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Engineering Retention: Improving Inclusion and Diversity in Engineering

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Engineering Retention: Improving Inclusion and Diversity in Engineering

by

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Abstract

The researcher sought further understanding for strategies and pedagogies employed to serve the diverse learning and engagement needs of underrepresented minorities (URMs) enrolled in academic engineering programs. The researcher defined for this study underrepresented minorities women, Latino, and African Americans. There is a need for increased representation of URMs in both postsecondary education and engineering profession. Underrepresented minorities are needed in the engineering profession to contribute to more complete solutions and to provide improved ideas for consideration during the design process. This study identified six factors utilized by engineering faculty and academic affairs in postsecondary education to improve retention of underrepresented engineering students' higher education: community, mentoring, role models, active learning, empathy, and academic habits. The retention of URM engineering students by developing a sense of community is key to URM students' success according to study participants. These six factors can be implemented with the goal of encouraging *all* engineering students at a university. Recommendations for faculty and academic affairs personnel are provided. Topics for further study are given for consideration.

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Chapter 1: Introduction

This study explores the current practices in the retention of underrepresented minorities (URMs) in engineering with a study focus on women, African American, and Latino students. An imbalance exists in diversity of the aforementioned engineering graduates, indicating a need for exploration of their retention. The researcher desires to develop an understanding of how underrepresented students entering STEM fields are retained and persist to graduation.

Addressing the shortfall of engineers is important, as enough engineers are not graduating to meet the industry's needs (Sargent, 2017). Education, government leaders, and businesses report that, as a result, the nation's ability to globally compete will be compromised (National Action Council for Minorities in Education, 2013). The National Center for Education Statistics (2016) indicates that academic engineering programs are graduating an increasing number of engineering students. The growth in engineering is attributed to the growing need for biomedical, environmental, and civil engineers (Bureau of Labor Statistics, 2016). One-third of manufacturing organizations report problems in finding diverse engineers to support the current needs of project design and development. Despite the recent increases in the engineering graduation rate the hiring problem has to be resolved (Casey, 2012).

Increasing the number of underrepresented minorities (URMs) will aid in meeting the future employment needs of engineers. Further, diversity of engineering graduates is needed by businesses to achieve global solutions to problems and develop new products which serve a wider clientele. Team diversity increases the likelihood of reaching a complete solution. The refined engineering solutions, developed by diverse teams, allow businesses to meet their financial goals.

An examination of several areas of engineering education was conducted to understand the current retention issues. A historical review of engineering teaching methods provides the background and understanding of the retention problem. Exploration of the engineering classroom environment demonstrates why diversity may not flourish in the modern classroom.

For this research, a qualitative, grounded theory case study design was the methodology utilized. The researcher has significant close collaboration with the participants in a grounded case study (Merriam, 1998; Yin 2009). A grounded theory design approach uses text analysis methods which are further outlined by Böhm (2004). The researcher extended the review of the data identifying common themes and organized the information into virtual spreadsheet theme buckets. The current practices in URM students' retention were collected using participant interview techniques. Faculty and academics affairs personnel from 15 universities which graduated higher numbers of URM engineers were interviewed. Interviews with engineering faculty and academic affairs staff provided insight into current practices connected to the retention of URM engineering students.

List of Definitions

The defined terms below support this research study.

Active Learning is an approach to teaching that includes anything students would be asked to do or called upon to perform in class, aside from listening, recording notes, and watching the instructor (Felder and Brent, 2016).

Community, is when URMs have a sense of sharing common interests, goals, and attitudes with others whether in a living arrangement, classroom or academically affiliated activity. These combined aspects improve intellectual and social connections between students (Levine, 1998).

Diversity refers to the way in which different types of people differ, which includes characteristics such as gender, age, race, mental, ethnicity, and physical abilities. Secondary characteristics such as income, education, religion, language skills, family, culture, status or geographic location contribute to the ways in which individuals are different from each other (Williams, 2013).

Engineer is a graduate of higher education in an engineering program of four or more years.

Engineering degree is a degree obtained from an undergraduate program of four or more years.

Gatekeeper is an introductory course in subjects such as mathematics, physics, engineering, and chemistry, often following developmental courses in the subject areas which explicitly or implicitly eliminate lower tier students (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2011).

Inclusion exists as marginalized groups or individuals feel as if they belong and are allowed to participate in the majority culture as valued and equal members of the community (Williams, 2013)

Intrusive advising is the deliberate introduction of structured student intervention when the student first indicates encountering academic difficulty to motivate the student to reach out and obtain help (Earl, 1987)

Lecture is instructor controlled and information transfer centered approach to teaching where the instructor works as the only source of information; a method of instruction where the instructor speaks and the students listen (Felder and Brent, 2016).

Non-inclusive indicates the lack of addressing academic learning, social requirements, or microaggressions of URMs in a classroom, activity, or community (United Nations Educational, Scientific and Cultural Organization, 2015).

Passive learning is also referred to as chalk-talk or throw-catch, which is a lecture using a chalk or white board and the student performs no other academic activity aside from taking notes (Fink, 2003).

STEM is Science, Technology, Engineering and Mathematics.

Stereotype threat is the experience of anxiety in a situation in which a person has the potential to confirm a negative stereotype about his or her social group (Inzlicht, 2012).

Underrepresented minorities The National Science Foundation (NSF) and National Center for Science and Engineering Statistics (2017) support the definition of URM in engineering consists of women, Latinos, African Americans and Native Americans, and can include people who have disabilities. For this study, URMs are women, African Americans, and Latinos.

Research Questions

The investigated research questions were:

1). What practices are engineering faculty employing to retain underrepresented minorities in engineering?

2) What practices are academic affairs personnel employing to retain underrepresented minorities in engineering?

The study intends to identify approaches needed for developing departmental engineering support, university programs, and engineering education instructional practices that have been successful in teaching engineering students.

Engineers Solve Institutional and Societal Problems

Engineers are increasingly being called upon to solve societal problems. Engineers are often licensed by their state of residence. Professional qualities include being a creative and competent engineer, but society requires engineers to have social awareness to meet social necessities and interests. Engineers, as part of professional standing, are to ensure benevolence in the use of technology and be socially responsible for ensuring progress is made in the implementation of the technology (Beder, 1995).

Engineers work in groups and teams to solve problems by providing innovative and practical solutions for a defined problem that uses technology (McCurdy, 2011; Pan, Strobel & Cardella, 2014). The education goal for the engineering students is to be able to solve complex problems that are presented by the engineer's employer or as obtained from society (Litzinger, Lattuca, Hadgraft, & Newstetter, 2011). The students must master singular areas of an engineering study to have the ability to solve these real-world problems. The engineering student must also understand the worldview (also known as the big picture, practical world or real world) and understand how these core engineering concepts fit together to innovate solutions or develop new or improved products.

Need for Diversity in Engineering

White male populations currently reflect a clear majority in engineering education. Engineering degrees to whites are 65.9% of the degrees granted. White males make up 51% of engineering faculty. A lack of diverse students in higher education programs, who show an interest in studying engineering is causing difficulty for organizations to hire diverse employees. Fairness is not the primary driver for the company's desire to hire diverse engineers. The diversity driver results from the population shift occurring in the United States. The result of this shift will be that white males become a minority. The U.S. Census predicts that URMs will pass the white majority population in the year range of 2040 and 2050 (Ortman & Guarneri, 2009). The companies are motivated to hire URMs because they are becoming competitive, strong engineers and aid in finding more efficient problem solutions (Wulf, 2002). Munson and Gallimore (2016) predict that by 2050, the U.S. will have no defined ethnic and racial majority.

Despite the availability of talented people and their individual ethnicities, engineers in the U.S. are predominately white males (Cross, 2014; National Academy of Engineers, 2004). However, the engineering profession aspires to effectively recruit, welcome and nurture URMs into the engineering profession. With increased diversity, problem identification and solving become more efficient and thorough.

The Society of Women Engineers (SWE), reports that 20% of the bachelor's degrees awarded in engineering and technology are awarded to women. These young women show a likelihood to leave the engineering profession after a short period of employment (Holmes, 2016). URM engineering students are averaging just over four years to persist to graduation, and fewer graduate to fill the pipeline of new engineers (National Academy of Sciences and National Academy of Engineering & Institute of Medicine, 2011; Lord, 2014). A paucity of diversity results, which creates problems for companies striving to reach new levels of engineering innovation, by building teams or groups that have a gender mix and include URMs (Varrasi, 2012).

Wulf (2008) asserts that firms and institutions need to have diversity to assure that innovation happens in their organizations and reflect the culture of their customer base. Buffinton, during an interview with Wallace (2016), stated that every kind of diversity in engineering is needed; the needed diversity includes—at a minimum—racial, ethnic, gender,

gender identity and expression. In 2015, 147 deans—representing the ASEE's Deans Council—gathered at the White House in Washington, DC in the U.S. to sign a document to set in motion to improve engineering education to, in part, "…further promote the pursuit of engineering education to all those who have been historically under-represented within our discipline; provide an educational experience that is demonstrably equitable and inclusive…." (Delaine, Williams, Sigamoney, & Tull, 2016) Engineering education is lacking the capability to prepare the diverse engineer to participate in an improved diverse design world.

In studies that compare groups with racial diversity to groups without racial diversity, the groups with racial diversity outperform the teams lacking diversity (Pentland, 2012; Phillips, 2014; Wallace, 2016; Wulf 1998). When an individual with an opinion from someone who possesses a diversity profile different from that person, a more thought-provoking response is often generated. No evidence has been found to show that an engineer's performance differs due to their social development such as gender, race, and ethnicity (Gibbs, 2014).

Without team diversity, Wulf (1998) indicates that the engineering students sometimes fail to understand the constraints that affect an engineering problem, leading to non-inclusive design solutions. Understanding of how a product might serve an international customer base will be difficult to achieve without a diverse engineering team. In an interview with Wallace (2016), Buffington states that the engineering field provides services to an infinite mixture of environments. Engineers need to be responsive to the complex problematic challenges and variables presented by the differing projects. When solving the problems introduced by these projects, Buffinton asserts that a population of diverse engineers with different skills, training, and life experiences is needed.

Diversity in Engineering Education

Faculty-directed classroom experiences that encourage URM engineering students to embrace diversity and create an inclusive environment have a positive impact on the social and intellectual development of all students (Felder & Brent, 2005). Engineering instructors must avoid subconscious assumptions that the engineering students have the same cultural backgrounds, have parents who attended college, come from traditional families, and are heterosexual. Referring to these assumptions and conditions of students' backgrounds in class can make students feel marginalized. The faculty members should use inclusive language and avoid stereotypes which diminish students (Felder & Brent, 2016). Classroom inclusivity will allow students to remain creative, and to have their focus on solving the assigned problems.

Diverse engineering students have difficulty arriving at college. A problem exists in getting diverse individuals to consider studying engineering. The American Speech Language Hearing Association (2017) reports that the difficulty in getting URMs' enrollment in engineering is multifaceted. Deil-Amen (2011) summarizes the concerns which limit URMs' to study engineering and other STEM fields. The concerns include lack of financial aid, general financial difficulty, balancing work and school, and the cost of room and board. The costs of higher education are burdensome to nearly all students; many URMs additionally, lack educational financial resources and may not understand the financial aid system. Specific barriers may include little family support, the lack of family understanding how to prepare for and apply to college, low test scores on ACT or SAT exams, and finally, a lack of URM role models within their family or community who have attended college.

Diverse engineering students have difficulty arriving at graduation. Graduation rates for URMs are declining. Female students comprise 20% of recent engineering graduates, but women comprise 55% of all college graduates (Ratcliffe, 2013). Recent engineering graduation rates for African Americans are 5.3% in engineering and 10.8% of all college grads, and Latinos 5.4% to 6.4% in all majors. The percentages represent a decrease in URMs participation in studying engineering over the years. The representation of Asian and White individuals in the nation's workforce is 69%, compared with 74% in 2001. Whites and Asians occupy 87% of the engineering workforce. Whites and Asians also comprise 84% of the employees working in computer professions and 83% in advanced manufacturing fields. Latino and African American workers represent 29% of the workforce available in the U.S. Latino and African American workers comprise 16% of the advanced manufacturing workforce, 15% in computer professions, and 12% of the engineering workforce.

The reasons for URMs not completing their engineering degree include the lack of visible role models, inadequate education preparation, ethnic/racial bias, a shortage of mentors, and poorly equipped elementary and secondary schools (Committee on Equal Opportunities in Science and Engineering, 2013). Even when groups of students have the same pre-college preparation, studies show that women and other engineering URMs do not perform as well as the white male engineering students and the URMs drop out at higher rates (Geisinger & Raman, 2013). The industry continues to be in need of URMs who can work in diverse teams, including engineering graduates capable of solving complex problems (Gibbs, 2014).

Innovation requires a difference in individuals as much as intelligence. Diversity in science and engineering refers to finding and utilizing talent and including skilled engineers across the social spectrum. Innovation and progress depend on our mutual differences as much as our intelligence. Buffinton explained to Wallace (2016) that to achieve success in an engineer's career, and to develop improved ideas, the engineer must take advantage of all individuals' diverse viewpoints. The statement that diversity and ability have equal importance in problem-solving is controversial but strong (Page, 2007). Page explains that if you have a group of engineers from the same background working on the same project, then these engineers may come up with the same approaches. However, someone from outside the group may offer other suggestions, because they have had different prior experiences. The more random the grouping, the more diverse the ideas. Gibbs (2014) explains that when groups of smart people work hard to solve problems, the diversity of the individuals in the group is more important than their ability. Diversity is not separate from the innovative process; diversity is part of the innovation of new ideas and concepts.

Diverse members of a team result in robust problem solutions. Diversity increases the opportunity for the quality and creativity of the group's final product (DiTomaso, Post, & Parks-Yancy, 2007; Williams & O'Reilly, 1998). Multiple people from differing backgrounds will develop robust solutions regardless of whether the individuals have significant experience and training (Owens, 2016). The individual's training received for an engineering education addresses the issues in not only engineering education but also in the ability of the student to perform teamwork. Owens (2016) reiterates that the enduring problem is that engineering schools are currently not capable of producing engineers, diverse or not. Page (2007) and Heath (2008) summarized that Page's work proved the innovative and creative impact of diversity (based on culture, race, gender, and religion) must correlate with cognitive diversity.

Technology businesses that employ engineers are finding that increased diversity in the organization improves their ability to compete globally. The diversity allows higher organization achievement, greater product innovation, and enduring business outcomes. Engineering innovation, to corporate survival, and competitiveness for industrial organizations, is a diverse workplace byproduct. Progressive companies, organizations, and institutions work to find opportunities to build inclusive product development and research teams to take advantage of the relationship between innovation and diversity (Varrasi, 2012). Munson and Gallimore (2016) report that companies with diverse workforces outperform and out-innovate their competitors. Utilization of diverse teams have helped organizations (numerous focus groups and interviews, 40 case studies, and survey of 1,800 professionals) to report a 45% increased market share and 70% of organizations report that the firm has moved into new business areas and markets (Hewlett, Marshall, & Sherbin, 2013). Page (2007) writes in his book that innovation and progress are less dependent on each individual's intelligence, and more on the diverse teams cooperating and taking advantage of their individuality coming together.

Academic affairs approaches to URM retention. Engineering student peers can help attract and retain URMs by serving as role models and providing examples of good study habits, a sense of community, tutoring, and coaching. Engineering institutions such as California State University – Long Beach, San José State University, Colorado State University, and others have opened Engineering Success Center (ESC) to offer students peer support. An ESC provides students with an area where peers can meet and study, give counseling, and provide support. The existence of an ESC can has been shown to identify students who may be struggling academically and the staff can offer help. University success can provide an engineering summer bridge program to prepare students for college, which replaces the need for first-year remediation courses (Dickerson, Solis, Womack, Zephirin, & Stwalley, 2014). This ESC will positively impact the student population's academic retention and performance. (Ortiz, 2016).

Pedagogical Needs for Engineering Education

The National Academy of Engineering (2005) indicates that the pedagogical teaching practices for engineering must change in the U.S. Without a change of pedagogy, the U.S. will lose their engineering preeminence by the year 2020. Despite this warning, engineering faculty continue to use traditional lecturing, which implements passive learning techniques. Passive learning pedagogy involves the instructor standing in front of the classroom and lecturing (Freeman et al., 2014; Knight, Carlson, & Sullvan, 2007; Smith, Sheppard, Johnson, & Johnson, 2005). The chalk-talk teaching style currently in use by engineering professors does not create a learning environment conducive to student persistence and program completion (Bernold, Spurlin, & Anson, 2007; Wilson & Maclaren, 2013). Bernold et al. recommend the content delivery, and that the expectations of students enrolled in engineering programs must be overhauled to advance the engineering teaching profession from a troubling poor learning environment. The overhaul of engineering pedagogy must be accelerated.

Conclusions

Diversity in engineering is important to business, society, and engineering. Understanding how to retain underrepresented minority engineering students using pedagogical approaches to provide learning opportunities is important to the engineering profession. Higher education institutions can provide direct programs to URMs which will improve their success. Faculty should provide compassion to the URM engineering student and the community in which the URM student lives. When a Latino or an African American, graduates with an engineering degree a positive change in the economic status of the family occurs (National Research Council (US) Panel on Hispanic Americans in the United States, 2006). Improving the ability for the URMs to reach engineering graduation will allow a positive shift in their financial status. The function of diverse teams is important to the engineering profession; an important result is the improvement of the financial stabilities of families.

Chapter two examines the literature and addresses the retention of URMs through identified academic affairs' programs and engineering faculty's pedagogy. Presented will be current thoughts on best practices for curriculum development for diverse learners, while providing the historical context of engineering education for diverse students.

Chapter 2: Literature Review

Introduction

This chapter provides a history of engineering education, followed by a review of the literature addressing including and diversity in engineering education. A review of the literature addressing inclusion and diversity in engineering education in engineering presented. The development of engineering educations background is provided to inform those who may not be aware of the history of engineering's educational requirements. In this review, the current and future engineering students' demographics are summarized, which will provide an understanding of the URM students' increased participation in engineering. An introduction to passive teaching and active learning is provided. The current teaching methods used in engineering are described, and literature supported teaching approaches for the engineering classroom are reviewed. Finally, a summary of actions that have been reported in the literature which aid in the URM students' retention and success are provided.

Historical practices in engineering education.

The history of the engineering education in the USA started with the Morrill Act of 1862. The Act was written to address the development of public colleges focusing on agriculture and the mechanic arts. Thirty thousand acres of federal land were given to states. Parcels of this land were sold, and the remaining land established the institution's campus. The profits from the land sale were used to start 69 colleges which would support the development of higher educational institutions for African Americans. Despite the donation of land to the mechanic arts, engineers have not embraced the Morrill Act as the creation of U.S. engineering education. However, the Morrill Act established the U.S. as the center of engineering education excellence (Williams, 2009). The Morrill Act established engineering programs in academia, and the curriculum was established to support a four-year standard engineering degree.

Effect of the Morrill Act. After the Civil War ended in 1865, the country began expanding of U.S. bridges, railroads, and shipping systems built by graduates from these newly formed institutions (Issapour & Sheppard, 2015). The number of colleges grew from four to approximately 100 institutions after 1900. In the early 1900s, women started enrolling in land-grant schools. Future engineers served in apprenticeships, as graduates were expected to graduate and join the workforce immediately. Before World War II, engineering courses consisted of practical training and laboratory experiences to provide learning opportunities.

Integration of underrepresented minorities into engineering. In 1934, George Maceo Jones was the first African American to earn a Ph.D. in civil engineering. Dr. Jones completed his doctorate at the University of Michigan (Titcomb, 2017). In 1938, the Indian Country Media Network (ICMN) (2017) reported Mary Golda Ross graduated with a master's degree from Colorado State Teacher's College and was the first Native American engineer. Ms. Ross was Cherokee and one of the first 40 employees of Lockheed Aircraft Corporation in Burbank, California. Despite the progress in advancing diversity in engineering, in the fall of 1941, Charles Eubanks at age 17 attempted to enroll in an engineering program at the University of Kentucky. Eubanks was an honor student at Louisville's Central High School. The University of Kentucky denied Mr. Eubanks application as the Kentucky Day Law did not grant African Americans and whites to attend the same institution. The National Association of Advancement of Colored People (NAACP) brought suit against the University of Kentucky. The Kentucky Board of Education established a two-year engineering course at the historically black colleges and universities (HBCU) Kentucky State College (currently known as Kentucky State

University) for African American students desiring an engineering degree. The Charles Eubanks versus the University of Kentucky is considered a landmark case in the advancement of equal access and rights in higher education (University of Kentucky, 2017). In 1943, Dr. Harry James Green, Jr. was the first African American to earn a chemical engineering degree. He attended the Ohio State University (Titcomb, 2017).

In 1970, the percentage of engineering bachelor's degrees awarded to women was 0.83%, the number increased to 2.3% in 1975 and the degrees awarded rose to 9.7% in 1980 (Eller, 2013). The incentives and finances also supported industry-associated R&D efforts at federal laboratories and universities. In 1974, the Society of Hispanic Professional Engineers (SHPE) was founded in Los Angeles. The goal was to create a national organization of professional engineers to be role models for the Latino community (Society of Hispanic Professional Engineers, 2017). In the 1990s, community colleges, technical colleges, and junior colleges were nearly free of cost, and students were deciding to move to these two-year degree programs to obtain a technical education (Cardozier, 1993).

