to do this.

We generally assume that if "they are here, they will make it" [7]. NAU is a leading institution on the national level in its focus on outreach to Native Americans, giving them a stronger voice on campus. Melissa has as much potential as any other engineering student enrolled in Research Experiences for Undergraduates (REU) through the prestigious NASA Space Grant Program. What sets her apart from her peers is that she had a vision—she is interested in helping clean up her own backyard.

Community need is one of the leading reasons for students, from different backgrounds, to participate in STEM-related REU. Melissa is no different. Interested in the impacts of the Gold King Mine Spill in her community, she wanted to develop new technology, using corn as a bio-sorbent to remove Cadmium from drinking water.

On August 5, 2015, during excavation at the Colorado Gold King Mine, loose material at the site gave way. This released three million gallons of acidic metal mine waste water into the Cement Creek, a tributary of the Animas River [39]. Among contaminants released was a combination of various heavy metals containing Zinc, Copper, Lead, Aluminum, Iron and Cadmium [40]. Many local rural areas were heavily affected in the aftermath of the Colorado Gold King Mine spill. The spill had affected various parts of the Navajo Nation and Southern Ute, including the area surrounding the Ute Mountains, by compromising crop production and ranching [40]. In these regions, the waterways forming the Animas River are a precious resource to the surrounding communities. Thus, this incident drastically impacted the locals' way of life.

With expansions in mining over the past 60 years, heavy metals contamination removal is critical to keep the waterways safe. According to the World Health Organization (WHO), Cadmium concentration in unpolluted natural waterways is typically below 1 ppb [41]. Health problems are associated with exposure to Cadmium when it is over the maximum contaminant level (MCL) of 5 ppb or .005 ppm [42]. Short term exposure could cause the following effects: nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. The long-term effect of Cadmium exposure includes damage to the kidney, liver, bones, and blood [42]. In comparison to the health effects of other heavy metals, Cadmium is one of the most harmful to humans.

Tests conducted at Cement Creek showed Cadmium levels at a historic maximum of 98.3 ppb [43]. Currently, the removal of heavy metals from water is of high interest to researchers who are investigating cheaper alternatives to reverse osmosis and other proven methods of heavy metals removal. Bio-sorbents have been tested as a viable alternative; it uses bio-waste such as rice husks, pecan shells, corn cobs, and corn husks. Treated and untreated absorbents have been shown to be effective at removing heavy metal contaminants at different pH ranges [44]. Corn, being the number one produced crop in the United States, would be a cheap, viable resource to use in the remediation of heavy metals in water [45]. Melissa saw that there has been little research into corn as a bio-sorbent for heavy metal, and saw the potential of it being used as an adsorbent. Thus, she proposed testing corn cobs for their effectiveness at removing Cadmium from water.

The proposal was approved by the NASA Space Grant Committee at NAU and Melissa started working on her research. While our study focuses on just one student, her situation is applicable to many others, who are more than likely experiencing similar struggles.

Melissa has been meeting with her mentor once, every two weeks to discuss the plan. Mentor and mentee came up with a tentative schedule, plan for testing, and tips/tools for literature search and research, as well as data acquisition, analysis and interpretation. The data used and presented in this paper includes pre- and post-survey, pre- and post-video recordings of presentations, meeting notes, and personal experiences noted throughout her work from proposal submission to presentation of the results.

Melissa completed a survey at the beginning of the study to self-assess her readiness for an academic career along measures including, but not limited to, understanding of the research process, skills in academic writing, self-efficacy, and skill in oral presentation. Table 1 lists all areas she ranked herself on a Likert Scale 1-5 (1: Little confident to 5: Strongly Confident).

Table 1: Student's Self-reported confidence for various activities or tasks

Activity/Task	**Pre**	**Post**
Understanding of Research Process	5	5
Readiness for more demanding research	5	4
Understanding how scientists work on real problems	5	4
Learning Lab Techniques	3	5
Tolerance for Obstacles	5	4
Learning to work independently	4	5
Skill in interpretation of results	4	3.5
Understanding primary literature	4	5
Understanding science	5	5
Self-Confidence	3	5 (3.5)*
Clarification of career path	4	4
Skill in science writing	2	3.5
Skill in Oral presentation	4	4
Understanding how scientists think	5	4.5
Ability to analyze data	4	4
Learning ethical conduct	5	5

* student reported her confidence is at 5 for her NASA research, but 3.5 in general

She also responded to some open-ended questions for the pre-survey:

Why did you want to be involved with this research/apply to NASA Space Grant?