The effect of research on engineering education. In the 1980s and 1990s, higher education engineering colleges and departments used industry monies and NSF to provide incentives and financing to engineering faculty to support and conduct research. In 1983, NSF established areas which commercialize academic research are referred to as Engineering Research Centers (ERC). This shift toward research reduced the time that professors could give to teaching. Engineering departments must understand that both engineering instruction and research are important aspects of engineering colleges and reward both activities. The engineering departments' goal is to reward faculty members who excel at research and those who primarily teach. Hiring faculty members that are skilled in research and teaching is the top priority for engineering department administrators (Felder, 1984; Felder 1994). During the 1990s, a study researching university professors' time spent in the classroom discovered that engineering professors had the fewest in-class and contact hours with students (Allen, 1997). Engineering curricula in the 1990s did not build links between students and practical tasks because faculty were not focused on teaching. Allen (1997) reports the concentration on research did not allow the development of mentoring relationships between professors and students, as engineering professors concentrated more on research than on instruction.

Underrepresented Minority Student Populations in Post-Secondary Education

The scientific fields, and particularly engineering, lack diversity of graduates and as potential company employees. URMs population percentages are 38.8% of K-12 public school enrollment, 33.2% of the U.S. college population, 26.2 % of undergraduate enrollment, and 17.7% of those entering engineering and science bachelor's degrees (National Academy of Sciences and National Academy of Engineers & Institute of Medicine, 2011). The National Academies report that in graduate school, URMs are 17.7% of total enrollment but are 14.6% of engineering and science master's degrees, and a paltry 5.4% of engineering and science doctorates. Currently, only 2.7% of African Americans, 3.3% of Native Americans and Alaskan Natives and 2.2% of Latinos who are 24 years old have earned a degree in engineering or the natural sciences. The URM demographics of the U.S. engineering student population between the ages of 18 to 64 show that women represent approximately 20%. African Americans are 13% while Latinos represent 17% of the student engineering population. Native American (Native American, Native Hawaiians or other Pacific Islanders, and those who report more than one race) are 2% (Committee on Equal Opportunities in Science and Engineering, 2013; May & Chubin, 2003; National Science Board, 2017; Ro & Loya, 2015). White males represent 60.1% of enrollment in 2015 (Yoder, 2015).

Latinos and African Americans make up 16% and 12% of the U.S. population. Respectively, they make up approximately 6% and 5% of the engineering workforce. Women make up 13% of the engineering workforce (Koebler, 2011). The number of engineering degrees as a percentage of all bachelor's degrees awarded reduced for all ethnic groups except for Alaska Natives and Native Americans from 1995 to 2005. African Americans had a decline from 3.3% to 2.5%. For Latinos, the decline stopped at 4.2% from 5.5%.

Women have seen no improvement in entering engineering in the last 13 years, In 2014, 24% of the positions in the engineering workforce were held by women who have decreased from 25% in 2001 (Bidwell, 2015). Rosen (2009) reports that engineering programs reflect an increased diversity in the faculty, and student body but that URM recruiting efforts must continue.

Yoder (2016) reports that over 80,000 engineers graduated in 2015. Of those 80,000 graduates, 19.9% were women, and over 14% were Latinos, African American, or Native American. The resulting small group of diverse engineering graduates must supply U.S. engineering employers. A need exists to increase the graduation of diverse students.

Need to expand the number of diverse engineers. The Bureau of Labor Statistics (2016) reports that engineering occupations will increase by 65,000 new positions in industry (Fayer, Lacey & Watson, 2017). The U.S. Congress Committee on Equal Opportunities in Science and Engineering was established to advise NSF on policy creation to expand diverse engineers numbers. The Committee on Equal Opportunities in Science and Engineering reviews programs and policies developed by the NSF for increased numbers of URMs in STEM. The

National Science Foundation (2016) engineering diversity data shows that a total of 86,294 engineers graduated in 2014, with 18,419 URMs. Women engineering graduates in 2014 totaled 16,987 and 10,508 were white women. Despite NSF's progress in getting women and URMs into STEM programs, progress is slow to attract URMs into the engineering fields (Committee on Equal Opportunities in Science and Engineering, 2013).

Attracting underrepresented groups to engineering. The National Academy of Engineering (2005) set a goal to increase the participation of underrepresented groups which included white women and racial/ethnic minorities. Changes to techniques which will increase underrepresented group percentages in engineering are the following:

(1) Outreach to underrepresented groups to inform them about engineering.

(2) Work with students from underrepresented groups to improve their success rate.

(3) Change the curriculum to promote success for all students, including students from URM.

Buffinton, when interviewed by Wallace (2016), summarized that engineering could attract women; the engineering profession needs to be an attractive discipline for women by offering clear opportunities and female role models. Buffinton clarifies that providing relationships and resources to all engineering students will improve all students' success in earning their engineering degree.

Cause of fallout of underrepresented minority versus the majority. The rigorous requirements of STEM studies can create family problems for the URM students because of interference with family duties (White, Altschuld & Lee, 2006). Buffinton, when interviewed by Wallace (2016), states that institutions cannot enroll underrepresented engineering students and expect that these new students will determine everything they need to know on their own. The engineering program that understands that some URMs' have close family involvement will not only survive the engineering curriculum but thrive.

The Need for Diversity in Firms and Institutions

The U.S. loss of design talent and the shortage of engineers hurts the U. S.'s ability to compete globally. When a design change, design improvement, or design innovation is required, the engineering design teams, society, and organizations need a diverse membership (Phillips, 2014). The engineering fields lack URM groups, which includes women (Gibbs, 2014; Phillips, 2014). Groups formed with individuals who differ in gender, race, and other dimensions bring different life experiences and knowledge to problem-solving sessions. A female and a male engineer will have different perspectives, and these viewpoints may be as different as an engineer and a chemist. These differences in thought are good aspects for a group to have when meeting to design new products or solve technical problems (Phillips, 2014). Men and women need to be on engineering teams to develop improved, innovative solutions. Buffinton (Wallace, 2016) emphasizes that the wider the team diversity experience range, the stronger the group.

Wulf (2002) remarks that engineering is a creative profession. Wulf states the general public stereotypical vision of engineers is that they are not creative. However, engineers are creative and often make unexpected connections between known things. A lack of team creativity could be the consequence of insufficient team diversity. Creative thinking and working in teams also need to be taught in engineering programs to ensure team success (Felder, 1984; Felder 1987; Felder, Woods, Stice, & Rugarcia, 2000). A lack of diversity, knowledge of creative thinking methods, and how to work in a team environment can result in not finding the best-engineering solution or better stated, the complete engineering solution (Wulf, 2008).

Life experiences aid diversity. Wulf (2008) argues that engineering teams without experience and thought diversity limit the application of diverse engineers' life experiences that contribute to complete and robust solutions. Wulf states that society pays a cost for the lack of diversity in engineering. The cost to humanity is a loss of opportunities, products not built, device designs not considered, new processes not found, and growth constraints that are not understood. Wulf further explains, that the needed diversity consists of, not only women and other URM, but also the individuals' life experience diversity. An individual's diversity is comprised of the engineer's distinct and extensive practical and academic experiences. Exposing a freshman engineering student to the engineering approaches through classroom experiences in their first year, and each subsequent year until graduation is important. These classroom experiences, combined with the engineering students' life experiences, are needed to build the engineer's thought diversity.

Engineering work environment explored. Engineers often work in teams, sharing, and communicating their knowledge and experiences with team members. The engineers use techniques, tools, and adapt processes in order to solve the stated problem (Santos, 2017). Corporations, employers, and parents have complained that the engineering education process does not graduate engineers who have these skills. Companies have found that engineering graduates display poor communication skills and a lack of understanding is commonplace in the recent engineering graduates (Rugarcia, Felder, Woods & Stice, 2000).

Engineering Teaching Methods

A visit to an engineering classroom today might reveal the following scenario. The professor stands in the front of the room writing on the board. The professor has written words and symbols on the board and is holding a sheet of notes. While writing on the board, the teacher reads the content of the paper, and simultaneously the students write down what appears on the board. Occasionally, the teacher asks a question, and a student will answer quite often the same student in the class that consistently answers all the questions. The instructor's traditional style focuses on lecture-oriented classes that deliver the subject materials with little time left for practical activities in the classroom. In the lecture-based teaching environment, Santos (2017) reports that the engineering student would not experience the practical world types of problems requiring the student to address a solution within a specified cost and time. The practical world problems are poorly defined and are not consistent. The student may not have an understanding of what the professor wants for a solution, or the breadth of the solution needed. In a traditional engineering classroom, students are encouraged to memorize and reproduce their knowledge on exams. The engineering students may not be encouraged to work together, or aspects of cooperation may be restricted amongst the students. This results in students that are not allowed to share their knowledge or even know how to share their knowledge (Santos, 2017). To improve learning, engineering professors need awareness of other teaching and learning styles to utilize skills such as cooperation.

Engineering professors often feel that their teaching requirement is to cover the syllabus material and they do not address the need for thought diversity in the classroom by offering alternative teaching methods (Felder & Brent, 2016). Felder and Brent confirm that engineering faculty believe that their responsibility is to cover the syllabus. Felder and Brent explain that many engineering professors argue that if the students fail to learn the material, the students' lack of learning belongs to the students. This teacher-centered approach by the faculty member who lectures to engineering students does not address many of the students' learning methodologies. Engineering professors need to address the learning needs of the entire class. Engineering professors have difficulty in developing and presenting classroom inclusive instruction that serves individual students. An instructor's utilization of multiple instruction modes will help enable learning for all students who prefer different learning styles and preferences. Focusing on a faculty member's research productivity and ignoring the faculty's teaching performance, Felder (2015) laments that some engineering faculty members who would change their teaching approaches will not change because there is no reward for the time investment. These faculty members correctly believe that spending time implementing new teaching pedagogy will hurt their career advancement because the instructional work reduces available research time.

Explaining the engineering classroom. The engineering professor may not be aware that their instructional techniques are insufficient. (Felder, 2004b). College engineering teaching neither provides nor requires skilled training before starting as a college-level instructor. Felder laments that when comparing engineering professors to pizza delivery people, the pizza delivery people receive more instruction regarding how to perform their jobs. The engineering professor may have received little to no pedagogy training prior to beginning to teach (Robinson & Hope, 2013).

Three engineering professors, Mastascusa, Snyder, and Hoyt (2011), explain how electronic slide presentations and lectures fail to promote learning to students in a classroom. Engineering professors should reduce using these passive styles of instruction and provide engineering students with pedagogy that allows the student to use their acquired knowledge. Providing active learning, which uses interesting learning experiences in the classroom, will promote student learning. Felder and Brent (2016) indicate that engineering graduate school does not teach graduate-level engineering students how to design or deliver engineering courses.

This lack of teaching preparation results in universities hiring new engineering faculty members who will require years of teaching experience to teach effectively.

Engineering students expect that the role of the engineering professor is to stand in front of the class and lecture on subjects (Perry, 1998). Compounding the difficulty for the engineering professor is the makeup of engineering students in the classroom. Crabtree, Baid, and Fox (1993) caution that the problem practicing and student engineers face is their inability to perceive that collaborative engineering and design are social processes. Walesh (2016) uses an example of poor writing skills to describe the engineer practitioners' problem. Practicing engineering professionals perform A grade level engineering work and communicate the work in a C grade (or worse) level and are indicated in poor individual performance reviews at work. Felder and Brent (2016) report that engineering students do not like professional skills assignments or tests if these tasks include writing and presentation assignments. Felder reports that one engineering student (Felder & Brent, 2016, p. 239) said the reason he went into studying engineering is to "get away from that crap!"

Professors assume that the learning strategies that worked for them when they were in college will work for all their students (Lenze & Dinham, 1999). As noted by Oleson and Hora (2013), professors will teach the way they learn best and how teachers taught them, to the detriment of student learning in modern engineering classrooms. The lack of engaging teaching practices could indicate that engineering classes are not often the areas in which education innovation occurs. Teaching and student learning can be especially difficult when students are from a diverse background: ethnically, culturally, and socioeconomically. A professor can improve the engineering student's learning by using flexible pedagogy. Flexibility in the way the teacher presents the material accommodates students to utilize a variety of approaches to learning (Lowery, 2009). Changes are taking place in engineering education. The universities have had a lack of competition, and outside influences have not existed to force change. However, businesses and internet organizations now exist that are willing to teach for profit, or even for free (Goldberg, 1994). Knowledge exists about what makes engineering teaching successful, but engineering professors continue to teach without active learning styles (Rugarcia et al., 2000). Felder indicates that universities are using cooperative and active learning, and that problem-based curricula and courses are continuing to be implemented and may indicate a new paradigm for engineering education.

Emerging practices

Felder and Silverman (1988) indicate that there are mismatches in the engineering student's learning styles and the traditional lecture-based teaching styles. Engineering URM students' learning styles indicate a preference for practice by doing. Figure 1 illustrates that students retain only a small percentage of the passive lectured material.

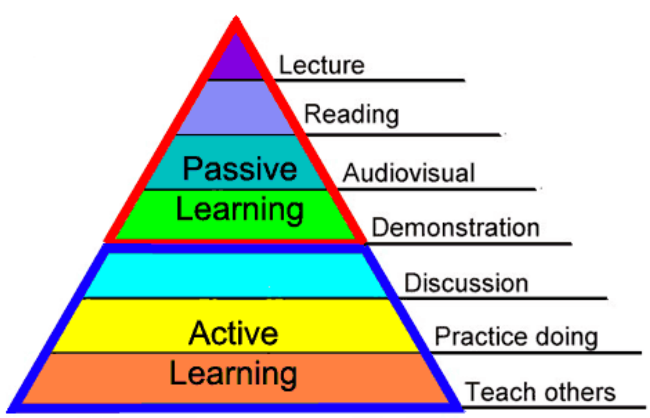

Figure 1. The learning pyramid. Representing the effective elements in learning. Retrieved from https://fitzvillafuerte.com/the-learning-pyramid.html

Felder and Silverman provide different effective teaching techniques for examination, and a small modification to an instructor's teaching technique could effectively overlap the preferred learning styles of the engineering student. Felder and Silverman conclude that the teaching styles of engineering professors and engineering students are incompatible in different ways. The mismatches cause the students to be frustrated, resulting in a loss to society of potential engineers.

Felder, Felder, and Dietz (1998) report that supplementing traditional lecturing with active learning and other effective teaching manners resulted in positive learning effects. Recent studies corroborate with past studies by indicating active learning methods improved learning, critical thinking skills, and persistence to graduation (Reason, Terenzini, & Domingo, 2006; Freeman et al., 2014). The more effective and active learning techniques that are adopted by the instructor, the higher the learning success will be. The report by Felder, Felder, and Dietz (1998) concludes by stating that as engineering instructors gain practice with active learning, the skill levels of the students will increase.

The engineering education improvement plan. Denton (1998) conveys recommended actions for all engineering institutions, (a) improve teaching practices and processes, (b) ensure the curriculum supports the strategic plan of the institution, and (c) expand outreach and beneficial interactions with students. Engineering teaching profession excellence aid the U.S. secure by improving the strengths of faculty, students, and curriculum. If engineering education does not change, a risk exists that other countries will seize the opportunity to advance while the U.S. engineering education system remains passive (Flaherty, 2015; Goldberg, 1994; Splitt, 2003; Wulf, 1998).

Changing attitudes toward engineering education. In recent years, there has been a slow change from traditional lecture style (passive) to a form of active learning. Often, discussion concerning active learning pedagogy polarizes engineering professors. Some engineering professors state that active learning is a fad in engineering teaching and indicate that the traditional, passive learning will prevail (Prince 2004). Active learning has been incorporated into classrooms for over 30 years with success reported in the literature. Passive learning does not provide the challenges students need to develop problem-solving skills (Warnock & Mohammadi-Aragh, 2015). However, some engineering professors still show resistance by avoiding active learning approaches and focus on lecturing in the classroom. (Denton, 1998; Prince, 2004; Rosen, 2009).

Curriculum design. Maciejewski et al. (2017) explain that the U.S. engineering education system is lacking in two ways which affect the recruitment and retention of engineering students. The first way is that students who are interested in engineering and who have demonstrated the aptitude and desire, do not understand the flow of the curricula. The students are not sure of how the courses interrelate, resulting in the decision not to study engineering. The second issue is that students who graduate from four-year engineering programs do not understand the scope of the engineering specialty or the engineer's role. The National Academy of Engineering (2004) provided guidelines and recommendations so that engineering graduates will be prepared to work in a changing global economy. The solution in U.S. engineering colleges to resolve the two problems has been to add more courses and credit requirements to the engineering curriculum, rather than changing the overall curriculum design. In the U.S., 1,740 undergraduate engineering programs were available to students. These programs differ from one another in their emphasis on engineering fields and different diverse student populations. These programs are constant in their objectives and goals. The focus of U.S. engineering education is the acquisition of technical knowledge. The National Academy of Engineering (2005) and the American Academy of Arts and Sciences (2017) report that active learning utilization will increase the participation of the URMs and increase the total engineering student retention rate. Furthermore, efforts to improve student retention support is, focusing on the first two years of engineering programs, to identify courses which are causing the students loss. The introductory courses are offered to explore majors such as physics, statics, and other introductory courses. The National Academy of Engineers (2005) reports that faculty focus on students in any positive encounter improves retention. The efforts to achieve diversity in students studying engineering may fail since the pedagogy is not focusing on the learning needs of all the students. Attention to cognitive styles will improve the achievement of all students. The retention of URM students in engineering education must address the cognitive learning difference in instructional design (Hansen, 1995).

Active learning and engineering student engagement. The non-traditional, active learning, teaching practice will increase effectiveness and retention with the use of different active learning pedagogy inside the classroom (Felder & Brent, 2016; Prince 2004; Prince & Felder, 2006). As students encounter active learning techniques within the engineering classroom, the students will become interested in participating and become more engaged, resulting in improved learning (Canale & Herdklotz, 2012). This will encourage others to pursue engineering as a career choice. Engineering education should develop critical thinking and analytical skills, inspire curiosity, and be accessible to a diverse range of students. Evidence shows that these teaching approaches in research courses will include active and student engaging techniques such as inquiry-based approaches (Anderson et al., 2011).

Freeman (2014) et al. provide a summary of preferred active learning practices encountered in 225 sciences, engineering, and math pedagogy articles. Wieman (2014) analyzed a total of 642 active learning journal articles and argues that any university and college that is teaching STEM courses through traditional lecture approaches is providing an inferior education to their students. Felder and Brent (2016) report that active learning is not a difficult teaching mechanism, but the instructional approach is learner-centered. A learner-center approach means that the students have more responsibility for their learning than in the traditional teacher-centered practices. Effective instructors are charismatic, sometimes funny, knowledgeable and articulate (Delaney, Johnson, Johnson, & Treslan, 2010). The positive active learning environment allows engagement of students (Felder & Brent, 2016).

1. Problem Based Learning (PBL)

Ishen and Giebauer (2009) report that PBL was introduced recently in engineering classrooms after successful utilization in the medical education field. The goal of the PBL approach is to teach students how to learn and to change the material used for the class towards more student-centered learning. The students are exposed to a problem activity when using PBL and utilize reasoning skills to identify needed new areas of knowledge. These newly obtained skills can aid in solving the supplied problem (Albanese and Mitchell, 1993). PBL helps a student develop skills that are necessary for the future engineering employment environment. Implementation of PBL by the instructor is through the presentation of practical design problems to the engineering students. This piques the students' interest as they realize the assignment is an engineering problem that needs to be solved. PBL use allows deep learning of knowledge and improves active learning (Du & Kolmos, 2009).

2. Project Based Learning (PJBL)

In PJBL an assignment is given that requires the performance of tasks which will result in a completed project. The product or outcome is a model, device, computer simulation, or engineering design with the outcome being a report or presentation. The instructor must make tradeoffs between directing the choice of projects, the course objectives, and the students' ability to choose projects strategies and outcomes (Prince & Felder, 2006).

3. Activity Based Learning (ABL)

The ABL instruction process is an extension of PBL. Learning occurs through performing a hands-on activity to meet a defined outcome (Fauval, Miller, Lane, & Farris, 2010). Engineering laboratory-based teaching is ABL teaching. Passive lecture is combined with experiences that involve performance activities with classroom instruction time in the ABL classroom. Various learning opportunities and assignments allow the students to become involved in the learning process rather than sitting and listening to lectures.

4. Flipped Classroom

Flipping the classroom involves having the students watch a video or read assigned material prior to arriving in the classroom. Educators state that the flipped classroom has existed for as long as students were required to do work before attending class. The flipped classroom has the student read an article and observe a lecture or perform another learning activity before coming to the class. Felder and Brent (2016) suggest not implementing the flipped classroom until the faculty member is confident using active learning techniques. The instructor then facilitates a learning discussion or activity in the classroom. Content can be made available to the students online in the form of lecture clips, short videos, and screencasts. Felder and Brent advise that these individual activities should be limited to six minutes or less for passive learners.

5. Team-Based Learning (TBL)

Team-Based Learning (TBL) involves developing a lecture or reading, that allows small groups of students to work together, outside of the classroom (McLaren & Kenny, 2015). TBL pedagogy often has students working in small groups and making presentations to a subset, or all of the students, in the classroom. Using instructor guided face-to-face time in the classroom allows self-managed learning group work and group assignments.

6. Hybrid/Blended Learning

Blended or hybrid learning refers to combining online learning with lectures (Zhao and Breslow, 2013). A portion of the course requires meeting in a traditional classroom, when various approaches and techniques are utilized. Hybrid/Blended learning can help improve teaching quality by supplying material both online and in the traditional classroom (Shattuck, 2010). The online component of the class once viewed allows students to become interested in the content before meeting in person. Upon reviewing the material online, the students are then able to augment the learning experiences further within the classroom. McLaren and Kenny (2015) describe that these styles of hybrid or blended courses often include face-to-face activities in a planned teaching approach and are combined with an online component.

7. Inquiry Learning (IL)

Inquiry learning has students involved in activities in which they are forced to think, and actively participate in developing an answer (Bonwell and Eison, 1991). The learning responsibility shifts from the teacher to the learners. In IL engineering students are given questions that need an answer, problems that can be solved, or a set of issues that they can observe (Prince & Felder, 2006). Harada and Yoshina (2004) state inquiry learning allows students to gain skills needed in the workplace, to engage in research, to determine their direction of education, and to encourage to become lifelong learners. After implementing inquiry learning, educators often have more satisfaction with their work and report that teaching quality improves (Harada & Yoshina, 2004).

8. Case-Based Teaching (CBT)

CBT pedagogy is effective when teaching courses such as engineering management (Raju & Sankar, 1999). An example of CBT is relating a story concerning a current engineering activity, a historical review of a problem, or even a realistic fabricated engineering case study and then subsequently, asking the students to investigate an aspect of the case (Prince & Felder, 2006). The case study is typically a real-life short story with interesting scenarios. The need for decision-making is included in the case study, and the students' decisions should be based on critical thinking.

9. Discovery Learning (DL)

DL instructors utilize an inquiry-based approach, thereby giving students a question to answer, a problem to solve, a picture illustrating a problem, or another problem issue. The students work on resolving the problem statement and developing solutions (Prince & Felder, 2006). Spencer and Jordan (1999) find the DL outcome is that instructors will guide students through the activity and will not wait for the students to discover the information on their own.

10. Experiential Learning (EL)

The EL model is a pedagogy that is based on reflection and observation (Fauval et al., 2010). Students experience a learning activity and reflect on that learning through writing or reporting. The students can leave the classroom and have experience in the field that is related to their area of study. The engineering students are given an experience which requires action. The students then analyze the experience and think of a solution. The students then act on the plan. If they are not successful, they repeat the process. The students follow the cyclic process until reaching a final solution or they receive new input from the instructor.

Engineering professor teaching styles. A need exists to address teaching techniques used by professors and instructors in engineering (Ndahi, Chaturvedi, Akan, & Pickering, 2007). The traditional engineering instructional paradigm of lecture, homework, and testing is ineffective. Felder recommends that instructors work on trying new arrangements of teaching in their classrooms. The goal is to implement active learning and not move immediately from traditional teaching to cooperative or action-based or problem-based learning in a short period. Cooperative learning, a form of active learning, engages students, and aids in the URM retention (Felder & Brent, 2007; Prendergast, 2013; Read, Ross, & Yates, 2016). Ishen and Giebauer (2009) report that interesting lecturers can enrich the classroom process, but these students will learn the material whether they have an enjoyable and enriching experience or not. Engineering students may not readily complete engineering classes with the support that the traditional teaching schemes provide.

Avoiding short-term memory overload, which is caused by lengthy lectures, is accomplished by switching from passive learning to an active learning process (Mastascusa, Snyder, and Hoyt, 2011). Mastascusa et al. report that a respite after filling the short-term memory can be held and is the time to insert a short active learning experience. During these break periods, the students are mentally processing the material that has been introduced recently. Matascusa et al. report that collaborative activity will help students to store the material in long-term memory. Engineering students do not worry about content during the activity: the collaborative activity allows students to have a better opportunity to develop long-term material retention. The students' understanding of the material should be checked with a short exercise to ensure comprehension. At the end of the lecture, a short reflective period should be given, or summary activity such as writing a one-minute paper (Felder, 1992). Reflective times allow the engineering students sufficient time to absorb the material presented by the instructor.

Faculty using the traditional style of teaching should work to integrate some form of active learning. Lecturing to the low-performing student (2.0 to 2.4 GPA) is not helpful as the style is not as interesting as active learning. The low performing student may leave engineering study instead of completing the engineering program (Gleason et al., 2010). The transition of engineering instruction will be difficult, as historically, engineering professors do not mollycoddle or pamper engineering students. Engineering historical documents state that coddling the engineering student is a serious error in engineering university instruction (Society for the Promotion of Engineering Education, 1917; Survey of Rutgers University 1927). Engineering professors teaching engineering today may still attempt not to coddle the engineering students. The use of active learning techniques is not catering to the engineering students but is the result of faculty adapting pedagogy to improve learning. Engineering students benefit from having their learning methods addressed by engineering faculty.

The gatekeeper professor. Gatekeeper professors are those that teach directly from the textbook or PowerPoint while students are trying to understand every word (Gasiewski et al., 2012). The professor often chooses not to publicly post the PowerPoint presentation because a one-time presentation of the material is deemed adequate. During this lecture, facts are presented, requiring the student to understand and write down information. The gatekeeper professor rarely wants to slow down while teaching. Students will not ask questions as the gatekeeper has already conveyed to them that lectures are for listening. The actions of the gatekeeper may discourage students from their major, or from engineering, by having to spend so much time trying to understand the content and not feeling connected to their field of study.

The effect of gatekeeping courses. Throughout the four-year program, the use of the iterative process of designing this curriculum is needed. Orzel (2009) describes gatekeeper courses where more than 30% of the students fail, or a high number of students withdraw early in the semester from the course, or students withdraw and pursue other majors. Organizations are working to attract and motivate students to study engineering, but the engineering educators believe engineering faculty tosses these students out of engineering (Koebler, 2012). The professors who teach courses with a high failure or withdrawal rate see a need for something such as gatekeeping to exist in several disciplines, including engineering. The National Academy of Engineers expects that institutions will avoid making the first year as a weeding exercise. The culling of potential engineering students is unfair to both the students and the faculty. The gatekeepers' control whether engineering students can continue taking engineering courses or not (Tyson, Smith, & Nguema Ndong, 2010). The student should decide if the engineering field is what the student wants to study and the area of study selection should not be the result of the instructional method used in the weed out course. A possible gatekeeping course positive action is that the potential result of having difficulty in the course will cause the engineering students to stop and think about their suitability for their engineering field of study. Vasquez, Fuentes, and Kypuros, (2015) give gatekeeping course examples in engineering as

Statistics, Statics, Electrical Circuits I and Computer Science I. These courses are a part of Manufacturing Engineering, Mechanical Engineering, Electrical Engineering and Computer Science majors (Vasquez et al., 2015).

Orzel (2009) explains the three competing engineering facilitation goals are:

(1) The requirement for lower level classes (typically 100 to 200 level) to cover the material needed for upper-level classes.

(2) For the faculty member to be engaging in the class so that the engineering student learns what they need to know.

(3) For the engineering students to think carefully about pursuing the engineering major.

These preparatory courses target engineering students who have not had an academic accomplishment, or performed rigorous coursework, which is fundamental to success in postsecondary engineering education (Vasquez et al., 2015). Santiago and Hensel (2012) found in their study that 30% of students who leave engineering studies reported academic difficulty. Of the students having academic difficulty, 34% had difficulty in Calculus I and 17% in Chemistry. Nearly 25% of students with academic difficulty did not return to the university to continue study in any program (Santiago & Hensel, 2012).

The identification of at-risk students early in the semester will allow the faculty to engage the students with the relevant material in improving their performance. Early identification of at-risk engineering students could help to identify the needed prerequisite material, review difficult concepts and integrate part of the knowledge that is missing into the course. Peer mentors must be selected appropriately and must be provided with adequate training (Vasquez et al., 2015). Peer-led mentoring sessions aid at-risk engineering students by coaching them through the resolution of problems and issues.

No approved practice to teach engineering students. Though no specific approved engineering pedagogies exist, engineering educators are working in the classroom to develop engineers who understand their field of study (Warnock & Mohammadi-Aragh, 2015). The development of tested and approved curriculum will result in courses and pedagogy that will improve retention of both the URMs and majority students. Engineering instructors primarily teach the mechanics, of how to reason through problems and not how to approach problem-solving. These engineering instructors use routine application of challenges, memorization and the professors do not routinely ask students to analyze situations and respond with solutions. Often, engineering professors do not desire or reward the student who expresses creativity and independence of thought. Faculty are not providing training to solve today's severe societal problems Using requirements to memorize and rote repetition techniques, (Felder, 1984).

Learning Styles and Course Design

Felder (2012) indicates that all students do not learn in the same way, and they do not respond with the same reactions to teaching styles. Those engineering students with different learning styles will have different strengths. Distributing the method of teaching—using various learning styles—will contribute to retaining them in engineering. Catering instruction towards one set of learning preferences or needs will be detrimental as this causes students to leave who would make good engineers. Instruction should be balanced, and utilize an alternation between teaching styles. Felder reports the result will be that the engineering students are comfortable to learn, and the education approaches will help the students to obtain practice and feedback.

The matching of teaching styles, techniques, and strategies to a students' learning style promotes students' understanding. Matching teaching styles to students' learning styles lead to a higher level of engineering students' material understanding and retention (Katsioloudis & Fantz, 2012). Broberg and Lin (2003) state that to be a successful engineering professor, the instructor must be able to utilize instructional arrangements incorporating all learning style classroom categories as needed. Adapting teaching techniques holds true for matching teaching techniques to personality traits. These personality traits are not used to categorize students, but to help understand how to teach so that all engineering students have beneficial learning experiences. The point of using learning styles is to teach in a balanced way rather than in one particular category over its opposite (Felder, 2010).

Engineering course design. In recent years, several institutions have made changes to course design and teaching requirements that have led to positive changes in URM graduation rates (Borrego, Froyd, & Hall, 2010). The seven changes are:

- Design projects in first year engineering course – Getting design experience early and often into the curriculum is important. The offering of different design experiences to the first year engineering students addresses the inability of engineering students to retain information by getting the engineering students excited about design. First-year engineering students are not scheduled to take courses taught by engineering faculty. The first year curriculum should add design courses incorporating interaction between the engineering students and faculty. First-year courses establish a sense of belonging to the engineering community for the new engineering students (Whitfield, Freuler, Allam, & Riter, 2011).
- Interdisciplinary capstone project – The interdisciplinary capstone project is an activity in which students will be part of multidisciplinary or interdisciplinary groups or teams to bring a system or product from concept to building a prototype. This project will include detailed design, material selection, total cost determination, planning, scheduling, and

product fabrication (and numerous other possible steps). The goal is to complete a design project and demonstrate skills that encompass the engineering program.

- Summer bridge program – The summer bridge program addresses the prerequisite knowledge and experiences needed to succeed in the first year of college. Bridge programs help the students to understand that their peers are a valuable resource. Activities are held during the bridge program to foster peer support. In a separate part of the program, the parents receive the student's academic success plan. The bridge program has been shown to improve engineering students' successful graduation rate by 20% (National Science Teachers Association, 2009).
- Learning communities or Integrated Curricula

  Zhao and Kuh (2004) convey that learning communities and integrated curricula have shared social and academic aspects. The same group of students is enrolled in two or more classes together. The co-enrollment ensures that the students encounter each other often and spend time together studying and doing projects together. The learning community becomes more effective when the students encounter the concepts learned in one course in other course's assignments. These activities build a sense of community among the students.
- Community-based Engineering Service Learning Projects – Community-based Service Learning is a teaching method commonly found in education and liberal arts (Jawaharlal, Fan, & Monemi, 2006). Service activities in the engineering field focus on the development of the engineering students. The community-based activity does not appear in the engineering curricula often. Service learning in engineering concentrates on the engineering students become socially responsible engineers. The experience prepares the

engineering students to have the ability to work on the complex community and social problems. The engineering students will solve these issues with a cost-effective technological method.

- Artifact Dissection – Artifact Dissection is a method of teaching engineering students about design principles and engineering concepts by having the students explore the engineered products they encounter inside and outside the classroom. Sheppard and Jenison (1997) indicate that dissection refers to disassembling and reassembling a mechanical device. Students work in groups to document and to perform an examination of the apparatus while disassembling the device. Finally, the students use their observations to understand the engineering reasons for the design approach.

Felder (1995) reports that utilizing teaching techniques, such as those outlined above, can be augmented with support actions in the classroom to improve learning. The professor can work to minimize the instructor's role as the source of all knowledge and place more of the learning burden on the students. Felder suggests using alternate styles of questions on the tests which would require the students to brainstorm, troubleshoot or outline the recommended engineering problem-solving approach. Felder recommends faculty to ask for feedback from the students and to implement the suggested changes that make sense in the classroom. This feedback could be obtained through midterm evaluations and considering the suggestions that come from many students and not just one or two isolated comments.

Approaches to Aid in URM Student Success

Engineering students may decide that their engineering classroom experiences no longer motivate them to continue in an engineering program. These students may move from engineering, or within engineering, or to another STEM discipline or another college. Walden and Foor (2008) postulate that students having difficulty in one area of engineering could thrive in another engineering specialty. Engineering departments should view these students as having academic performance challenges in only one engineering discipline and introduce them to other educational opportunities within differing engineering fields. Advising sessions with the engineering student who is having trouble in one area of engineering and could be provided in another engineering discipline, program, and curriculum. A different engineering discipline would provide an alternate path to success. The relocation of poorly performing students to other areas of engineering can improve student performance. The problem is that often engineering departments see these students as immediately lost from the engineering program, with a resulting perception that the student is a poor performer. Engineering departments need to have empathy for these students and work to see if the students may perform well in a different engineering field of study.

Sometimes URMs leave because of the engineering courses being difficult but often because they feel like they do not belong to their department. Not feeling as if they belong in the engineering college is the strongest negative factor for all students. Marra, Rodgers, Shen, and Bogue (2012), find that academic rigor is less of a reason for the URM leaving engineering. Understanding the reasons for engineering students changing majors or leaving college for not feeling as if they belong in the engineering institution is complicated. The feeling of not belonging occurs when the engineering student does not feel connected with their peers or colleagues. Having a diverse mix of students in the class does not mean the classroom is completely integrated. When students do not perceive inclusion in the classroom, the implication is that a diverse classroom atmosphere does not exist (Ruggs, & Hebl, 2012). National Academy of Sciences and National Academy of Engineering and the Institute of

Medicine (2011) state that the success of the URM engineering student may depend on how the student participates in activities such as study groups, peer-to-peer support, social events, mentoring and tutoring. Social integration and academic support programs can help the student to succeed. The creation of activities that increase the student's academic and social integration help the student to understand all the support resources that are available on campus (Palmer, Davis, & Thompson, 2010). These complaints about not belonging indicate an area the engineering departments across the U.S. can investigate and implement continuous improvement activities to make all students feel welcome (Marra et al., 2012).

The success of diverse students. An engineering degree is a transformative accomplishment for any student. For students from underprivileged backgrounds it can change the trajectory not just their lives, but their families and even their communities. Institutions can help URM students by engaging these students directly in major-related student organizations and research activities. The administration of engineering programs can develop inclusive science cultural events that bring diverse students together. Engineering departments can decide not to wait for high schools to send prepared students from high school, but can work to improve the readiness of the student and ensure the inclusion of the URM students in all educational opportunities. (Chang, Sharkness, Hurtado, & Newman, 2014).

Universities need to increase the number of URMs studying engineering and to retain them; the retention and increasing the number of URMs engineering students coincides with the general requirements of universities in the U.S. (Gates & Mirkin, 2012). Implementing an ESC which utilizes activities shown to aid in the retaining of URMs in engineering is important. An ESC will assist in the retention and persistence of engineering students. The student ESC is a leader-peer run facility that provides a place to study, a sense of community, and study skills which include tutoring and coaching. The ESC needs to have faculty participation. The organization EAB (2016) reports that without the faculty engagement in the program student success initiatives are prone to failure. With faculty involvement on the other hand, making critical changes and reforms that pertain to academic policies, curricular requirements, transfer articulation and advising practices will result in engineering students' success.

The ESC would impact students through efforts in mentoring, research, and education. The mentoring is a combination of peer, staff, and faculty mentoring. The undergraduate engineering students perform faculty-guided research in coordinated with the success center. The education aspect includes intervention, advising and individualized development plans (Wilson, Iyengar, Pang, Warner, & Luces, 2011). Engineering learning and community centers can be successful in the retention of students. A center includes project team work areas with computer support. The center provides areas for students to build and store projects. Incorporating the capabilities of the laboratory space with first-year classes aids in building the students' interest in engineering (Batill & Gedde, 2017). These activities enhance student retention through improved success in undergraduate courses and faculty support. Usually, success in undergraduate courses occurs readily because of the structured approach to implementing the mentoring, research, and education. The success center can tie into the other campus organizations to work cooperatively. Students also learn about research opportunities within the engineering departments; the students engage in peer mentoring and other support activities. Using well-designed mentoring programs, students develop strategies to enhance their thinking skills. Mentoring programs found in the ESC emulate the apprenticeship model used in engineering in the past to help guide the student toward becoming practicing engineers (Wilson et al., 2011).

Tomasko, Ridgway, Waller, and Olesik (2016) also suggest using an engineering bridge program designed to help the URM engineering students feel prepared and welcomed at the university and engineering department. Students who have participated in bridge programs have a strong sense of belonging and are well prepared. An engineering summer bridge-program targets populations of URM and first-generation college students in engineering, which results in higher improved persistence and retention (Tomasko et al., 2016).

Academic experiences of URMs in high school. Latinos and African American students are likely to encounter difficulties in primary and secondary education due to not having quality teachers in science and math classes (National Science Board, 2010). These barriers cause Latino and African American students to be less prepared to enter into STEM fields of study in college (Ruggs, & Hebl, 2012). The National Academy of Sciences and National Academy of Engineers and the Institute of Medicine (2011) reflect that engineering education needs to develop a culture that expects that every admitted student will graduate, including URMs, first-generation, and low-income students.

The creation of a safe environment for all students in which the students feel comfortable taking risks and asking questions is necessary (Ruggs, & Hebl, 2012). Inclusive and diverse classroom have benefits which range from increasing learning to improving social interactions (Gurin, Dey, Hurtado, & Gurin, 2002). However, problems occur involving the URM students' interactions with faculty, other students, and the university. Faculty continue to believe that URM students will perform at low levels. The faculty bias causes issues with participation in and outside the classroom. However, the URM students may be happy for these bridge, tutoring, residential housing, and other programs, though some URM students associate a stigma associated with their participation in the program (National Academy of Engineers, Institute of Medicine, 2011; National Academy of Sciences, 2011).

Hurtado, Milem, Clayton-Pederson, and Walter (1999) have indicated that institutions should work to expand the URM participation in engineering. Achieving URM participation can be performed by:

(1) Involving faculty in departmental actions known to increase diversity.

(2) Students should encounter and meet with faculty outside the classroom.

(3) Initiate curricular activities that promote dialogue.

(4) Increase training and sensitivity of staff who are working with the diverse students.

(5) Include diverse students in meetings and organizations.

The goal is to increase the URM students' involvement in programs on campus. Having underrepresented faculty on staff can lead to student success, the problem is finding and retaining these teachers (National Academy of Sciences, 2011).

Conclusion

A need exists for student diversity in engineering. The URM student population will increase in future years due to birth rate demography. Currently, the trend for engineers' enrollment and the number of engineers graduating is growing. A need still prevails for more women and other URMs to graduate.

Engineering students who have difficulties in class must not be weeded out from engineering, including STEM programs, without an attempt by faculty and academic affairs personnel to help the student to succeed in engineering or another field of study. Students who do not like the engineering design classes, or who fail to succeed in the other engineering courses, should be directed to a skilled advisor who will work with the student to determine the best career path for them. The effort needs to be made to advise these academically troubled students to retain them within the STEM environment.

The use of pedagogy other than straight lecturing is important. Interspersing lecturing with active learning is an improved teaching method. The move from a teacher-centered method of instruction will allow engineering students' learning to improve and be engaging. However, if the teachers are not familiar with active teaching techniques, they should not attempt to implement every method of active learning. The goal of the instructor is to make incremental changes while implementing active learning. Making more than three changes to add active learning to any course can be discouraging to both the teacher and students. The desire is to improve students' performance, and the instructor should celebrate meeting that goal.

Students may initially reluctantly participate in the method of instruction where the student is responsible for their understanding and learning. Appropriate support and guidance should be furnished to the instructor when using active learning techniques. Maintaining instructor support and guidance is paramount. Otherwise, the result will be inferior learning outcomes, poor evaluations, and developing of hostility in students.

Active and inquiry-based learning and teaching will aid in increasing URM retention. Focusing on the engineering students' learning styles will add to the students' decisions to keep working towards having a career in engineering.

Chapter three outlines the process for obtaining the field data. The researcher traveled to various institutions to perform field interviews. Identified institutions graduating a significant number of URMs received visits. The field interviews will provide the information needed to answer the research questions.

Chapter 3: Methodology

The researcher intends to identify approaches needed for developing departmental engineering support, university programs, and engineering education instructional practices that have been successful in teaching engineering students. The chapter outlines the process utilized by the researcher to investigate the research question.

The investigated research questions were:

1). What practices are engineering faculty employing to retain underrepresented minorities in engineering?

2) What practices are academic affairs personnel employing to retain underrepresented minorities in engineering?

Research Design

The study is a qualitative grounded case study. Creswell (2003) stated a case study occurs through the researcher exploring a setting or context in depth. The program can be an activity, an event, a process, or one or more persons. Activity and time bind the case study. A requirement exists to review large quantities of semi-structured or unstructured qualitative data.

The case study methods followed Merriam’s (1988) book which addresses the case study process. The researcher’s data interview process occurred in a professional, skillful manner. The scope and literature review may have changed based on the conditions, comments, trends, and new information encountered during the study.