"After going to AISES [American Indian Science and Engineering Society] national conference and seeing Native Americans presenting high-level research I made it my goal to one day present there. I really admired researchers presenting science they were passionate about and hope to be like that one day."

What are your expectations from this year?

"I hope to learn a lot and grow as a scientist. Instead of just studying in the classroom, I hope to use what I have learned in a real world setting."

What are some challenges you are facing right now?

"Right now I am struggling with time management. I am still trying to balance my jobs, research and school successfully."

What is your post graduate education plan?

"My goal is to seek a Ph.D. in Environmental Engineering and I hope to show my younger cousins they can get whatever education they want."

Discussion

It is not uncommon for marginally disadvantaged students, in faculty mentor-mentee relationships, to experience challenges before getting back on track to pursue STEM fields as part of their undergraduate degree [7], [46], [47]. In a longitudinal study, Mendez et. al. [48] concluded that common academic interests would bridge any cultural or generational gaps between mentors and mentees.

Melissa started her college career in Fall 2015. She is a junior in environmental engineering; her current cumulative GPA is 3.63, and she has been on the Dean's List every semester except one. Her pre-scores for understanding of the research process and of science and how scientists think were fairly high from the outset (Table 1).

Melissa struggled quite a lot with time management and her commitments. She decided to drop a course she was auditing. In addition, she survived a couple of significant losses, including two recently. Originally, she planned to use Inductive Coupled Plasma to analyze Cadmium in water. After meeting with the chemistry lab technician, she realized how time intensive and expensive the test would be. She decided to adjust her proposed method of analysis to the readily accessible HACH Method. She put together the list of materials for testing and ordered it. Not long afterward, she realized she had ordered double what she needed. Luckily, with the help of faculty here in the department, that mistake turned into an advantage for Melissa and three other students to use that extra testing material for capstone projects. She went through lab safety training, and prepared herself for experiments to be completed in the lab. For the first three lab meetings, her mentor was doing the experiments with her; after these supervised experiments, she felt ready to conduct the following procedures independently. On the first day she was alone in the lab, she mistakenly ended up using filters that had been used for other analyses instead of her preconditioned filters. This caused problems for the analysis of Cadmium concentrations. After quickly realizing her error, she took full responsibility to go back to the lab and re-do all the experiments that had the wrong filters. She returned with accurate results. As a result of this evaluation of data, in learning how to report accurate and consistent data, she had to show patience and decide what would be necessary for proper data analysis. Overall, this experience has helped her grow as a person, scientist and an engineer.

Between the academic and personal challenges she experienced, she sometimes felt overwhelmed; there were times where she felt she was totally lost. Luckily, she was seeing a counselor, and had close friends and her mentor, who always supported her. These factors may be related to her response to the item "Tolerance for obstacles," which dropped from 5 to 4 in the post-survey. Her self-confidence increased from 3 to 5 in the same survey. She did make it clear that her self-confidence was related specifically to this project (ranked at 5). Overall though, she believed she was at 3.5, which is still an increase from her pre-survey. Her self-reported "Skills in oral presentation" stayed at 4 and did not change from pre- to post-survey. However, the additional analysis of the student's oral presentation skills, after she presented her results to the statewide symposium in April, showed that her confidence and her delivery has much improved. Her self-reported "Skill in science writing" increased from 2 to 3.5; this is an area that we will be able to analyze after she concludes her research and starts creating the poster. Finally, she expressed her resilience to the challenges as reflected in the stable score of 4 for "Clarification of career path." She still intends to obtain a doctorate degree.

Melissa has completed her analysis of Cadmium removal with corn as a bio-sorbent. As a result of her experiments, she concluded that corn is an effective bio-sorbent for higher concentrations of Cadmium levels, 25 - 80 µg/L, with removal efficiencies of 46% -51%, respectively.

To date, she has presented her results three times: her mentor, the local NASA Space Grant representatives, and the statewide NASA Space Grant Symposium. She received positive feedback on her oral presentation, clearly improved her skills over the course of the year. She was compliant with the time limit, and she improved her ability to convey her ideas by reducing the number of fillers she used (e.g., "like"). She is scheduled to present two more times, at the NAU Water Symposium and the Undergraduate Research Symposium.