Research Setting

The researcher used data sets and public information to select those universities graduating higher numbers of URMs with an attempt to study those institutions exceeding the expected number of URMs based on local demographics or performance of peer institutions. The researcher contacted representative individuals at those institutions to discuss teaching and the retention of URMs. A convenience sample was obtained which consisted of individuals in faculty and academic affairs personnel who consented to be interviewed. The data was organized and coded to identify those trends that support the retention of URMs. Reviews of available engineering demographic datasets and qualitative interviews were used to gather data. The research goal was to determine successful approaches for retaining URM in undergrad engineering academic programs.

Listed in the selected institutions in Appendix A are the populations that were studied and sampled. A list of institutions was created based on an institution's high percentage of URM degrees granted. The interview goal was to speak with a subset of those organizations that are representative of the institutions that graduate larger numbers of URMs versus the total pool of those engineering degree-granting institutions.

A mapping website was used to map the cities of the institutions for each URM. A composite map was generated for each of the URM categories. By producing a final combined map, the researcher identified three zones to visit. One zone covered Georgia and Florida. The second zone covered Alabama, Mississippi, Louisiana, and Texas. The third zone included Illinois, Indiana, and Michigan. The third zone was chosen to investigate universities where relatively high numbers of women have performed well in engineering and successfully graduated.

The researcher contacted individuals who work at the highlighted universities in Appendix A to schedule interviews. The contact faculty and academic affairs names were obtained from the American Society for Engineering Education (ASEE) (2017) member database. Often, the dean's offices referred the researcher to faculty or academic affairs personnel. University faculty listing on the institutions' websites were also used.

The study resulted in visiting or communicating with three to five participants representing each university. The total number of institutions visited in this study was 15. Sampling stopped in this study when the incremental learning became minimal because the researcher observed previously experienced phenomena. The data gathering continued until each theory or category of data became saturated with no new available data.

Data Collection

The researcher reviewed accessible public data regarding universities that service underrepresented populations. McMillan (2016) suggested the review of documents and websites offers investigators conducting a multi-site case study an enriched understanding of each case. The researcher determined the top 45 engineering schools that graduate women, African Americans, and Latinos. Access to the American Society for Engineering Education dataset was utilized to obtain demographic information regarding participating institutions and the graduation rates of URM. Independent data sources were also used to confirm the ASEE information. The confirming data was obtained from university websites and published reports. The ranking was established by combining the number of diplomas to African Americans and Latinos and calculating the percentage of diplomas granted to these two groups.

The development of the research instrument's questions supported the grounded case study. These questions aided in the identification of actions and programs that helped in the retention of URMs. The eight questions assisted in keeping the interview process consistent. The questions sought to understand the participants' experiences with educating and retaining engineering students. The expectation was that these questions identified strategies, pedagogies, and supporting systems to indicate how the URMs are successful at being retained and persisting to graduation. The questioning exposed the participants' experiences, beliefs, and feelings about the use of teaching style and the retention and successful URM's graduation rate. The goal was to have the individual explain their experience of the phenomenon. Interviews were recorded using a digital audio recorder. The researcher worked not to influence the participant's statements. The interviewer also utilized note taking, which allowed tracking of what the individual said during the discussion in case additional information was needed. The recording ensured the interviewer's discussion flow was maintained, helped the researcher focus on what was being said and organized thoughts, and allow time to note additional questions. The researcher transcribed the recordings. Further clarification was sought on three interviews during the transcription phase by following up via email with the participant requesting their input. The researcher sent the transcripts via email to the participant for verification. Thirty-six participants reviewed the transcripts and reported they were acceptable, which was 43% of the participants indicating the transcript represented their interview content. Eight of the interviews were returned with minor editorial comments to correct the spoken word of the participants. The researcher informed the participant that they could respond to changes and that after one week the assumption would be made that the transcript was acceptable unless the participant updated the transcript. Over a time range of October 2017 to February 2018, the researcher collected information using various data collection techniques. Aside from these interviews, the researcher collected supporting literature, print data, and other documentation found or offered during site visits. The researcher also observed the locations where students studied, ate, and relaxed while the students were in their academic environment.

The researcher individually interviewed deans, chairpersons, appropriate faculty, and graduates who are knowledgeable of teaching and active learning at these institutions. Members of the American Society for Engineering Education organization, published articles regarding engineering education, were contacted to help prepare the researcher prior to traveling to the field to perform interviews. Each participant needed a connection to the group of universities under study. The researcher remained open to discussion with any top 45 faculty and academic staff members who expressed interest in discussing the retention of URMs. Every effort was made to avoid snowballing the participants. No unplanned interviews were held during site visits.

Formal approval was obtained from the Institution Review Board (IRB) before communicating with any representatives from the 45 institutions. Before an interview, the participant signed an IRB approved participation and consent form. The researcher contacted engineering deans, chairpersons, faculty, and graduates of the selected universities that could contribute to the case study by email (note that larger schools have a chairperson for each engineering department). The researcher found the deans' and chairpersons' and their email addresses by researching the university websites or utilizing the ASEE website.

To initiate the study, the researcher attempted to make contact with the dean of engineering via email before contacting other individuals at that institution. There was a 24-hour wait period before contacting potential participants at the university. This time was given in case the deans wanted to provide introductions to their personnel. The researcher contacted one or more potential participants the day after the deans of the university were contacted. The researcher did not offer an inducement (financial or another reimbursement) to participate in the study. The researcher sent a scripted email identifying himself as a Murray State University faculty member, with a request for a meeting as the subject line. The email contained a summary of why the researcher was contacting the possible participant.

The potential participants were informed that the researcher was seeking information regarding their interest in meeting in person, or phone, or Google Chat. The input from these discussions helped to schedule the potential visits and establish the travel logistics. These early discussions with universities' representatives helped to schedule personal visits. These visits allowed the researcher to experience the university for an extended time (1 day for each site including travel to the next location). The researcher expected that a subset of individuals would respond only to email communication. The researcher sent the consent form via email before sending questions to the individuals who were participating in the study. Ten responses were received by email as the participants stated they were not available to provide answers.

During the interview, the researcher engaged the participant in introductory comments. The researcher first reviewed the consent form with the participant, after the review the researcher obtained a signed consent form before starting the interview. The researcher read the statement to the participant, and then after requesting permission, turned on the voice recorder. The researcher then engaged the participant with the questions. The interview concluded after the last question was fully answered.

The researcher connected the transcribed recorded interview with a code reference number keyed to the individual. All data files were stored on the researcher's laptop or on the researcher's backup storage (the storage of the memory device is in a locked cabinet). Access to the researcher's computer requires password authentication. In the transcriptions, there are no direct references to any participants. The memory card in the recording device was purged and overwritten during normal use. After coding the last interview, the recordings were saved, and the recorder cleared any participant recordings on the device. The researcher transcribed 77 interviews and formatted 10 email responses.

Case Study Procedures and Roles

The researcher visited in person a representative sample of faculty and academic affairs personnel at 15 universities which graduate women, African or Latinos. The universities overlap with all three of these minority groups persisting to graduation. The researcher developed a spreadsheet with characteristics identifying the universities. The first year retention rate and acceptance rate data were included in the spreadsheet. The researcher noted a possible relationship between retention and acceptance rate while entering data. The goal was to study the selected universities having the higher retention rates and representation of the URM engineering graduates.

Data Analysis

The researcher reviewed the transcribed interviews searching for common themes to organize the data and bucket the information. Yin (2009) suggests five manners of analyzing the data. The anticipated process used to analyze the data was reviewing and collating using pattern matching and explanation building. The researcher's role is critical as the interviewer, and the researcher is the key to the interpretation of the lived experiences. In a grounded design, Lawrence and Tar (2013) report that the goal of grounded theory is to find a theory or theories that closely tie to the evidence and are consistent with the empirical data. An issue with grounded theory is that the method is labor intensive. The data collection, techniques of coding and grouping, development of categories and gathering information from the data guides the development of theories which aided in theme development. The study's research goal is to develop theories that associate with the positive and negative retention of URMs in engineering.

The theory is grounded, as the theory emerges and explains events and relationships, the researcher works to understand the lived experiences of those processes and people. By analyzing the collected data from the participants' lived experiences, the researcher began to understand the participants' world as repeated concepts, ideas, and elements began to emerge.

The researcher kept a diary which started on July 17, 2017. The diary contains short sentences, short paragraphs or extended writings on the experiences encountered. Memos were written and filed for future reference, to aid in documenting the lived experiences for reference during the coding process. The researcher reviewed this information and bucketed the material into common codes. Reviewing brochures, websites, handouts, and other published information revealed additional quantitative data. Study data developed from collected data for providing quantitative analysis for identifying trends. The principle scheme used for baselining the analysis was Observing, Think, Test, and Revise (OTTR). The analysis has been iterative, as the initial observations were reviewed and considered; the researcher's thought process shaped the subsequent data collection. In the observation state, tentative bucketing, and thoughts were associated. During this thought process, consideration of the collected information, and alternative explanations, were used to create and confirm the hypothesis. The effort continued with additional data collected through subsequent observation or review. Finally, in the review stage, the analysis of the observations and new data was considered and documented. The repetition process analysis occurred until the data obtained explained the research questions (Texas State Auditor's Office, 1995).

Transcribing

The researcher recorded the audio of the interviews. The researcher transcribed the interviews by playing the taped interviews and typing what was said by the participants into a

Notepad file. After completing the transcriptions, the researcher sent the transcript back to the interviewed participants and gave them one week to respond and report any changes.

Developing Theory

The researcher looked for inferences and developed theory in the transcriptions. Collating the information was performed by using associative techniques (Guest, Namey, & Mitchell, 2013; Ritchie & Lewis, 2003) to bring information together and consider the meaning. Microsoft Excel was used to group concepts of similar information and trends by working with a spreadsheet. The information was entered into categories within an Excel spreadsheet. The author wrote short papers addressed to the file which documented the current thinking of importance. Finally, the researcher worked with the information and reviewed the data.

The case study goal is to present the data without interpretation and abstraction, allowing the participants to tell their own story in chapter four. The author maintained a spreadsheet that tied participant abbreviated thoughts in a spreadsheet, these entries were linked to the participants through random naming. Fictitious names were chosen for the participants. The names chosen were chosen randomly and have no reference to the individual other than an attempt to link to gender identification. Names commonly used for both genders were occasionally used with no intended implications of name selection.

The researcher will write a descriptive narrative using field notes, researcher interpretations, and interview transcripts and finally, building theory or theories by using abstraction and interpretation (Lawrence & Tar, 2013). The researcher will be constrained by his training as an engineer: despite efforts to be open and understanding the researcher will have difficulty stepping away from the researcher's structured organizational and analytical approach while reviewing the data.

Confidentiality

Collected data in any form are protected to maintain the anonymity of the participants. The names of individuals contacted for interviewing were not shared. Only the researcher could identify the individual subjects in the survey responses. Every effort was made to prevent external individuals from identifying an individual participant in the study, or their specific response. The data will remain securely stored after the completion of the study, for a minimum of three years, after which the data may be destroyed.

Anonymity

The confidentiality of the information obtained from the participants in the research means that only the researcher can identify the individual subjects. The researcher made every possible effort to secure the data and surveys inaccessible to anyone not involved in the study. No one outside the research effort was allowed access to information that may link the respondents to their data, surveys, interviews, or any form of response.

Reliability

Yin (2009) expresses the importance of achieving case study reliability. The researcher worked on documenting the study process so that performing the same study would yield the same results if the study is repeated by others. To aid in the documentation of the case study protocol processes were developed, documented, and maintained. The researcher documented the recording arrangement used for coding the data with enough detail that another researcher could reproduce the output.

The researcher employed the process of triangulation through the use of various sources of evidence and avoided the use of one observation in any data gathering area of study and examined the data gathered at each study site. Each university location was compared to the other sites looking for explanations for the studied phenomena (Merriam, 1988). The researcher checked back with those interviewed to determine if the results and decisions made were plausible. Subsequently, the researcher confirmed with other individuals in engineering and education research roles and discussed the project. The dissertation committee provided feedback when the researcher seemed confused or distorted.

The researcher's preconception was engineering instructors were going to believe that they had been successful at using traditional teaching approaches for extended periods of time. These professors continued to mimic the passive pedagogy that they experienced as college students. An approach of more of the same arrangement of teaching could indicate that the majority of the instructors were not using active learning techniques. The researcher set aside the desire to encounter active learning and accepted that individuals could use any combination of teaching techniques. The researcher listened carefully to explanations given during interviews and had no preconceived perceptions of how underrepresented minority students should or could behave in the described situation.

The researcher used intuiting (University of Missouri, 2017) while performing the investigation. The researcher observed and ensured that blindness to new information did not occur. The researcher looked, listened and worked to grasp the experienced phenomena and compared these observations to related phenomena. The researcher focused on the process of reviewing the phenomena reported to instruct students and programs to aid retention. Aside from teaching and class requirements, the researcher was focused on the research effort. To improve the researcher's skill, the researcher made an effort to discuss methodology with experienced case study researchers.

Internal Validity

The researcher was careful during questioning to identify factors that affected the retention of URMs. The researcher worked to ascertain whether the groups within URM are affected in the same way. Competing factors within subgroups of URMs can be influenced by their environment.

Bracketing

The researcher used bracketing techniques to set aside assumptions regarding the research. The researcher reviewed with Dr. David Whaley and Dr. Melony Shemberger at Murray State University to assure the grounding of the researcher in methods and observation. The researcher consulted with Dr. Rebecca Brent and Dr. Richard Felder regarding active learning to support the study.

Subjectivities

When summarizing the case study, subjectivity in the presentation and evaluation of the summary reports can occur. The researcher addressed the interpretation of the data and any subject inferences, to ensure that the results of the case study can be extendable. The researcher ensured the sample size of engineering faculty interviewed and institutions visited was significant.

Study Limitations

The study limitations are:

1. The researcher is a white male. The researcher is approaching 60 years old. The researcher is studying the effect on an underrepresented group. The researcher is a privileged individual in society and may not recognize essential information when encountered due to context, environment or sociological phenomena. The researcher,

because of age and other similarities, may have allowed older white males to feel comfortable to discuss diversity.

2. The researcher investigated a broad set of engineering institutions. No matter how the researcher divides the visited universities, the researcher cannot expect to represent all the engineering institutions' approaches to retaining URM.
3. The researcher obtained a sample size that is adequate to infer methods which positively affect the representation of URMs. However, the results are a representative of the study environment. Conclusive results will have to be performed by directed quantitative studies at a later time.
4. The researcher is a second generation university graduate with supportive parents who believe education comes first for their children. The researcher does not know what he does not know. The importance of previous or current generation participants inform the researcher of cultural experiences.
5. Gender, or ethnicity, of the respondents, was not recorded for the individuals participating in the study but were interpolated by the researcher. The gender or ethnicity of the individuals who declined to participate could be interesting to investigate.
6. The investigation was the researcher's first qualitative case study effort. A precisely defined method for a case study does not exist. The effort to carefully plan and organize the research in advance is significant. The researcher performed an adequate preparation to ensure the study's success.
7. The researcher is a licensed professional engineer and certified project management professional. The researcher prefers a systematic approach to the research and data

gathering processes. The researcher's rigid approach could have limited the identification of individuals to participate in the study. The researcher's formal request for an interview could be offputting to some individuals who would not participate because of the direct approach utilized.

8. Some engineers resented being asked to sign a consent form to participate in the study and refused participation. At least one engineer wanted their university's legal department to review the form before signing and declined to participate. The presence of the IRB approval form discouraged some individuals from participating in the study. The consent form may have reduced number of participants.

Chapter 4: Research Findings

Introduction

The purpose of this study is to determine what actions are being taken by faculty and academic affairs personnel to retain URMs in their universities and specifically in engineering. This study is supported by interviews obtained during visits to U.S. universities in three different areas of the country. The goal was to speak with faculty and academic affairs personnel regarding their view of teaching methods and programs that retain URMs. The instrument consisted of questions to investigate these areas.

Participants

The participants were selected from the ASEE website membership listing. There were 394 email requests sent to faculty and academic affairs personnel at universities selected for participation in the study. The selection of faculty participants was random, all faculty contacted had an equal chance of being selected to receive an email invitation. The emails requesting interviews had 161 individuals responding and indicate interest and possibly having questions. Potential participants showing interest but did not participate had issues with the consent form as they did not feel the formal consent was required. Sometimes the response emails would redirect the contact to others who might participate, some individuals determined they could not participate when the in-person interview would occur. The 161 responses represented a 40.9% individuals indicating interest and the 89 signed consent forms 20.3% affirmative response rate. The final participation rate resulting from the emails was 19.8%. Two individuals did not participate in the study after having provided a consent form. The other seven individuals participating in the study are leaders in the field of diversity, or active learning who were contacted directly by the researcher. These seven leaders all signed consent forms prior to their interview.

The participants noted an unwillingness to participate in interviews during the academic year. If faculty and academic affairs personnel are busy, even though they are interested in participating, the may not have responded positively to the interview request. The researcher noted in one memo to file early in the study that not all interview requests were responded to positively:

> I had two responses from [a university in Texas] that read as if the person was angry. Similar to one I received from [a university in Florida]. The individuals used words like *unable* or *unwilling*. The messages were terse. The underlying cause of the message is concerning to me.

The researcher traveled to visit the 15 participating universities and interviewed 74 of the 87 participants. Thirteen of the participants were not available at the time of the visit to their university or would only participate via email. After the interviews, the researcher sent each participant a handwritten thank you note. Each interview was manually transcribed by the researcher. The researcher then emailed each of the participants the transcription Notepad file. Thirty-six participants responded, a 43% response rate, that they had reviewed the transcription. Twenty-five of the 36 participants, 69%, requested no changes and found the transcript to be representative of the discussion. Eleven participants had changes; two participants had changes which they considered significant. Nine participants did not like how the transcribed spoken word was not grammatically correct and made minor edits to add a professional tone to their comments. The other interviewee who had a concern removed the participant's research team students' information. The participant felt that the students could possibly be identified from descriptions given in the interview. The participant was concerned that a FERPA violation might occur if the transcript was not changed to remove the students. The participant supplied an edited transcript which is used for this study. No participants indicated improper transcription had occurred.

Table 1 describes the regions where the participants were employed. Nearly a third of the participants graduated from the top 45 universities in the study, 26 of 87 (29.9%) participants graduated with a bachelors degree from these institutions. The three regions included seven universities in the trip through Florida to Georiga, five universities in the trip through Texas to Alabama (two universities were removed from this visit due to the destruction caused by a hurricane that occurred shortly before the visit) and the visit to the Midwest involved three universities. The other areas involved a university with Latino and Native American populations; the other institutions involved selected consultants or leaders in their fields who were associated with resolving URMs academic issues.

Table 1

Regions and number of participants interviewed

Region	Count
Florida to Georgia	33
Texas to Alabama	33
Midwest	13
Other Areas	8
Total	87

Table 2 describes the gender and ethnicity of the participants. The gender mix is interesting as the participants, when interviewed, did not describe nearly 50% representation of women within their engineering departments, yet the female participation was nearly 50%. The results were expected to match the 20% -25% enrollment found in U.S. engineering programs.

Also noteworthy, women had a greater desire to participate in the study than the men as a greater number of men were asked to participate.

Table 2

Participant Gender and Ethnicity

Gender	Ethnicity	Count	Percent
Female		39	44.8%
	African American	6	
	Asian	1	
	Latino	5	
	White	27	
Male		47	54.1%
	African American	6	
	Asian	5	
	Latinos	3	
	White	33	
Other		1	1.1%
	White	1	
	Total	87	

Table 3 illustrates the departments where the participants are assigned to within their institutions. Engineering is the largest group. The Engineering group is comprised of deans, directors or Engineering academic affairs professionals. The Engineering academic affairs personnel work only with activities and engineering students. The four Academic Affairs individuals are responsible for all campus Academic Affairs activities.

Table 3

Department Participation

Department	Count
Engineering (includes Academic Affairs)	15
Biomedical/Bioelectrical	10
Mechanical/Materials	9

Table 3. Department Participation (continued)

Department	Count
Computer Engineering/Science	8
Civil	7
Engineering Education	7
Electrical	6
Industrial	5
Academic Affairs	4
Administration	3
Aerospace	3
Chemistry	3
Non-Engineering	3
Ethics	1
Library	1
Mathematics	1
Nuclear	1
Total	87

Table 4 conveys information about the individuals' positions and ethnicities. The first point of contact at the institutions was the Dean of Engineering. In some instances, the deans had been promoted to a higher position. This resulted in provosts responding to my inquiries. The data shows that Whites dominate most positions. The director position has a representation of African Americans, as many of these individuals are leading diversity centers.

Table 4

Position and Ethnic

Role	African American	Asian American	Latino	White	Total
Dean/Provost	1	1	2	11	15
Professor	1	1	2	9	13
Assoc. Prof.	1	1	2	11	14
Assist. Prof.	2	1	0	9	12
Director	5	0	2	4	11
Chair	1	2	0	4	7
Consultant	1	1	0	2	4
Lecturer	0	0	1	3	4
Academic Affairs	0	0	0	2	2
Staff	0	0	1	1	2

Table 4. Position and Ethnicity (continued)

Role	African American	Asian American	Latino	White	Total
Adjunct	1	0	0	1	2
Eng. Adv.	0	0	0	1	1

In table 5, the participants' pedagogy understanding as determined by the researcher, based on the responses provided by the participant when ask about their teaching in a classroom. Each participant was evaluated by their descriptions of their pedagogy style. For the participants labeled as having *none*, the individuals are confused by the term pedagogy, and they do not refer to teaching in terms referencing instructional practices. The term *some* would indicate an individual that does not reference pedagogy styles or terms but has an awareness of teaching and learning methods. A participant that is *informed* refers to pedagogy and learning and teaching styles, shows awareness of teaching methods and is aware of instructional design. An *expert* describes pedagogy, instructional design, course design, curriculum, scaffolding and offers

Table 5

Pedagogy level of participants

Level	Count
None	7
Some	11
Informed	11
Expert	57
Unknown	1
Total	87

examples of teaching styles. A participant would be labeled as *unknown* if they did not answer the question about their preferred teaching style.