Melissa's desire to serve as a role model for future students echoes one of the concerns of this paper, namely, to what extent can mentorship by someone with whom the mentee can identify help to support their resilience in the pursuit of engineering? Statistics describing the prevailing representation of various groups in engineering suggest that the 4D/3D minority status of the mentor-mentee pair presented in this paper is atypical in environmental engineering. Though the mentor is not Native American, she shares other dimensions of minority status with Melissa which may play a role in her sense of self-efficacy. The post-survey asked open ended questions to address the issues mentioned above:

How do you identify yourself?

"I am a member of the Navajo nation. Born for the folded arm clan and my paternal grandfathers clan is the bitter water clan. I am also half German form my mom's side. My family is form Huerfano mesa. This is how I present myself as a Navajo woman. Thank you.

Yá'át'ééh shik'éí dóó shidine'é . Shí éí Melissa ******* yinishyé. Bééshbich'ahii nishłį. Hashk'aan Bit'ahnii bashishchiin. Bééshbich'ahii dashicheii. Tódích'ii'nii dashinalí. Ákót'éego diné asdzáán nishłį. Ahéhee'."

Do you feel you belong in the Environmental Engineering Department? If so, why, if not why?

"I think there are issues in any program, but I really have enjoyed the engineering program so far. Engineering is not easy in any sense. The environmental engineering department it self is small but that [i]s one of my favorite things about it. I think we have credible staff that know their filed very well. Some instructors don't have the best class setup, but I assume all department[s] have [a] class like that. I want to go in water focused engineering, but I feel our program is to highly focused on only water. We only take one air quality class yet we have two water resources classes. I personally think the department could benefit for the expansion of their air quality education."

Why did you choose "Dr. Danisman*" as your advisor for NASA SPACE grant?

*Name changed to protect mentor's confidentiality

"She was the only professor I felt I comfortable enough to ask. She had been incredibly nice to write me a letter of recommendation [in my] freshman year which resulted in myself receiving an internship. I wasn't taking many other engineering classes, but I also don't think I would have been comfortable asking other professors. I had admired her for being the one female instructor I had in engineering and being a minority in multiple perspective[s]. When she told stories of her working hard in school learn the same we were in class I could see someone like me succeeding in STEM."

What did it mean for you to have Dr. Danisman as your advisor?

"_Honestly it has meant the world. I have struggled a lot this semester and whenever I was anxious see[ing] her calmed me down. I would be very stressed about not knowing what to do and then I would see her and feel focused. I honestly really appreciated having Dr. Danisman as a mentor when I was dealing with so many personal struggles. I think I would have been shut down easily or even given up if I had any other mentor. Dr. Danisman was the support I desperately need to finish this project on top of a very emotional semester. I can't describe how much I appreciated having a mentor I trusted and believed in me."_

What are some strengths and weaknesses in this mentor-mentee relationship that you had?

"_I think one of the crucial parts of our mentor mentee relationship was trust and emotional support. For me I really needed a mentor that wasn't strictly about the research but also cared about me as a person and supported me in the research process. We both trusted each other to communicate and keep each other informed. We worked well together as a team especially as it was a small research project in terms of people involved._

One weakness that resulted in a bit of an incident was communication. I felt confident when I was doing testing but I just assumed instead of asking for help. After that incident I learned to communicate better. I worry about bothering people and how I am viewed to other. This was something I think was a weakness that got better over the duration of the project."

With the question of identity, Melissa related her identity to her ethnicity rather than engineer. Having had experience with the Navajo education pedagogy, the Navajo schools and community focus on heritage, during the early stages of education, and connectedness to the community, also known as communality [49]. The students recognize and become proud of their heritage, as well as wanting to give back to the Native American community. Student development in the traditional academic system comes into focus later. As Melissa progresses through the NASA Space Grant and her future capstone, she will build her research skills, practice engineering and be recognized as an environmental engineer. In turn, she may add engineering as a dimension of her identity [50]. There may also be a reciprocal relationship between a sense of belonging in the field and the integration of "engineer" into her core identity. If an individual feels that their chosen profession is a place in which their contributions are valuable and welcomed, it follows that they will be more likely to see themselves as meaningfully connected to their professional community. In turn, this could foster a greater sense of self-efficacy and identification with their field of study.