Table 6 shows the frequency that the code words occurred in the response table. These code words' frequencies are indicative of the relative importance of the topic as expressed by the participants.

Table 6

Frequency of codewords occurrence

Code Term	Count
Community	52
Mentoring	48
Role Model	42
Active Larning	40
Empathy	30
Academic Habits	28

The researcher analyzed the engineering acceptance rates (EAR) for the 45 universities in this study. The goal of this analysis is to determine if there is a correlation between the EAR (the percentage of individuals accepted into the program versus those that applied) and the first year university retention rate. This analysis was performed using a bivariate correlation test. First Year University Retention Rate (N = 45) had a M = 86.5 [59, 98], SD= 10.1, the EAR (N = 45) had M = 49.9 [5.7, 100], SD = 22.2. Universities that have a low acceptance rate correlate to high first-year retention, $p \leq .01$.

Summary of the participants' characteristics. The participants and their attributes have been provided to develop an understanding of their backgrounds and aspects. The participants are diverse, and cover a broad range of lived experiences that are a combination of their own education and their current employment. This diversity provided rich responses that are helpful to explaining the methods to improve URM retention. The participants' assistance and cooperation were very important to this report. The sharing of stories, and their encouragement to compile their story, were paramount to the success of this study. The researcher explored the participants' reasons for taking part in the study

Reasons for Participating

Some participants provided a reason for why they participated in the study. Not all participants were asked for the reason why they participated in the study. After traveling to several sites to speak to participants the researcher asked the participants why they chose to answer positively to the request for an interview. Participants often filled their personally allotted time and the researcher did not want to become annoying. Five participants provided detailed responses. One of these responses is offered by Sally, a lecturer at a Midwest institution stated:

> I appreciated that your focus was on supporting underrepresented minorities. For some reason when I see that term, I tend to exclude the women. So, for me, that really meant the students of color, African American, and Latinos students at this institution and in engineering more broadly. And, I think that is a group that we are attempting to support but not in the right ways. And, I think it is worth thinking about and talking about that more. Part of why I agreed was that it was this week, and my days got easier. I taught my very last class. Had this been last week, even though the topic was of interest to me I would have said no I can't do it.

Carlos, a director of a new excellence in engineering education institute, provided this viewpoint as his reason for participating:

> I think it is a really interesting area of research and after all, it is an important topic to understand for underrepresented minorities, transfer students, nontraditional students what is being done and what can be done to improve that and it also goes hand in hand

> with institutional research. So, getting a feel for the population for the university and what works and what doesn't work is important.

Charles, an NSF researcher and department chair, summarized his reason for speaking to the researcher as:

> …I have moved into this senior associate chair role where I have larger maybe departmental pull, and then in charge of our faculty search for the last six years now and such. So I have gone to SACNAS [Advancing Chicanos/Hispanics and Native Americans in Science] and ABERCMS [Annual Biomedical Research Conference for Minority Students], I see such great opportunity in these (URM) students. And trying to make those connections, this group of students will become the next generation of faculty. At the end of the day, this has been a long-term interest of mine, I am not necessarily sure where it stems from, it is one of those things that I have attached myself to I guess for better or worse.

Rex, an engineering faculty member stated, “I know how hard it is for people doing Ph.Ds. [sic] to get interviews and stuff and I figured I would help.”

Participant Understanding of Diversity

The participants were asked to describe their understanding of diversity. Participants descriptions ranged from a general description which indicated that they had an awareness of the state of diversity at their university. All the participants had a concern for diversity and recognized a reason for their institution to improve the enrollment of URMs, or that the social and academic situations for existing URMs at their university needed to be improved. The following are quotes from a sampling of participants that describe their understanding of diversity. Justin, who is a dean at a minority-majority university summarizes:

> diversity means not just racial diversity, but diversity in all of its forms. In my opinion, also diversity of thought, people don't think of that as well, freedom of all, and inclusiveness of all, religions, disabilities in addition to race.

Jason, a recently retired senior engineering professor, stated “student diversity focus on demographic variety (race, ethnicity, gender, sexual orientation, etc.), and other important categories which include levels of intellectual development, approaches to learning, and learning styles and preferences.” Participants often addressed issues that expanded beyond addressing gender and ethnicity. The need to address socioeconomic status (SES) is important. Sherry explains that her department’s understanding of URMs is broader and is not just:

> …thinking only about gender and ethnicity for us, it goes way beyond that, we are looking at learning styles, we're looking at disabilities, …we are looking at diversity as a whole of everything. Not just what color is someone in my class, what genders are there. Looking at addressing, …different learning styles, and the different teaching styles and how it is affecting the diversity in the classroom because we realized that it relates to many things and not just ethnicity and gender.

Diversity also includes ability. An individual may have limited physical or mental abilities that need to be addressed. Brenda reports that her group’s work goes well beyond gender and ethnicity and that when discussing:

> our mission in terms of diversity and inclusion. So, there's a gender aspect to that. Also, a race aspect to that. Also, an aspect of ability levels when they have different abilities than the typical student may have, they may have physical limitations. They have academic limitations I think that we open that up pretty broadly and that we have a focus, or an

> acceptance of those from a gender standpoint, transgender and all of that, we try to be very open and inclusive when we talk about diversity.

William, a male African American faculty member at a primarily white institution in the Midwest, he states that he has developed an understanding of diversity as part of his research and studies over time. During the interview he explained his understanding of diversity as:

> …every student who comes to us, or might come to us, brings a unique set of experiences and background which could include their cultural heritage, their racial heritage, their economic heritage, their experiences between rural and urban settings. And, each of those changes their approaches to problem-solving because they are thinking about engineering and their socio-technical actions and their ways of being successful as a student. So, I think of it in a much broader context, not populations so much, but realizing that there are valuable experiences within each individual. That said, systemically we have recognized that there are barriers to some populations because they are underserved in varying ways, or underprepared. So, they're either coming from schools that do not have the resources, or rigor, in their education to prepare a student to deal with our program, and we're not prepared to help them to transition in many cases into our undergraduate programs so they bring diversity in preparation. And, then there's the issue of their comfortability, if I can use that, in the sense that, do I belong here, is this a place that I feel welcome and is this place that I feel at home, as an academic student and as a person. We've been realizing that there are some barriers to that as well. I think that we have to realize diversity at a lot of levels.

At a large southwest institution many URM communities are served. The presence of the diverse community was not unusual for this participant. The researcher's question about the participant's view of diversity confused the participant because of her institution's diverse mix of students. Alex, a faculty member at a large western university, explained that in his classroom he promotes student engagement to enable collaboration across education, engineering and health sciences. Alex has this view of diversity:

> Student diversity, in my opinion, comprises of several attributes including social, economic, demographic, personal, and professional aspects of individual students. An engineering student at the University of Arizona (UA) may come from the one of [the] southwest states, may have been exposed to engineering prior to starting our program, may be a first-generation student from a URM community, and is probably part of multiple professional and social communities within the university. Another engineering student may have a completely different profile/identity/identities. UA is Alaskan-American serving as well as an emerging Hispanic-serving institution, and the college of engineering reflects efforts and values related to those designations.

Gabe adds that he has an opinion of what diversity consists of, and reports the efforts he needed to reach out to diverse engineers. This study is aimed at the retention of URMs which includes women. Gabe's following comment is included as the condition of women in the engineering workforce that may cause women engineering student to leave engineering and transfer to a degree program which has a friendlier environment towards women post-graduation. Gabe addresses the plight of women engineers as an underrepresented minority in engineering:

> I cannot speak for other faculty, there is an effort to do what you can to reach out to underrepresented minorities. You know many of my coworkers, for instance one of my regular collaborators is a woman at Columbia University. I am familiar with her and watched her career, and she is a person to point out a woman in engineering who has

> done great work. So some people say that everyone is cutting her slack because she is a woman and she is not as good as men. And, on the other hand, on the other side of the coin, she is four times as good as any man as she has had to fight for every bit of intellectual respect that she has ever gotten, and I see this as still persisting views and attitudes toward underrepresented minorities of all flavors, and I have this positive attitude and you know that comes from personal experience rather than any wide policies. The policies at the university do their best to promote diversity.

There is a concern about addressing diversity becoming too large having so many defined groups that it is difficult to address effectively. The definition of diversity is expanding as subgroups are forming. For instance, Latino Americans are beginning to be identified as chicano, mejicano, cubano, and other groups because individuals within the classification of Latinos do not identify with a European heritage. Academic affairs personnel state they are concerned that there are so many diversity subgroups are forming that almost all students fall into one of the subgroups. This makes nearly everyone a class of minority in some way. An associate provost at one large diverse engineering institution in the south reported that a committee to study the retention of white males in engineering had been formed because as a group, they were not performing as well as diverse comparison groups.

Kennedy, a minority engineering program director, has this view of this problem:

> I think in the broader definition of diversity, we can lose sight on underrepresented minorities and lose the importance of lessons learned during the civil rights movement. We have decided to diversify diversity. But while we look at all of the different types of diversity, we must simultaneously keep our finger on the pulse of marginalized ethnic groups to not exclude anyone.

Diversity needs to be comprehensive and include all those who do not have equal access to a university engineering program. Faculty and academic affairs personnel need to employ continual assessment of their institutions to ensure that the definition of diversity continues to evolve while offering inclusive solutions.

The understanding of the participants' definitions of diversity is important to this study. The participants' definitions provide useful working definitions for the expansive URM community. An issue with this broadness is that funding may not be available to address the range of individuals involved in the URM community. The expanded URM communities need empathy and support from the faculty and academic affairs personnel.

Research Questions

The purpose of this study was to investigate what engineering faculty and academic affairs personnel consider effective at retaining URMs. The investigated research questions are:

1). What practices are engineering faculty employing to retain underrepresented minorities in engineering?

2) What practices are academic affairs personnel employing to retain underrepresented minorities in engineering?

The study intends to identify approaches needed for developing departmental engineering support, university programs, and engineering education instructional practices that have been successful in teaching engineering students.

Retention of Underrepresented Minorities

Yoder (2012) identified multiple activities at universities to improve retention of students. These activities included tutoring, mentoring, learning centers and other programs to aid students. Separate from the list of activities was a statement that universities had practices to improve the development of communities for students. This study has identified six areas of focus to aid in the retention of URMs. The focus areas to improve retention are: *community*, *mentoring*, *role models*, *active learning*, *empathy*, and *academic* habits. The retention of URM engineering students through the development of a sense of community is identified by participants as key to URM students' success.

Community aids in improving the success of all students. Developing a sense of community is important. The URMs are better able to succeed when they experience, a community, a sense of belonging to the university and in the engineering departments. The National Academy of Sciences and National Academy of Engineering and Institute of Medicine (2011) informs that the desire to participate in a community and establish a sense of belonging is key to the URMs successful navigation of their education pathway. The URMs need to find a cohort that they identify with and utilize as support. This inclusive university environment must feel like home to the URMs. Jasmine, a director of Excellence in Engineering Education department, summarizes the need for the URMs to feel at home:

> …on a broader scale, the key is finding a home in the big university. It could be in my program, and hanging out with me, it could be hanging out with NSBE, it could be SHPE, it could be building the car, there's a car they build, there's a concrete canoe that they build. I think the success is getting them as freshmen to find a home, and I think that [those] finding a home quicker do better than the ones who don't because for some students [said city] is the biggest city that they have ever lived in.

Cesar, a faculty member at a Midwest university reports that the URMs need to feel comfortable at their university. In class, Cesar's students work in cohesive and supportive teams. Cesar explains that creating a place of feeling content and that:

> …having a space that the students felt like is home and where the academics program staff are welcome and dialog and feel comfortable with students is also really important, it is a structural issue.

Justin is a dean at a large minority-majority university that services Latinos. The Latino families need to be included in the education process. Justin explains the importance of family to URMs:

> Here in this valley people are very family oriented and they sacrifice a lot to get an education, I believe we're about the poorest place in the entire nation. We're number one for poverty. People will sacrifice such a great deal to come and get an education that they put their full effort into this. They are very respectful, they respect not only the professors, but they respect themselves, and their families more, and therefore I think they respect the value of education more.

Family and community are important to the URMs. The family helps to provide a strong and supportive environment; although, at times the family needs are placed above the student's education requirement such as homework and study time. This is important to provide the social support needed by the URMs. Richard, adds this concerning the importance of family:

> Many underrepresented minority engineering students feel home at [said university]; a good number of the students follow their family's tradition to come to [said university]. They feel honor to be here, and they know they can get help to be successful even [though] their high school's preparation may not be perfect.

Hans, an associate dean of academic support, reports that it is important that when discussing retention and URMs that the effect of family must be considered. The family needs to be included in discussions regarding their student. Hans explains:

> When minority engineering students are recruited, you recruit the family. If you aren't ready to work with the student and the family, then you will not retain them. This does not mean that the parents work as advocates, you have to educate the parents and extended family of why what the student is doing is important and how to set priorities.

Faculty can aid in the creation of an environment in which the students feel comfortable and allow the students to approach them. The environment can be welcoming if faculty and staff show that they care and provide positive feedback to the URMs. A faculty member can improve the environment for the URMs simply by taking an interest in the student's well-being. Stan is an administrator at a university in the southwest that has a high URM population:

> As a large public university, we do admit just about everyone who applies, but the faculty care about the students here so even though it is a large university, a large college, there is a feeling of home, and I think the students recognize that and they're comfortable approaching the faculty. We do have the faculty teaching the majority of our classes. I think that helps too.

Residence Halls can be used to build programs that will make the URMs feel part of the community. This will aid in building the living portion of the university experience. If the URMs can encounter individuals who will provide information, advising, or even commiseration, this will help the URMs to feel part of the community and succeed. Good learning experiences help to retain people; however, sometimes these experiences have to be forced. For instance, tutoring in the residence halls allows students to gather in one place to do homework and ask questions as needed. Robert, an education consultant and leader, emphasizes:

> …we establish the muscle memory and the consistency of aid and a coach to be deliberate in overcoming obstacles. So, I want it [tutoring] to be very anticipatory, and

> when obstacles happen, I want it to be very intrusive and surround students with super support systems whether they need it or not. And then, after your first two semesters if you no longer need it you are fine.

A living-learning community is important, and a feeling of being part of the community aids in the retention of URMs. The living-learning community can require the URMs to participate if the student receives financial aid at the institution. Fiona, an associate dean of academic affairs reports:

> If a student gets a scholarship from the college of engineering, or even the university we have to work with that, if they get a scholarship they have to live in the community, that community has a course identified with them in academic and professional development and I can assure that is the majority of the minority students. They receive some sort of assistance, and therefore they have to live there and again, that type of help can make them successful.

Living-learning communities also work when students voluntarily participate. Tiana, engineering education faculty researcher, explains about the living-learning program at her Midwest university:

> …there are programs for women, there is this WISER program. Women in Science Engineering Residence Program [WISER] which is, well it says what it is. But, the students live together their first year while on campus, and they take some of the classes together, so it is really a strong learning community. We are really building a lot of things like that to support students along the way.

The living-learning community creates an environment where students have roommates with similar courses and course study requirements. A student taking calculus is paired with another individual who has taken calculus, will take calculus, or is in calculus at the same time as the roommate. There is not a possibility for the roommate, or other person in the same living arrangement, to suggest changing the students major to one similar to their own which does not require calculus. Alan, a dean at a Texas university, says that the student is often:

> …wondering how he/she is going to get through a Calculus I exam, now they don't have a roommate say why are you taking calculus, if you were in my major you wouldn't be taking calculus, now they have a roommate that may sympathize, and say I empathize, and why are we both taking this and at least they have someone to follow and at least we have seen higher retention rates from semester to semester and a higher retention rate of freshmen to sophomore of our students living in this community.

The study requirements for roommates in the same living arrangements will be similar. Tutoring is available in the living center common study area. Student peers can help each other to study, have sympathy regarding the homework quantity and solve problems. Phyllis, a faculty development consultant, explains that she believes URMs can be successful in a community where there is a support system. Phyllis said, “I think underrepresented minority students do best in programs where there is academic and emotional support built in. Students need to feel that they are not alone and that there is help available when they need it.”

The formation of these communities begins upon arrival at the university. The URMs benefit from the identification of support systems as soon as a relationship develops. Tomas, a director of an Equal Opportunity Engineering (EOE) program, explains a plan for freshmen at his Texas university:

> …our first-year interest groups. And, we call them FIGs for short. And, that cohort of students in a FIG take similar classes, and the cohort has similar majors, and they create a

> study group, and they create resource habits, and they create help-seeking behaviors in those groups and those peers. And, then they follow each other during their upper division's classes, and essentially they graduate with each other and keep each other kind of motivated as well. So, that community is a smaller community, there are communities like the Society of Hispanic engineers, The National Society of Black Engineers which is NSBE and also an organization on campus that is unique to us is Pi Sigma Pi, which is a minority academic organization which was founded by the founder of EOE to help… to help other people. People serving people is their tagline for Pi Sigma Pi, and it really was created because we all, one person can't solve this problem and be there for all. So if we create this culture where we are helping each other…

URM students can be successful as long as they have access to the resources that are needed for success. The URMs may be comfortable working together in their communities. However, these communities may provide a comfortable environment but separate them from the majority students. A recipe for success to develop a community is described by a teaching professor Brianne:

> Across all students they need the resources to have the ability to learn, they need to learn to manage time, they need to learn to juggle getting involved with campus. And, developing that cohort of friends that can help them through. And, then on the minority side, I think it is beneficial to have that minority engineering program because you can make friends with everyone else in your department, sometimes it is nice to see some other people from similar backgrounds, maybe you are a first-generation student or something. We do have several first-generation students, but they are not necessarily ethnic minorities. So, I think it is kind of connecting with people and knowing resources

and have someone truly support you throughout. You are not a number in a crowd, you are a name and a person.

All students can benefit from a community environment and the URMs gain support from the community. To succeed, the URMs are in need of a support system that involves their peers, faculty and academic affairs personnel. No one person can provide the needed support for the URM to be academically successful. Henri, a faculty member at a large diverse western university, summarizes the impact of the community to the URMs:

> …there is a special value to the sense of community that they form among themselves. And, I think there are, there are times that there are challenges to different demographic groups, so for example let's think about students who may be faced with DACA like issues, because that is a huge part of the [our university] population, it is helpful for them to be able to exchange the psychosocial support they need. I think with both of these challenges it is helpful to know what types of resources that are on campus or in the area that they may seek out in order to handle different hiccups that might come with that status, so there is a sense of, …I think for underrepresented groups there is a meaning that says find your tribe and love them hard. And so, like those who are from underrepresented groups, and that could mean a variety of things, they find those people that they also share that characteristic, whether that be related to some aspect of life like single moms, or veterans, or DACA or whatever they find others that share that characteristic and then form a community within themselves and swap stories and/or advice. I think that is what facilitates the success for underrepresented groups.

The researcher recorded his thoughts in a diary. While traveling to the different universities, the researcher made notes in his diary. The researcher made observations at a minority institution, in a large common student study area, and noted the following:

> The study area is very noisy. The floors are tile squares. Students are grouped together, mostly three students at a table. At first, no student diversity was observed at the study tables. As time passed, multi-ethnic study groups formed. Tutoring was occurring between men and women, and all the different ethnicities were working together.

At a different land-grant southern university, the researcher observed students who walked around campus to determine where students were congregating to study. After passively watching the students early in the day, the researcher noted students heading to the engineering library to study:

> Students were found studying on the bottom floor of an engineering library. White men and women were studying in a common study area where low conversation was acceptable. Other than white women, there were no URMs present. As the morning progressed, African American students would enter the study area and engage in conversation with the white male and female students and then leave. The researcher then followed the African American students and determined that they were studying in a diversity center. Conversation with the director of the diversity center revealed that the students felt comfortable in their study area and they were provided the same technical support in computers and printers that were available in the library.

The URMs have multiple community needs. Faculty can help to develop communities in their engineering departments. Amber, a research faculty member, continues with thoughts regarding the expansion of the gender community within engineering:

> We women gather in engineering every month, and we talk about engineering and other issues. This is a group that gets together to discuss the biases, advancement, and things like this. And then the LGBTQ initiatives started two or three years ago, when we opened the center for LGBTQ&A communities, which didn't exist before. We had some professors who were out there to work and were good resources to our students and were doing activities outside of campus, but we weren't all part of these types of activities, so two or three years ago things started to change. You always had student organizations such as pride alliance and such other organizations on campus, but now that we have the office on campus, we can have safe space training that we can take. The safe space definitely raises awareness; they also organize events and panels, so that outlines what is going on down there. There are also lots of other events organized by this center. So especially for intersectional identities like African American transients and others, what this group is organizing is specifically in engineering. The panels that were organized were in STEM; these were in the college of science. The reasons we are organizing the workshops specifically in engineering is that in the literature we are the least inclusive.

Safe spaces can be developed to aid all URMs. The above quote shows the example that faculty can work together to establish programs and training to aid in improving the climate for URMs.

The efforts to promote community often are combined with mentoring opportunities. Not all communities' developments are successful. Some large southern universities are not seen as a comfortable community for all URMs. Tatum, a department executive, explains the experience for Latinos and African Americans and their comfort at her university:

> So, for African Americans [said university is not comfortable]. For Hispanics, [said university] is comfortable and that is why our future is brighter because this is a place

they can call home, not yet so strong, as we don't have fourth generation Hispanic (said university) yet. But, for African Americans, it is still very uncomfortable for them. Sometimes there are African Americans in the class, …but they are very few [African Americans].

The development of community often provides a foundation for relationships to form between those helping to orient the URM students and the faculty and students that support them. Sally, a lecturer at a Midwest institution, reveals a connection between community and role models:

> Having mentors/role models, …that might be faculty who look like them [URMs] or seem like them in various ways. For those of us who don't look like them can still disclose other experiences and that might make us look like them or seem more personable or whatever. I think having graduate student instructors or other successful students that could come in and talk would also help those students. I think that having those sorts of organizations [NSBE, SHPE] that we just talked about is helpful. But, I don't actually know about the research that has been done on that. In general, I think that developing a sense of belonging [is important]. But, what that looks like that, I don't know.

Johan is chair of a difficult engineering program. Johan explains the reason for his mentoring program's success occurs by helping to build relationships and communities:

> I often tout the mentoring program where the goal is to provide a foundation while you are here at the university that is well presented, and resourced, so that if you need help with homework, there is someone in that mentoring program that will help. They have a discrete mentor, [to] two mentees… is the ratio they typically run. [Mentors] take you to

> meetings, get you engaged and develop a support network and help you develop friends to study with, and give you resources for studying for when you need those outlets.

These mentoring activities can help the URM to develop a social network with one another. This interconnection of programs and problem-solving approaches indicate that continuous improvement must be made, not only in creating communities, but by providing multiple corrective actions, including mentors and role models.

Mentoring provides direction for URMs. *Mentoring* programs establish a link between faculty and students. Universities have also implemented peer support networks; these establish links to peer students that helps to support retention. Ann, a faculty member who researches engineering education, explains the importance of women having mentors:

> You need mentors! I am telling you that you need mentors! You need somebody else who can work with you, help you. They are in the position to tell you what is the pathway. If you have few people who can be in those positions, those persons become overloaded. We need people who can mentor, it is a lot for the person who is the first, you know, and it is a lot of load that comes from the people that are coming looking for advice from this person.

The researcher observed at a Midwest university that students were gathering at a study area in a main engineering building atrium. Students were meeting in this area and some upperclassmen women were speaking to other younger women students. One of the Women in Engineering office staff members noted that senior women engineering students mentor freshmen students. The peer mentors inform the younger students of the engineering environment and provide input about the path the younger women engineers and the success path they should follow.

Mentoring can promote an inclusive engineering learning environment. Alicia, an academic advisor in a dean's office, is strongly supportive of faculty mentoring, and says that engineering faculty should have less focus on research resulting in improved retention. However, Alicia notes that for faculty:

> …the incentives seem to be primarily on the how many R1s [research grants] have you secured, and obviously, that is important. ...I would think that more incentives [offered to faculty] and more promotional incentives in teaching and mentoring would really go a long way in developing this culture of inclusiveness that we're trying to develop.

Herbert, a faculty member at a majority-minority university, reflects on the need of mentoring for URMs and the inclusive environment that faculty can develop:

> …at [said university] we also we spend a lot of time mentoring our students. You know, we have a lot of office hours, we have an open door policy, usually most of us faculty. Like, if I am here working and someone [a student] shows up, and it is not my office hours, they can come in and talk about whatever they want to talk about. Whether it is their career, their class, or whether they are even my student or not. So we're accessible. I feel like we're reachable, as opposed to other places I have worked where the faculty were not. We at least try to be accessible and help the students out, because their success is our success.

Mentoring is needed based not only on ethnicity but on gender. Preparation for the university may also vary depending on the high school that the student attended. Sherry, an instructional professor, summarized this:

> …females they actually do very well here in engineering. Hispanic males do not do as well here. I think that the ones [URMS] who are successful, …I think that has a lot to do

> with the high school preparation [the students received]. That the ones who have never heard the word trig and now they're coming into engineering, and you know, and seeing their eyes that they haven't come from very good [math and science] preparation. Students have found mentors, gotten involved with faculty members, something to kind of motivate, and help keep them on track.

Professors' participation in mentoring is very helpful and improved when combined with peer mentoring, which aids URM students when faculty are not available. Alicia, an academic coordinator at a southern university, reports that what is wanted among engineering faculty:

> …is our [URM] representation among groups in the faculty. And so, if they can see themselves in faculty and they can sort of imagine themselves succeeding in the same way, then that is what we see is going to be the most impactful. …we have peer mentors and things like that.

Savannah, an instructional faculty member, describes a situation in which providing mentoring may be difficult, because of funding issues in the engineering department.

> So, I think we need more mentoring; I would like to see that. But, I know the college of engineering is having [budget issues], and I have done this [summer bridge program] for a couple of years. I know that they're not doing it this year; it is always a funding issue having mentor students for underrepresented minority students coming in [new to the university]. They have the same self-efficacy issues that females have in engineering. So, I have mentored some of those who were all different kinds of engineering majors, not just my department, I think it is having someone that they can come to when they have some sort of issue. It can be an academic obstacle, it could be a roommate problem, you know it could be any type of problem.

URM students who receive mentoring from faculty will experience community; the students can also build their community experience through peer mentoring. When faculty members are not available, peer mentoring will aid to improve the retention of URMs. Peer mentoring can be used in conjunction with faculty mentoring to improve the URMs' retention rate. Faculty mentoring may be supplemented with peer mentoring. Women in industry are often available to engage women students as mentors. Kiera, a professor at a southern Florida university, provides information about industry supported mentoring:

> …peer mentoring and we have WISE mentoring. Which is Women in Science and Engineering and that is a mentor from industry. And, that is a woman from industry who will mentor [women engineering students]. That is a seven-month experience.

Peer mentoring programs are often formalized, and as part of the program provide a method to train the peer mentors. Maya, a director of a Women in Engineering office at a southern university, describes her mentoring program:

> Peer mentoring would be the other big component of what we do. So, every first-year female student that comes into the [our university engineering school] we match them with an upper-class mentor in their major. So, that's been happening for a long time. We train the peer mentors. We provided them with kind of the syllabus for the year and what to reach out and discuss with their mentees for the year.

URMs are a part of the peer mentoring programs at universities. The peer mentoring aids the African and Latino freshmen and sophomores in that they can see upperclassmen like them providing the peer mentoring, or other students can receive mentoring from someone who bears similarities to themselves. Johan describes a mentoring approach that he has developed in his engineering program:

> I also have a mentoring program that was put together by upperclassmen—mainly juniors and seniors—that volunteered to mentor underclassmen. A number of individuals who sign up for the mentoring program are disproportionately high on the underrepresented groups, and as such that mentoring program is really doing a solid job in helping those individuals get the resources that they need.

The difficulty for engineering departments to overcome is that engineering faculty are rewarded for obtaining research dollars. Faculty are remunerated for advising at research-oriented institutions. Alicia would like to have priority placed on mentoring and providing incentives to faculty:

> …I would like to see more priority on mentoring for promotion and more incentives [financial, course load reductions] …and more promotional [consider mentoring as support for faculty promotion and advancement]. Incentives in teaching and mentoring would really go a long way in developing this culture of inclusiveness that we're trying to develop.

If research faculty are not provided with incentives, they may not willingly provide mentoring to students. Some faculty provide this mentoring without receiving monetary or other incentives. This faculty mentoring is done for the benefit of the students. However, the priority will be research, and if there are no other methods to obtain mentoring, the URMs will suffer.

Role models aid in retention of URMs. Being able to observe a *role model* to URMs, or someone who looks like themselves aid in the URMs' success. URMs succeed when they can see a role model. When the URMs see someone similar to them, they believe that they can also be successful. Role models are often those who aid in mentoring students.

The need for faculty who look like URM students is reported in the literature to be important to the success and retention of URM students. Having diverse faculty with whom the URM students can see themselves as successful allows the students to develop an engineering identity where the students feel empowered to be successful. Carlos, a director of a new Excellence in Engineering Education Institute, reports the importance of diverse faculty:

> It is very important to have a diverse faculty… creating role models for the diverse student population... We struggle with it, but I think it is very important, and I think we gotta keep working on it. Our dean—we have a female dean—and these issues are on the forefront in our college, and she hammers on that all the time. I think it is. I think we have a fairly diverse faculty. We could do more, but it gives a whole range of opportunities. It gives, for example, given what happened in Puerto Rico [severe hurricane just prior to the interview], …we have some faculty who are from Puerto Rico; it is much easier to have a discussion and invite some students and figure out how the college can help [in Puerto Rico]. Here we already have that, you don't have to get some person to try to lead that, who perhaps has never been to Puerto Rico. And so, just from a practical point of view, these things can be very powerful.

The diversity of students includes factors of race and ethnicities; the factors can also include the quality level of education received in low U.S. socio-economic status areas, where the school systems are impoverished. These school districts may not be able to provide dual credit or Advanced Placement (AP) credit for students. Racine states, that as a woman from Appalachia when she was in college:

> …I had to find my role models some other place. No one looked like me, and I encountered very few who were first in family to go to college, which I was also. So I

> actually think if you're an underrepresented person of color, you have a hard time seeing yourself in that role because you haven't seen anyone like you, and if the institutions don't have professors of color—and I think we're talking about underrepresented professors being women, and professors of color, and many institutions don't currently have those people of color you can address that by bringing visiting professors for a day, a week, some period of time, even a seminar in your seminar series, and you can bring into that your students, you can bring in an African American faculty, and some African American students in a perfectly legal method. So, I think the role modeling is part of it.

Graduating with a university engineering degree can be life-changing, not only for the family but for the family tree. Some students see the engineering degree as shifting not only their individual financial status but as a positive shift in their family and community. Kennedy, a minority engineering program director who obtained an engineering degree reports:

> …my motivation to become an engineer was to overcome poverty. No one in my family ever attended college. I don't know how I got to college, but once I got there, I realized that if I could get through it, I would never be poor again. Once I understood that a college degree could change my whole life, that's what I focused on. I wanted to be able to reach back and help my family, it was about being a role model, to other students. It was about making my mom proud, my church proud, and all that good stuff.

Dennis states that URM students need to see someone with a background like them, to be like them. The URM students may be first generation, and have no one to turn to in their family for advice about college. These students need a mentor, a role model to provide guidance. For some individuals, this may be a person that the URMs may not personally know, but they can emulate. Dennis, a faculty member who works with students in the Black Belt in Alabama summarizes:

> I was at the National Center for Women for IT. I went to their summit, and the one thing they always say is that you have to see it, to be it, and that you need role models, and you need someone from your background to be able to do that. So in my own case, I am a first generation [graduate of college in my family], I am the first case in my family [that went] to college, I am the first non-farmer. I didn't grow up on a farm everyone else—in my family did—and I found a famous [computer professional], someone from the computer industry from my next town over. He did it [graduated college with a computer science degree], maybe I could do it.

Women can benefit from seeing successful women in engineering positions. The women engineering students see practicing engineers and prosperous women. Elodie describes how women role models blend with other programs that women can benefit from:

> …women students can kind of see a role model for what they are aspiring to do and they can [be successful also]. There are enough women faculty to serve as mentor for students. So I think having the role models present makes a difference.

Organizations like SWE and WISER have programs which connect women engineering student with practicing women engineers. Henri adds to this by providing an explanation of why role models help women students to learn:

> …one of the reasons women may leave engineering is that they don't see people who look like them. They don't have any role models: I think of [Albert] Bandura. The fifth way that we learn is by seeing models, and therefore one of the challenges for the engineering women. Women need to be more apparent in engineering.

The URM faculty can find themselves invited to classrooms to place the URM faculty member in front of students as an example. This places a strain on the faculty member who is asked to provide this service. Sally, a lecturer at a Midwest institution explains the impact on one of her coworkers:

> …one of my co-instructors was an African American man, who I felt like got tapped all the time [to speak to classes and organization because he was African American]. So, somebody needed a guest lecturer for their class. Let's put him in front of the class, it is really good to have him in front of the class. And, of course, he was an early tenure, tenure-track, and he did not need 16 extra requests for speeches every semester. So, there are two sides to that, for sure.

There are URM faculty who do not agree that role models are needed for URMs to succeed. Faculty members who are currently teaching, often did not have role models to emulate at the time they were students as they were URM pioneers. At the time these individuals were in school there were very few visible URM faculty members or grad students (1980s time frame). These successful URMs wonder why current students need role models to be successful. Matthias, an African American faculty member, presents his opinion:

> I don't think a lot of the majority faculty actually understand how much of an additional burden that is [to be invited to classrooms and organization meetings]. So that becomes a real challenge, because again, if the underrepresented minority student doesn't understand the burdens [teaching classes, lesson plan development, tenure package, student hours, etc.] on the underrepresented minority faculty. This is a lesson even I remember from grad school. If you don't succeed, and you're not here, a lot of the problem goes away, not in a good way. If there are underrepresented minority faculty here, what is their

> primary activity? Getting tenure! And, if the students don't understand where that bar is for someone to get tenure, and is not engaged in the student organization, or the infinite mentoring or something like that, the students attribute this to a very, very different set of reasons. I do remember a few years ago there was a panel of underrepresented students that had a discussion about this, and I said okay, why don't you ask me? And, they said ‘well, you could come to our meetings.’ And, I made the point, ‘okay folks first off there are more of you, than there is of me; if you're university students, it is no longer to be expected that you wait for the adult in the room to come and help you, or come and talk to you. And, I kind of like my evenings. And, if I am in a different life stage, I am not thinking about doing pizza and Pepsi from 7:00-8:30 pm every night.’

A female African American faculty member, Henri, when asked if she receives requests to visit classrooms, or attend meetings as a role model for URMs, responded, “Surprisingly, I don't. I don't get a lot of requests that are phrased in that way.”

Active learning aids in student retention. That general student success is important, with regard to *active learning* having a positive influence on students’ success. Active learning aids URMs’ success was mentioned in four instances. Participants mentioned that active learning as a teaching method could help lead to retention and the students’ success. When asked whether active learning is helpful in retaining URMs, Emerson, an engineering education faculty member, agreed enthusiastically and stated:

> Absolutely. It helps all students, but in particular them [URMs]. Because it creates—well, they think that the mechanism is that for both black students and women—it [active learning] helps because it tends to be more community oriented. But, the evidence is there that it benefits all students, but in particular, women and minorities.

Stefan provides a positive statement supporting the use of active learning. He explains that his courses are taught:

> …aligned with team-based learning approach. I have evolved into that over time, by using active learning. And turning those active learning experiences into team learning, and now I am making just about everything team based. So, that is how it is probably easiest described, but I use a lot of elements process education, which is more of an educational philosophy where you focus on processes, and processes of learning [sic]. So, my goal in the classroom is not just to have the students learn the content, but to learn how to learn that content, because they are not going to know everything they need to know when they leave my classroom.

Implementing active learning is a combined focus for NSF funding. Rex, a professor in the Mississippi Delta region, clarifies how the combined research of the universities aids in the expanded use of active learning. Rex explains that in the courses that he teaches, he uses collaborative learning (a form of active learning) to improve learning for all students. When Rex teaches he:

> …brings different active learning technologies. My eyes are open to stuff like active learning, problem-based learning, and I actually have an active grant with seven other institutions to integrate collaborative learning and interaction gamification, problem-based learning, in my classes. I do a lot of active learning in terms of whiteboard, team effort learning. For the first couple of lectures, it is the traditional lecture style to form a foundation in the course content. And I break them [students] up into groups, and then they move off to the boards to solve problems. There is a little gamification and face-to-face approach whereby, as soon as teams get the correct answer, each team member earns

> some points. If one team member gets the solution for the team, then that team member gets some additional points. I find that it is very valuable because the team really gets them so excited otherwise. We have some active learning classrooms for this pedagogical approach.

Chairs and deans conducting performance and teaching reviews of their faculty reported that 10% to 24% of their faculty use some form of active learning in the classroom, with a flipped classroom being used by a majority of this faculty group. Few faculty members within this reviewed group are exploring advanced styles of active learning. Jasmine, who has a somewhat negative opinion toward active learning being helpful to URMs' success, exclaims:

> …there's supposed to be benefits right? I don't know. There's pretty much everybody is supposed to be doing more of that [active learning in their classroom]. And, it is theoretically supposed to be better. I don't know. And the students, and the students are different now. They have this three-second attention span, and other stuff. …I used to look at this stuff called aptitude treatment and reactions, right? So you try two [classes], one active learning, and one nonactive learning, and you do it [perform the teaching as an experiment], and then you say everybody does better on the active learning. But then you do the group between the high achievers, and the low achievers, and maybe you find out that for the high achiever it didn't help, and for the low achiever it did help. So, when you averaged them, it looked like it went up, but for who, right? That early stuff [comparison teaching methods], this is old stuff [determining if all students are helped equally], you pretty much will find that high achieving people will achieve no matter how you throw the stuff [classroom material] at them.

Because all faculty do not all support the use of active learning, there is difficulty in getting the faculty to use active learning in their classrooms. Rex, a professor in the Mississippi Delta region, is a supporter of the faculty's use of active learning. However, Rex expresses some doubt about the status of active learning in the classroom:

> …I still think we have to look at [active learning]. We still have a lot of professors who teach using the old style of lecture-based teaching, and I think it is sort of difficult to get them to transform into more active learning, a more engaging approach to students. So, that is, I know that is a challenge.

Faculty may not pursue the use of active learning due to material not being readily presented in an active learning environment. Faculty in introductory courses have difficulty conveying the large amounts of formulas and basic information in an active environment. Tiana has difficulty in teaching with active learning in her in her course:

> …introduction to electrical engineering course where, I guess I shouldn't say you can't teach it [the course material] in active learning in a flipped classroom. But for me, it is just easier to use a lecture style approach for many things, but then [also] to introduce two, or three, or four active learning events during each class period.

Female faculty members support the use of active learning to improve the understanding of class material by female students. Jazlyn discloses why she believes active learning is a positive learning style for women engineering students:

> It probably goes back to, and along the same reasons why people have asked me why I am successful in engineering: I think it's because I don't ever notice that I am the only woman in the room. I can't say anything separate for students except for a learning style that I would grasp. Someone might ask me "Why?" But, I have not actually thought

> about it. And, that is why I enjoy the teaching the way I do. It is active learning, and that's the way I wish I might have been taught. And so, maybe since I do fall in that category of URM, maybe that's why it is helping out.

There has to be buy-in from faculty to use active learning. The research faculty may need financial incentive to put their research aside and attend instruction sessions regarding the use of active learning. Rex, a southeastern U.S. faculty member suggests methods to influence faculty to use active learning in their classrooms:

> If you want faculty to come and participate in that [active learning] workshop, then you need to compensate them. And, you have to adequately compensate them basically for the workshops during the summer. Then you can monitor them during the year. If they change, you can give them some merit pay, or bonus, for actually implementing the new approaches. If you come in with new people, especially those who majored in education, and they want the department to change and say this is how you should teach math, then you're looking for trouble. Giving appropriate incentives along the way for people to change, for instance, I think that would be good.

Concluding her interview, Jasmine suggests that perhaps active learning is being marketed and promoted as a method of teaching with results that are being hyped as important. Jasmine states that students may be happier in an active learning class because:

> who wouldn't want to stick around for interesting classes? However, just because active learning is supposed to help retention of students this doesn't mean that it's true. Media and proper selling convinced people that they wanted to smoke cigarettes, despite the health issues which were hidden or not displayed. So, is active learning better? I think

> active learning is more interesting and that engages students. However, that doesn't mean active learning is a better pedagogy.

None of the participants involved in the study were definitively against faculty's use of active learning. However, there were faculty who were not sure that active learning teaching styles were more effective than lecturing. The lack of negative opinion suggests that faculty who do not use active learning chose not to participate in this study.

Active learning can lead to an increased URM retention, but is not a method that ensures URM students' retention. The majority of interviewed faculty supported active learning, however, the faculty members that expressed issues in regard to active learning had specific concerns that require additional research. Active learning should be combined with other activities also designed to help to retain URMs, as discussed in the following sections.

Empathy is important to the retention of URMs. Empathy is demonstrated through faculty advising, which allows students to know the faculty and the faculty to know the students. Roli, a female faculty member, reports the success of faculty building student relationships with the students in the program that she directs:

> One thing that many students remark upon in their graduate exit interviews is that the professors in this department, "know" them, that we have more of a family feel, and that professors care about their success. We have smaller classes (approximately 50 to 55 per class) which allow for more individualized attention. We require faculty advising for pre-registration each semester to encourage further interaction between faculty and students.

Empathy is needed to aid the progression of URMs in engineering. Empathy is not needed to cosset the URMs. Nor does empathy imply a reduction of the rigor of the engineering curriculum. The empathy that the faculty can provide involves taking notice of the URMs' wellbeing outside the classroom. Donald, a professor of ethics whose research interest focuses on studying engineers, explained the need to establish rapport with URMs as:

> Engineers have an obligation to promote this feeling of connectedness so they can do better engineering. There's something intuitive to that argument, and I think most engineers and my engineering students too [feel connectedness]. As they're building this skill set, it is important to build this empathy also…[and this] is where engineers can fall to their code of ethics. They can do no harm to the public. So that will help others to be empathetic because their work is targeting the individual and not the public. Civil engineers work with the public they have in their mind: the public, because they are not building a bridge, a roadway, or a structure; they are building it for a public. Whereas the biomedical engineers…, they're usually building devices for an individual, or a group of individuals, to share in the benefits of their target creation, their target is usually somebody and identifiable.