Melissa's undergraduate experience may help her persist and pursue a doctorate program in engineering. Vieyra et al. determined that African-American females do not readily participate in undergraduate research projects, unless they are required to do so. One of the reasons expressed, for not participating in research, was "low confidence in her ability to conduct research" [51]. After the mandatory undergraduate research experience, the students pursued graduate degrees and pharmacy school [51].

In a 2016 study by Byars-Winston et al., the researchers observed that a research training institution may have different affects on gender and racial/ethnic groups. For instance, African-American males "reported significantly higher negative affective/emotional arousal for doing research" [34]. On the other hand, Hispanic/Latina females developed a stronger identity with STEM from their research experience. Hopefully, as Melissa continues her research in her capstone year, she will develop a stronger identity as an engineer.

Relatability to a STEM field has been examined in many studies. One of the factors that contribute to relatability is the mentor's personality [30]. Prunske et al. found that the personality factor was a primary reason, especially among women, to choose a mentor. In this instance, Melissa expressed her comfort in approaching Dr. Danisman. Upon evaluating Melissa's comments, she appreciated the opportunity to engage and communicate with her mentor, which aligns with Prunske et. al.'s findings in what makes an effective mentor [30]. In addition, this experience correlates with Byars-Winston et. al's finding that "a bidirectional path between mentor effectiveness and skills/career knowledge" improves the student's self-efficacy in research skills [32]. Finally, Daniels et al. determined, among the Latino/Latina population, that quality of mentoring was more impactful than the amount of time spent on undergraduate research project [52].

Another factor of relating to STEM fields is career availability. Ghee et al. wanted to determine whether a summer research program could enhance a "students' research self-efficacy, awareness and commitment to pursuing a research career" [33]. In a study of 450 participants, Ghee et al. determined that Hispanic students significantly experienced a greater understanding of “careers available in their discipline and the research skills”, as compared to Asian, African-American, Multiracial/Other, and White ethnicities [33].

Based on Melissa’s comments, it appears that having a female mentor was a factor in the strength of their relationship. She perceived that she shared a degree of identity (first-generation, female engineer) with her mentor. In addition, she could share her challenges with her mentor, who could provide support and protect her feeling of belonging. The finding correlates with a study on female peer mentors influencing the retention of female engineers [31]. Dennehy and Dasgupta determined that “women with female mentors reported more stable belonging than those without mentors or with male mentors.” In addition, female mentors were able to mediate the female mentees’ “anxiety about engineering”.

We understand that our case study, an n=1, cannot be used to generalize the experiences of all female Native Americans in engineering. As documented by the NACME, the number of female Native Americans, in engineering, is 1 out of 13,000 in the US engineering workforce. As noted by Matthews [7], Native Americans in STEM suffer from more severe disparities than even other underrepresented minorities; the statistics relating to Native American women are even more stark. Based on our literature search, our understanding is that, in this particular domain of study, large data sets are not available due to the small number of Native American students in engineering at any one institution. At NAU, it is very rare to see a local Native American participate in an engineering degree program; thus, the number of available cases to which we had access was limited. This case study does open the door to conduct future studies on a national level, increasing the n value. We will need to contact each academic institution to determine and recruit candidates for a larger, intersectional study.

Until as recently as 2012, studies have been conducted to evaluate minority retention in STEM fields through the pipeline perspective [53]. The pipeline method of analysis aggregates study participants into male versus female, and White versus non-White. Due to emphasis on quantitative analysis, researchers cannot explore the racial and ethnic patterns in STEM retention because of the emphasis placed on statistical significance. Hence, we are advocating qualitative analysis, of each individual, to determine how to attract and retain underrepresented populations in the STEM fields. Johnson, in her study of campus climate and sense of belonging in STEM majors, stated that “[T]he small numbers of Black/African American, Latina, American Indian and Multiracial/Multiethnic women resulted in grouping together all women of color for the regression analysis, leaving the unique intersections of particular racial/ethnic and gender groups unexamined” [54]. As Metcalf stated, we need to “conduct research that accounts for the spectrum of experiences” of underrepresented ethnic/racial groups, especially Native Americans who are “historically excluded from analyses because of low n values” [53].

Furthermore, our primary concern in utilizing this case study, in our review, was to provide detail showing how structural and institutional constraints can be seen in individual students’ lives. In addition, resilience is neither an exclusively group nor exclusively individual phenomenon. Individual resilience is supported by group representation and collective efforts toward equity. We believe that our case study reflects this dialectical relationship between individual and group dimensions of resilience.

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