Faculty members may not be aware of the issues students are facing. The faculty members may be focused on their own tenure-related promotional needs. Participants felt that the faculty members who provide empathy and compassion to URM students; aid in their retention in engineering.

Academic habits are key to URM students' success. To aid in the retention of URMs, their *study skills* and *academic habits* need to be improved beyond the academic habits and study skills developed in high school. Study skills are needed for success for all students. The URMs may not have attended K-12 systems which yield good study skills. Providing URMs with methods to improve their study skills will significantly improve their ability to be retained.

Faculty and academic affairs personnel need to provide intrusive advising with the advice given to students for improving their students' study habits. Math preparation is a concern for URMs, and efforts need to be made to address math shortcomings, time management, study skills, and academic habits. Summer bridge programs, boot camps, and summer camps can be used to improve the students' knowledge in these areas.

Monserrett, a director of an engineering student success center, summarizes the importance of students having strong study skills by relaying her personal student experiences:

> Sometimes, if the faculty member's mind is in the clouds, they just don't understand what you [the student] do not know. It takes intuition, and judgment, and empathy. Now, to try to draw out what you don't understand and to give different examples. Giving homework, giving solutions after the homework. A homework without a solution afterward is useless. It is really a good formula, you give homework, and after the students have done the homework, you give them the solutions. You can see what you did on the homework, and you can look at the solutions, and you have a pool of knowledge. And you study a lot, you don't pass engineering unless you study a lot. I think that it, the intuitive part is importing, and caring is important. My brother was a high school principal and in teaching for his entire life. He says, "students don't care how much you know, but how much you care," because every single kid that comes here thinks that the kid next to him is smarter than him.

Programs have been developed by academic affairs personnel to address the URMs' study skills and to provide tutoring to close the knowledge gaps. An associate dean of academic affairs, Fiona, explains how students make contact with her organization:

> …it is these three major programs that students get to know our office, and they are indoctrinated early with our office, and they are equipped with time management, study skills and academic and professional development, to the point where we watch our overall retention. That's not all of our freshman students. There are 2055 students in our freshman class this year, we're working with a little more than half. But, it’s one of those, the rising tide floats all boats for the college; the residential hall program has an 83% five-year graduation rate. I think that's one thing [residential program improves retention]. I think a second thing is some policies that are of interest, and one of those policies is to have an enrollment management plan, that if you have a 3.0, you will always get your first choice major; if you have less than a 3.0, you may not necessarily get your first choice major. That is done so that if you give a student a bar, they will hop right on over it. So if you rank the freshman GPA steadily over the years, you probably have the 3.0 GPA in place for 10 years now.

URM students are often the first in their family to pursue a higher education degree. These students have performance concerns aside from academic issues, and they may not know how to resolve the issues they are encountering at their institutions. To resolve this concern, Alicia reports that at her organization they:

> …target underrepresented minorities and first-generation college students. We have so few first gen college students, but they're hard to, we don't want to single them out, so we don't have a group specifically for them, but we try to make sure that they are in one of these FIGs with us. We are with them every week, and we see them at study session times, we talk about test-taking strategies, time management, how to take care of yourself, and we bring in other students who can talk about their fears and stuff like that,

> so students [URMs] really see themselves succeeding even though they might feel discouraged that first couple of weeks on campus.

Academic performance is directly related to study habits, and Fiona, an associate dean of academic affairs, explains that:

> …the thing that we emphasize is, I don't want to say this, it is your [the student's] academic habits, stupid, OK. So it is like, it is the economy stupid, it is not your brain. There's nothing wrong with your brain, you got admitted to [this prominent university; name hidden]! We know you are smart. You have pretty nonexistent study skills, and, we find that [lack of development of study skills] because these students never had to study. And, they do not know how to handle the work that is given to them in college. I see this across the board. In engineering, in particular, one of the things—I tell the students is**,** I tell them lots of things—it is about time management, it is about study skills, it is about learning the material, not just memorizing the material that you did in high school. Here we teach you something, and we expect you to figure something else out based on what we teach you. And, you just can't do that overnight: you have to use your study skills. That's what we emphasize, and by positive reinforcement. The point is, you are not stupid, you know you can do this work. It is just going to take you a little more effort to figure out your best habits. That is pretty much what we concentrate on. It is the [students'] time management. Usually, the study skills and a lot of professional development and that tends to come in handy when you're looking for those internships and things. Our goal is to keep them here, to keep them in engineering for as long as we can. As long as they want to be.

Although, Fiona was speaking specifically about URMs' needing help with academic habits, she noted that improved study habits were needed to aid in keeping all students in engineering. The hope is that all faculty and academic affairs personnel support the positive persistence of URMs.

Concerns That Negatively Affect the URMs

Participants in this study identified issues which affect the positive retention of the URMs. The concerns are for the URMs' self-efficacy. The identified issues were *low self-efficacy*, c*lassroom environment and faculty*, *stereotype threat, welcoming environment*, and *isolation*.   The negative effects could affect the retention of URM students, and the cumulative effects of these issues could cause the URM students to determine that engineering is not a welcoming profession.

Low self-efficacy. Low self-efficacy results from isolation from other students created by special activities provided for URMs. The URMs reported being questioned by majority students and faculty about what special program they were participating in. Interviewed faculty and academic affairs personnel report that some faculty are hostile toward URMs in the classroom. The negative environment may be difficult for non-URMs to comprehend. Kennedy, a director of a minority engineering success program, attempts to provide an explanation of what a URM student encounters in the academic environment:

> I don't know how easy it would be for me to articulate it… As an example, if I am allergic to the smell of fish, and I walked into a restaurant, everybody else might be fine, but I am going to get sick if a strong fish meal is presented to someone sitting nearby. Other people that walk in may not be affected, [the other people] don't see a problem, and cannot relate, but those that are affected suddenly become ill, tense, and stressed out.

> Others looking at the situation may minimize what’s happening. Their response to the situation may be, “What's wrong with you?”

The majority of faculty or student members may not be aware of the URMs’ perception of the environment. Kennedy provides a second explanation of URM students’ perception:

> If I drive in a rental car through miles of cornfields late at night and get stopped by the police, I could think, “Hey wow! The cops are here, and they're going to help me!” Or, I might feel, “Oh no, what's going to happen to me?” The mindset that a student brings to the university setting is important. The university may not be sensitive to the cultural needs of a diverse student body, but they should be prepared to address cultural ‘triggers,’ that left alone can present barriers to student success. For example, when majority students see, and engage, underrepresented students on campus, there may be layers of perceptions that can promote, or retard, positive peer relationships. On the outside, students are students. On the inside, are the perceptions students have of each other, and of who they are, and why they're here.

Kennedy provides a situation where faculty and students offer opinions and thoughts:

> For example, students come into this institution, and they're high performers within the College of Engineering. But when greeted by majority students, they're being asked if they are on the football team, or the basketball team, or “How did you get here?” Or, “What affirmative action program did you come through to get into engineering?” Even having a minority engineering program in place [may be ineffectual], for some students that don't want to be stereotyped, or don’t want to identify as someone that needs assistance. They may be hesitant to get involved [with the minority center] until they are

in academic trouble. So, there are a lot of different dynamics at work when you look at underrepresented engineering student success.

Classroom environment and faculty. Not all engineering academic environments are pleasant. Actions of one or more faculty working to make the environment difficult for URMs will negatively affect their performance. Ivy, an African American faculty member at a southern university is concerned by the attitudes of at least one, if not more, professors:

> The attitudes of other professors [are a concern]. Our students have an average of 29 on the ACT, and [when] we have a 60% DFW [grades of D, F, or Withdraw] rate in [a] class, it just can't be students. You know, the Ivory Tower is alive and well. There are certain professors who decide that certain students just don't belong here, and, it is their job to figure out how to get them out, not necessarily to teach them what they need to know to come along. Not that this is all professors, but that is certainly some.

URMs' stereotype threat. URMs are affected by stereotype threat. Stereotype threat occurs when the individuals feel or are in danger of feeling that they are acting in line with a stereotype that other individuals apply to URMs. Ivy explains that URMs can be concerned about conforming to stereotypes associated with their minority status:

> I feel the students suffer a little bit like that. Trying to be who they are, and if you're African American. But, the second that you bring that [being African American] into the classroom, all of the sudden you are pigeonholed. And, you know it. So, the environment with some of the professors can be quite a bit hostile. Again, reducing isolation helps that. We need to be better, we just plain need to be better! We have to take more responsibility when we have a class.

URM welcoming environment. URMs are not all affected by the environment in the same ways. African and Latinos can experience different feelings in the same classrooms as instructors or peers. This difference may be due to the URMs' personal outward appearances. Emerson, an engineering education faculty member, explains that:

> …this is what we're seeing, black students don't feel safe to contribute [in the classroom], but Latino students feel fine. And, given some of the political weirdness that has gone on in the last year, you would have expected to see that the Latino students felt like they weren't safe to contribute, right? And we had a conversation to try and break this down. And, unfortunately, other than the benevolent explanations that come about… we're actually wondering, is it because many of our Latino students don't necessarily look like Latino students. They can pass for white, so white students will not necessarily treat them differently, even if they were inclined to treat them differently, if they acknowledged the fact that they were Latino.

Not all URMs arrive in academic environments that are welcoming at their universities. URMs do not always feel comfortable and that they are desired at their institution. Kennedy, a director of a minority engineering program in the Midwest reports:

> In academic environments that can be perceived by some underrepresented minority students as threatening, the desire to be successful can be negatively impacted. I have had students that came from environments where they were part of the in-crowd, and everybody appreciated them. They did well academically in high school and got all the great grades. When they came to [said university] their first encounter with being called out of their name [called out, as in being insulted], feeling excluded from team cohesion, or being ignored, when they put their hand up in their classroom was emotionally

> devastating. What's going on? Why don't I fit? Where is my community? I am not saying 100% of students feel that, but my office, I often vet those kinds of questions. I see it a lot.

Blake, a department chair at a southern university, brings the focus back to what is needed from faculty in the classroom, engineering departments need "understanding faculty, [having] faculty that understand that yes, we have people from different backgrounds, you know, ethnicities, and that they [faculty] understand they [URMs] have unique challenges as compared to other students." The focus of faculty needs to be on the success of all students.

URM student isolation. There is a concern that the programs that help the URMs separate and isolate the URM students from the majority students. The programs that help the URM students also set them apart. These programs may have the effect of improving the URM students' performance but isolate them simultaneously. Lidia, who is an instructional faculty member with a responsibility to teach and perform university service, explains the concern about separating students:

> …the college actually has a deputy director of diversity, and she has all kinds of initiatives that she spearheads and pushes throughout the college. So, throughout the whole university for the freshman (and bring in students who may not choose this profession) I know there is a bunch of outreach that she does. We have student organizations like NSBE that are very active, they have tutoring and things like that. So, I don't know, I have mixed feelings about it because I think that by and large these students are capable, and we should include them in every way. I think that these special things can exclude them in some ways. We will put them in their special club room and we

exclude them from learning from the other students or working with other students and interacting as much.

Emerson reports student issues can occur in team assignments. Team structure is important to ensure that teams consist of at least two URMs. Emerson stated that when two URMs are present the team allows all to be included in conversations. A team should not be allowed to form with a single African American on a team as a negative team environment can develop; the white team members—if there are two or more white members—may ostracize the single African American student. Students on teams perform peer evaluations and if issues are reported to staff members then Emerson explains:

> ...if the staff members have concerns [about described behavior] they could go out and find somebody. And, they could just walk through the students and get a sense of what is going on. That's helped us tremendously to identify maybe a cohort having a particularly negative attitude and we start to hear about it or a particular individual starts showing up and behaving differently. So, having a space that the students felt like is home and where the academics program staff are welcome, and dialog and feels comfortable with students is also really important, it is a structural issue.

These described negative issues can affect the performance of URM students. Unfortunately, these reported situations are indicators that negative classroom environments exist and are creating an uncomfortable learning situation for URM students.

The success of women. The third investigative field trip in this study involved visiting universities in the Midwest that graduated women at a higher rate than the southern U.S. universities. The three Midwest universities visited were predominantly white institutions with strong plans of increasing their diversity. At two of these universities, faculty and academic affairs personnel indicated that their institutions would not use race or ethnicity for admittance of students due to state or national legislation. The institutions were able to average producing 208 women engineering graduates, which is above the average graduation rate at other institutions. The Midwest institutions averaged 388 women graduates which nearly approaches double the rate of other institutions. The Midwest institutions' size alone cannot explain this interest rate by women in the engineering field of study. The participants offered insights into how the increase in women occurred.

When asked what actions were taken at their institution to increase the number of women at their institution Emerson, a faculty member of engineering education, summarized research that covered this topic:

> …back in 2012–2013ish …it really started with noticing that the median GPA …of women who enrolled in engineering at [said university] was a 4.0. Guidance counselors were deciding not to have women apply to [said university] engineering, unless they were the cream of the crop. Where there are plenty of guys who may have been interested [in engineering], and they were encouraged [to apply] even if they did not have that kind of credential, and that kind of performance in high school.

And Emerson continued the story by saying that the engineering department participated in educating the guidance counselors. To increase engineering applicants high school advisors were told:

> …the need was to diversify the application pool by pushing back by saying send us more [women]. I mean it is not all about GPA, but for sure, could you at least please send us women that are in terms of high school GPA and SAT scores like comparable to the pool of men [who were advised to submit applications]?

Emerson reported the result of women engineering students was an increase in the percentage of women applicants:

> …we moved up toward 30% I think, certainly above 25%, even though nationwide it has been stuck at 20, 20, 20, no matter what anyone does, so we made immediate progress on that one.

At another institution, a discussion occurred concerning the successful increase of women graduating from engineering programs. Anthony, an assistant engineering dean of undergraduate affairs at a Midwest university, responded with excitement when asked about their higher female engineering graduation numbers:

> I am glad you say that! Because we have been bashed forever for not doing enough. And, it is true, at the turn of the century, specifically between 2002 and 2008, the number of women had gone down. For various reasons, first the dot-coms burst, and the bad economy, and so on. But, since I have been here, I have made a big push for the recruitment of women. We have basically doubled the size of the female population. Not that this is truly great, as they are a percentage increase of low numbers, but now in our freshmen class, we have 380 to 400 depending on how you look at it, and we are trying to push this number higher. In the last few years, I did a calculation recently, [the] average increase in the program has been 150%. So, if we were able to sustain this growth by 2021, perhaps we would be at 30% women, [and] by 2030 we would have gender parity. …right now we are at 22% overall, the freshmen class is right now 24% or 25%. So there is a bit of a ripple because we grow further and further for a while but at some point, we will be saturated because the pool has to [outgrow] the total pool. We need women to pursue engineering and a larger percent in terms of the general population. If the

> availability of women is 25%, we will stop at 25%, 26% perhaps, but every percent beyond that will be very expensive, very difficult, and a lot of work. But if there is growth, then maybe in schools where women are exposed to STEM, and they see engineering as a good career for them [they will see] it is not just male dominated. [For] many companies, of course, this is still the case. But now approaching the quarter level of females in the program, the girls seem more like themselves in their major. Some majors we already have gender parity; in bio-engineering we have more women than men right now because of the topic. Other majors, they may even have 30%. But, the more techy [sic], nerdy type of majors have the faculty exactly the same—and because of the huge pool—and the faculty being successful, we have been able to recruiting [sic] women for the freshmen class between 35 and 47 percent, depending on how things fluctuate a little bit…

Women are graduating in higher numbers with an engineering degree in universities that are located in a belt region, which ranges from Illinois to New Jersey. Unfortunately, in the Midwest, the recruiting of African and Latino students is difficult as the distribution of these URMs are found mostly in the southeastern states and URMs can be recruited only from local urban settings. These universities are developing programs in these urban settings to develop an interest in students to study engineering after graduating from high school. Universities which are trying to increase diversity may focus on increasing the number of recruited women. This focus occurs because identifying individuals by race or ethnicity is difficult, and unless gender is chosen as a factor in recruiting, there is no guarantee of selecting underrepresented minority students.

Discussion

The engineering education process has historically produced white male engineers successfully. The methods to educate the white male students may not be extendable to aid in the retention of URMs. The following comments support the six themes *of community, mentoring, role models, active learning, empathy,* and *academic habits*. Kennedy, the director of a minority engineering program, reveals how the six themes are interrelated through:

> …the engineering education program …is all about looking at pedagogy, curriculum design, classroom structure, leadership, policy design, and other factors that help us know how to teach more efficiently and with greater impact in a diverse classroom. We have to be prepared to deal with the change in demographics of the students who are coming into the classroom. Especially, at [said university], we have a very, very large international population and these students have different needs as do underrepresented minorities. I am not sure that our classrooms are designed for this level of diversity. When I was in industry, we had to retool every time we made design or product changes. Different products call for different parts as well as a different manufacturing process. Whenever there is a change in the body of a vehicle, you would strip out old tooling for new [and] develop a new process before introducing a new product to the line. In manufacturing, you cannot run a different product through a process it was not designed for. You have to change your process to meet the needs of the raw material. I really see that in education, we see something wrong with the product, but we really see something wrong with the process. So, that's my lean [systematic method for waste minimization] analysis…

Engineering education must be modified to be supportive of all students. Engineering faculty should expect that changes are needed for educating engineers. For an engineering student engineering courses need to have structured lessons that tie to learning objectives. Faculty need to move the engineering students in a planned progression toward understanding. Kennedy, offers the following for teaching engineers by incorporating the:

> Engineering Design Process [4 key steps to STEM teaching and learning] to integrate course curriculum, teaching style, and assessment, into the design of a course will facilitate student success. The course asked questions such as: what are your curricular priorities? What are you overarching outcomes for the class? And, how does that translate to the day-to-day activities of students in the class? How do you design a syllabus that translates the objectives of the class to a comprehensive syllabus? How do you establish each week's activity through concept mapping and embedded outcomes to increase student learning? What are the factors and layers of thought that the teacher or student brings to the class that may prevent or support achieving course objectives? How does the instructor assess whether we are reaching goal attainment throughout the school semester? What pedagogical style and methodology is the class built upon? Problem Based Learning is something that we studied and focused on. As well as, promote collaborative learning.

The incorporation of aspects of active learning into the classroom is important. Active learning methods are not utilized constantly, but should be included to aid in information retention by the student. The modern engineering classroom performance assessment has changed to be based on student demonstration of knowledge versus grading on a scale which dictates the number of students who receive grades based on statistical distribution. The engineering student is provided a clear path to understand the requirements to be successful in their engineering courses. New methods to retain all students when implemented at a single university are important to retention of URMs and must be considered for use at other engineering institutions. Emerson, explains the assessment changes and their effect at his university that resulted in improvement in the retention of all engineering students:

> It [the changes are] is backed up by the fact that the first-year to second-year continuation rate is 90% plus which is great. And, contributing to all that is, you asked about our pedagogical practices, one of the big pedagogical practices is that we [our engineering education faculty] don't use norm reference grading, which is that we don't have a predetermined that this many of the students will get As, and this many people get Bs, and this many people get Cs. We tell students at the start of the class what the standard is for getting an A, a B, a C and so forth. And, we tell them what they need to do to meet that, and we do what we can to get them there.

Setting a standard for student performance is important. The engineering faculty member should teach the learning objectives, and then test those learning objectives. The assessments for any course are to be tied to the learning objectives. The URM students will succeed when programs to improve retention for all students are implemented.

Summary

There are six dominant themes for improvement in the retention of URM engineering. The areas of community, mentoring, role models, active learning, and academic habits work interdependently to improve the academic success of the URM engineering students. Within each of these six areas is an underlying need for empathy toward all students. Having empathy does not mean that students should be “mollycoddled,” but that faculty and academic success personnel realize that demonstrating the desire for the URM students to succeed can significantly affect their academic and social performance in positive ways. The researcher’s discussions with the participants followed the advice of Robert, an educational consultant, “I think the other thing we need to bring to these conversations is the desire to be loving. I use that word, the L word; people respond to authenticity” when discussing URM success.   The six areas explored need to be implemented to aid the URM engineering students. Which of these areas should be emphasized to improve URM retention is difficult to ascertain. Arguing that any particular of the six focuses be implemented alone is difficult to support. The participant Alex a faculty member in the Midwest, summarizes, “we need to do more of everything to support URM and all students.” When asked what efforts would help URM students he replied, “several things: recruiting and retaining diverse engineering faculty, carefully-designed, active learning based courses (particularly at the sophomore-level), and peer and/or faculty mentors.” Presently, universities are implementing combinations of these six programs somewhat randomly. The implemented choices are perhaps influenced by the research grants and monies obtained to support research in each of these efforts. Retention abilities shall be best determined through a Pareto Analysis [a statistical technique in decision making] of URM engineering students’ needs at a university. The developed list of activities will aid in the implementation of a support plan, rather than relying on the influence randomly distributed programs based on successfully funded grant applications. Chapter five provides a summary of the main findings and the recommendations for faculty, administration and academic affairs personnel to take to improve the retention of URMs.

Chapter 5: Conclusions, Discussions and Suggestions for Future Research

Introduction

This chapter addresses the recommendations and conclusions of this study. This grounded study performed a systematic review of multiple universities to identify activities that improved the retention of underrepresented minorities (URMs). Recommendations are provided for retention improvement of URMs at engineering institutions. Future recommended research areas are addressed. The retention of URMs is important to the engineering community, and in a broader sense, to the global community, as diverse engineers will aid in providing complete solutions to engineering and social problems. Wang (2018) predicts that in 2030, only 52% of freshmen students will be white. This is a change from 2010, when 63% of freshmen were white. The future is going to require that engineering faculty and programs adapt to allow URMs to succeed.

Conclusion

The six factors identified in chapter 4 are recommended for engineering institutions to improve the retention of URMs. These six factors have been identified to include *communities of learning*, *faculty mentoring*, and *peer mentoring* as having significance in positively affecting the retention of URM students. The URM community consists of the students' faculty and peers. The URMs benefit through faculty and peer involvement that goes beyond academic mentoring needs. All students, and specifically the URMs, benefit when they receive any positive attention from faculty, which helps them feel a part of the university's community.

Communities assist in URM retention. The purpose of the community is to allow the URM students to develop a relationship on the university campus. URM students who have settled into a community are in a position to be energized by the academic engineering environment. The developed excitement is fostered by seeing others who are energized like them in similar academic endeavors. Students who are living in—and cooperating with—their communities generate discussions on topics of interest and develop ideas. The development of ideas in their communities will enhance the academic education that is provided by their faculty. As the students generate new creative ideas with help from their community, and discuss these ideas with faculty, a bond will develop. The faculty-centered bond will expand the community, which generates additional excitement within the community, leading to a greater interest in joining that community. The cycle of community continues to self-propagate as new members enter the community.

The Institute for Broadening Participation (2016) suggests that encouraging Black and Latino students during student orientation to form communities ensures their academic success. The majority of faculty participating in this study support this recommendation of early building of communities. The National Academy of Sciences and National Academy of Engineering and Institute of Medicine (2011) encourage the creation of cultural education communities which improve learning.

Zhao and Kuh (2004) convey that learning communities and integrated curricula have shared social and academic aspects. Zhao and Kuh determined that learning communities are effective:

> The findings generally corroborate previous research and conceptual work in this area, indicating that participation in some form of learning community is positively related to student success, broadly defined to include enhanced academic performance, integration of academic and social experiences, positive perceptions of the college environment, and

> self-reported gains since starting college. The effects are somewhat stronger for first-year students. (p. 132)

Hurtado, Carter, and Spuler (1996) describe the importance of programming for URM students to engage in, by stating that, "…retention programs may work to overcome some of the disadvantages of student backgrounds" (p. 40). The programs implemented by the departmental engineering majors aim to foster students' academic and social integration by helping them adapt to the rigors of the curricula and expectations of the faculty, and introduce them to support resources that can help them maximize their potential.

Marra et al. (2012) disclosed that, "Perhaps especially applicable to students from underrepresented groups, the perceived 'climate' in engineering programs contributes to students' feelings of belongingness and is potentially detrimental to their retention in those programs" (p. 3). These complaints about not belonging indicate an area the engineering departments across the U.S. can investigate, and implement continuous improvement activities to make all students feel welcome. Marra et al. detail the impact of any students' lack of belonging, and how it negatively impacts retention in engineering:

> The lack of belonging factor was also the only factor to be significantly related to the type of major students chose after leaving engineering (e.g. technical or non-technical). The more lack of belonging was a factor in their decision to leave, the less likely students were to choose a new major that was technical. The potential hypothesis of this result is that once students feel a lack of belonging in the very technical engineering major, that belief may generalize to other technical majors leading these students to gravitate towards non-technical majors. (2012, p. 24)

Purdue Engineering continues to work at activities that “establish a sense of ‘family’ and ‘belonging’ to help minorities adjust to the social climate at a majority university” Yoder (2012, p. 18). The importance of *community*, and a *feeling of belonging*, have been identified as important to the retention of URM students in engineering. The participants show a clear preference for the building of communities to aid in the retention of URM students in engineering. This study confirms the importance of community, as reported by the National Academies and the literature which supports the development of communities for URM success.

Mentoring promotes retention and community. This study has confirmed Yoder’s (2012) report mentoring is an effective approach to retain students. Mentoring and advising can help the student to be successful in classes, however, the mentoring is just as important to help build the students’ identities as engineers. Mentoring can be performed by faculty, senior faculty, student peers, or professional advisors. Programs with industry can be established where mentors are currently employed or retired engineers. Professional engineering societies can be contacted for mentoring support. Marra et al. (2009) expressed that women who found “…contact with female mentors in STEM fields allowed girls to visualize themselves in these fields, thus creating ‘possible selves’” (p. 8).

Palmer, Davis, and Thompson (2010) report that there is intersectionality between the mentoring and building a community that the URM students can become involved with through mentoring:

> The mentoring component helps students become involved in the campus, which increases their exposure to support systems inside and outside of the classroom, facilitates the development of relationships with role models, and enhances their commitment to the university. (p. 442)

Mentoring methods using faculty, professional advisors or computer-based student mentoring and reporting systems can be costly.

> [These] early alert systems, whether they are manual or automated, are personnel intensive. They increase the workload on faculty and administrators and, depending on the institution, may be viewed as placing unrealistic burdens on the same. This challenge has prompted the use of student mentors as the first line of engagement with underclassmen, a lower cost option and one that is relatively easy to implement depending on the size of the engineering department. (Reid, Ross, & Yates, 2016, p. 21)

West Virginia University maintains their approach to mentoring while controlling costs. Other schools report using graduate students to mentor first-year students. (Yoder, 2012).

The findings suggest that mentoring is a strong motivational factor for retaining URMs. Mentoring, is effective whether guided by faculty, academic affairs personnel, graduate students or student peers. Faculty mentoring adds a benefit for the URM as the faculty member understands the engineer's function in education and in industry.

Role models encourage URM identity growth. The use of role models is important for aiding in the retention of URMs by improving the URMs' self-efficacy. The literature suggests that the presence of role models aids in the URM students' ability to succeed in engineering. The participants in the survey generally confirmed the perceived value in having faculty who were similar in appearance to the URM students.

Not all faculty support that role models are important for URMs to succeed. Some URM faculty members referenced themselves as proof that role models are not needed, since they achieved their doctorate with minimal support from individuals similar to themselves. One African American professor stated that he thought there was little value to the URM students to have a URM faculty member role model who does not share the same academic interests. A URM participant, Matthias, emphasized that he did not believe role models were needed to ensure URM success. If there are no similar academic interests between a student and faculty member, Matthias wondered why the URM student would consider approaching a URM faculty member for mentoring, or support. Despite this statement, a reported reason for poor retention of URMs is that role models are not visible in the classroom and in university leadership positions (Committee on Equal Opportunities in Science and Engineering, 2013).

Following the interview with Matthias, the researcher asked URM faculty participants if they had been contacted to visit classrooms as guest lecturers if there was adequate time. As a reply, they stated that they had not been called upon to act as mentors in this manner. Enough counter opinions were heard to question a need for the role models to aid all URMs in succeeding. Additional research is needed regarding the burden on the professor and the benefits received by the URM student.

Reid, Ross, and Yates (2016) state that role models can aid URM students' success. However, if the role model is seen as floundering, this can have negative effects on the URM students:

> The observed experiences of others with whom a student can relate are also crucial to fostering self-efficacy beliefs, especially when the individual is uncertain about his or her own abilities or has limited experience with the task or in the domain, as is the case for freshmen. The success of a role model who possesses similar attributes is particularly helpful in raising self-efficacy beliefs (Pajares, 2002). This may be represented by the educational levels and occupations of parents, or the accomplishments of an

> upperclassman. On the other hand, watching a role model fail could have a deleterious effect on self-efficacy. (p. 26)

Mentoring has been confirmed to be important in the retention of URMs. The role models have responsibilities to succeed and to consistently positively act in ways that URM students can emulate.

Active Learning and relation to URM retention. Faculty need to adapt their teaching methods to be inclusive. The continued use of methods of teaching that are successful in educating white males must change to inclusive learner-centered teaching methods. The literature supports that active learning is beneficial to all engineering students. Prendergast reports that, “An active learning environment and a positive first-year experience produce strong indicators of success and increased retention rates in engineering” (2013, p. 1). The literature supports the use of active learning to retain the URM students. Read, et al. (2016) report that active learning strategies aided students at a minority-majority institution in Texas, since the university could not afford to start a first-year engineering education program with faculty that focused on engineering education the university. According to the authors, the university engineering program

> …modified their curriculum and graduation requirements to front-load collaborative learning efforts (e.g., design-, project- or team-based learning courses). For example, Prairie View A&M students declare engineering before arriving on campus and thus get exposed to an introductory engineering course that addressed the distinction between the various engineering disciplines. Citing that “before we introduced this course in 2006, students just left engineering” out of frustration, it became clear that they did not fully understand the nature of the discipline they selected…. (2016, p. 16)

Felder and Brent describe the cooperative learning results obtained when using Peer-Led Team Learning:

> …the PLTL implementation described in this study fully qualifies as cooperative learning. On average, the workshop students significantly outscored their traditionally taught counterparts on individual course exams, final course grades, retention in the course, and percentage earning the minimum acceptable grade of C- for moving on to the second-semester organic chemistry course. Similar results were obtained specifically for female students and underrepresented minority students. (2007, p.5)

Sloane (2016) confirms the findings reported by Felder and Brent and has found that URMs have a higher level of retention with PLTL. When utilizing active learning in "gatekeeper" courses Sloane reports:

> As a strategy that fosters active learning, Peer-Led Team Learning (PLTL) holds the potential to provide much of what PCAST [President Obamas' President's Council of Advisors on Science and Technology] deems necessary to improve URM student performance in introductory courses and retention in STEM majors. In the first of two studies presented herein, we found the PLTL model to be effective in improving scores for both URM and non-URM students in an introductory college science course. In the second study, we found PLTL to be associated with higher levels of retention among URM students. We conclude that participation in PLTL can help URM students who may struggle to identify with STEM to develop stronger STEM identities, which, along with higher achievement, may lead to enhanced retention. (2016, p.1)

Active learning aids in the retention of URMs, however, the researcher identified that only 10% to 24% of faculty are using active learning. This information was garnered from the chairs, directors, and deans of engineering colleges who are in the position to evaluate faculty teaching. The researcher is concerned that this number is not indicative of a significant use by all faculty of active learning styles. The researcher did not record any diary entries during this study of observing a class session taught with active learning: the researcher sat in waiting areas outside classrooms and listened to faculty teach while waiting between interviews. The researcher did not observe a single class being conducted as anything other than a passive lecture, or as a problem-solving session.

Participants interviewed for this research support the use of active learning. The number of those using active learning in the classroom (because they perceive it to be important to URM students' retention) is not indicative of the value of active learning. Faculty members and academic personnel expressed concern that active learning experiences had not been for improved learning on the lower, middle, and upper performing students' classroom distribution, to determine whether any of these groups negatively suffered consequences because of the use of active learning. The researcher remains optimistic that the active learning process aids, URM students and continues to support its use in any classroom. To improve URM retention, the researcher suggests that active learning is used in second-year classes and that these classes address the various learning styles which engage engineering students. This study supports the literature, and confirms that URMs benefit from active learning, especially during the URMs students' first and second years. The findings suggest that active learning theme is a motivational factor for URM students' retention but is not a sole factor in their success.

Engineering acceptance rate. One of the themes to emerge from this study was recognized when using quantitative methods for institutions' inclusion in this study. Acceptance rate and retention rate appeared to the researcher to be interrelated. The acceptance rates for the

45 universities vary. First Year University Retention Rate (N=45) had a M = 86.5 [59, 98], SD= 10.1, and the Engineering Acceptance Rate (N=45) had Mean = 49.9 [5.7, 100], SD = 22.2. The researcher performed a bivariate correlation test which illustrated that universities that have a low acceptance rate into engineering undergraduate programs correlate to high first-year retention, $p \leq .01$. Participants at many of these universities reported that the average ACT score was greater than 30. At one institution, an assistant dean mentioned that students with 34 ACT scores would not receive any scholarship assistance, as 34 was an average ACT score for acceptance into the institution's engineering program.

Discussion

This research was intended to identify the factors that faculty and academic affairs personnel utilize to retain URMs in engineering. The participants showed a clear preference for *community, mentoring, role models, active learning, empathy,* and *academic habits* as factors aiding the retention of URMs. C*ommunity, mentoring, role models,* and *active learning* have findings that have contributed to the understanding of the implementation and importance of these factors to the URM students' retention in engineering. Three of these factors, *community, mentoring,* and *role models*, have been identified as having a strong motivational factor for the URM students' retention in engineering. The factor of *active learning* has significant support in the literature, and the participants' perceived influence on the URM students' retention in engineering. However, participants supplied comments which question the benefits of *active learning's* significance to student retention, and indicate that *active learning* is an interesting instruction method that students enjoy. Although the findings for *active learning* are generally compatible with the literature for *active learning*, there are several areas in which participant views differ from the reported positive implications of student retention.

Two factors, *empathy* and *academic habits* were identified as motivational factors by participants, yet the total references to the two factors were low. The implication of the minimal mentioning of empathy and *academic habits* is that these could be important factors for future research, as the interview instrument for this study was not constructed to explore these two factors directly. The participants may have provided information on *empathy* and *academic habits* as information that the researcher should know, but had not specifically directed a question to the participants addressing these factors. Conducting further research is justified to determine the importance of *empathy* and *academic habits*.

The participants suggested that to benefit the URMs students' retention plans should be implemented that simultaneously support *community, mentoring, role models, active learning, empathy* and *academic habits* programs and activities. These findings are consistent with previous research. Future research would be to determine the most effective combinational implementation of the six factors to maximize the retention of URM students.

The two correlated variables that emerged from the researcher's analysis were engineering *acceptance rate* and *university retention rate.* The implications of this relational finding are that only the students with the ability to perform standardized testing will be admitted to universities with a low engineering acceptance rate. The universities will continue to have a low percentage of URM students in their programs. The admittance to the universities will trend with the percentage of URM students who perform well on the standardized tests. Some universities work to influence this percentage by considering other factors such as *leadership role in high school, class rank,* and other attributes that possibly indicate the students' potential success. Confounding the URMs universities' admissions issues are federal and state laws which disallow the use of ethnicity in determining admission and acceptance into the university.

In this study, there are 49 participant quotes with some of the participants having more than one quote included in the study. There are five participants who are quoted often in the study to provide guidance, explanation and understanding, and who have an identified relationship of similar education background which has emerged in this study. These participants are *Kennedy, Matthias, Robert, Phyllis, and Donald. Kennedy* provided an engineer's view of how to solve the URM retention problem, and provided an insight into how the URM students' feel in certain situations. *Matthias* provided a counterintuitive perspective to retention methods through the use of role models. *Robert*, who has successfully improved URM engineering retention and persistence rates at two universities, expressed the importance of empathy, and love, to aid in the URMs' success. *Phyllis* provided a viewpoint that succinctly addressed the method of success for a URM student. *Donald*, at the end of his interview, implored the researcher "to find others like himself, that were interested in engineering but were not engineers, that have interest in engineers." (The researcher did not change his approach according to Donald's specification.)

Kennedy, Matthias, Robert, Phyllis, and *Donald*, all have one educational trait in common: engineering is not the first degree that they pursued. The undergraduate degrees held by these individuals, in no particular order are: music education, psychology, sociology, and philosophy. Three of these individuals have earned degrees in engineering. Three have worked in engineering. One of the remaining two is a fellow in an engineering discipline, the remaining individual teaches courses designed for engineering students. Other participants also stated that they had training in other fields before studying engineering. An example is Jazlyn, who had studied social work until late in her undergraduate degree. Jazlyn notes, "I switched to civil engineering because it is essentially social work on a larger scale." She continued by stating that "it was important to note that the *civil* in civil engineering is actually a contraction of the original name *civilian* engineering. The program of study was developed to support *civilians."*

The identified relationship that has emerged from this research indicates that those who have discipline development outside of the engineering fields may be able to communicate, or have the desire to disclose their experiences, and recommendations in improving the URM students' retention. This study is a social engineering effort, and in itself, is an example of the value of a diverse virtual team formed through the common trait that emerged from the interviews, regarding the retention of underrepresented engineering minorities.

Recommendations

The results of this study provide a basis for recommendations for consideration for implementation by an engineering program. Implementing these recommendations will aid in the retention of underrepresented minorities. The first recommendation is that the university should perform an assessment of the state of diversity in the engineering department at the institution. This assessment will quantify the participation of URMs in the engineering majors. This exercise is performed because participants have stated that an institution cannot develop an action plan until they know the current status of URMs at their institution, and set a goal for the number of URMs the institution aims to have enrolled, and be a part of faculty and staff. Once the numbers of the URMs currently enrolled in the programs are established, the future URM student enrollment growth in the engineering programs must be defined. Then, the increased target number of URM students can be determined that are sought to be added to the university, and to their engineering departments. Subsequently, a list of actionable items will be developed to meet these goals.

The engineering departments should work to establish communities for URM students. In large institutions, the communities often exist where students can flourish; in smaller institutions, the communities structured by the university help allowing URMs to find a community readily. The academic affairs personnel will need to introduce URMs to potential communities purposefully. It is recommended that the engineering departments work with their institutions to establish a general engineering community where the students can flourish. This can be accomplished by providing a living-learning engineering student community.

A living-learning URM students' community formation can be assisted by furnishing an area for studying and tutoring. Zhao and Kuh (2004) support learning communities to aid in students' learning. Tutoring should be made available at a location within the living-learning community complex. The academic affairs departments will need to determine that URM students are participating in at least one community.

Aiding in the further development of the URM community, faculty mentoring is recommended for students, which can be implemented formally, or informally. Denton (1998) recommends that student and faculty interactions occur to improve the learning environment. The informal program may be supported by role models who provide active or passive support for the URM student. In informal programs the community may work to inform individuals of the availability of a role model for mentoring or advising. If a mentoring program is not in place for URM students, a formal program should be established before implementing peer mentoring. Students could be mentored by faculty in their office. Or, in a casual setting such as the living-learning community or an off-campus location.

URM students academic performance and career development could be improved when formal advising sessions are held with *all* (includes URMs) students. The faculty advising is helpful to URMs as they may be first-generation college students in need of guidance. This requires that mandatory advising sessions be held for *all* students regardless of ethnicity or gender. At a minimum, URM students must meet with an advisor prior to registering for, or dropping any, classes. The act of dropping classes is to be discouraged and should be only allowed if approved by the students' advisors. The advisors' endorsement is suggested as some students engage in the dropping of courses when they believe they will not obtain the course grade that they want to have on their transcript. These students may drop because they will receive a C, which is a passing grade; some students view a C as unacceptable. The engineering faculty should be encouraged to proactively contact students, or consult the students' advisors, when the students are in danger of failing.

To promote URM students' academic success a first-year engineering education center should be established to allow common core engineering courses to be taught by engineering faculty interested in teaching. Denton (1998) recommended that the teaching practices be improved which would result in improved learning. This focus on first-year engineering retention is expected to improve learning for all students which is supported by Borrego, Froyd and Hall (2010). This change requires significant work. Implementing a first-year engineering instructional team may require hiring new faculty members or reassigning existing ones. This engineering education team should be comprised of faculty who have an interest in engineering education and may be considered faculty of practice instead of research faculty. Professors of Practice help promote the integration of academic scholarship with practical experience (American Association of University Professors, 2004). Faculty of practice, as compared to research faculty, often perform university service in combination with their teaching assignments and do not perform research. Faculty members that make up the first-year engineering education department may perform research in engineering education, and may not be pursuing tenure. The faculty of practice are reviewed and compensated based on their ability to teach engineering courses well.

Practical Recommended Retention Aids

The retention of all students from year to year is the goal of every engineering department. The participants from this study provided ideas and approaches for URM students' retention. The participants and the literature both suggest that after students succeed in their engineering sophomore year studies, the majority of students will persist to graduation.

The dean and chairs of engineering departments should survey their faculty and engineering students, to determine that hostility does not exist in classrooms. URM students should be anonymously asked to identify situations where they do not feel they are part of an inclusive environment. Academic affairs personnel will check DFW (grades of D, F, or Withdraw) rates for the required engineering degree curriculum. Classes with high DFW rates should be reviewed with faculty who may work to resolve concerns. Faculty teaching methods, the curriculum, preparation for the classes, prerequisites or other similar areas may require modification.

Academic affairs personnel should be *intrusive* (this word *intrusive* was previously provided by two participants who stated first-year students should be required to engage in tutored sessions) in providing tutors to the URM engineering students. Tutoring in the first year should be mandatory for most URMs. The implemented tutoring program would be arranged in a convenient place where the URMs, and other students, would work on their homework in the presence of tutors. If tutoring help is needed while studying at these locations, the tutor would be close by, and could readily assist the student.

URM students should be included in a first-year three-credit course, which would grant an introduction to engineering. URMs need to build their identity as an engineer. This exposure aids all students in that they are able to learn more about what it means to be an engineer. Some engineering curriculums do not have students taking engineering classes until their sophomore year, and sometimes the first engineering class is not taken until the second semester. Taking an engineering class earlier in their academic careers will enable them to perceive themselves as engineers.

Students should take courses utilizing active learning in their sophomore year. Alex, a faculty member in the Midwest, reported that passive lecture courses are less likely to retain URM engineering students during the second year. Second-year classes can include any of the active learning experiences, such as laboratory sessions, undergraduate student research, teamwork, and class discussions. These active based activities will help to retain the URMs.

Recommendations for Future Research

This grounded theory design study was performed to identify themes organically (revealed during the interviews), and provide further information which supports the exploration of identified topics and themes. The following questions have been identified during this study to be considered for future research. The continuation of this study would be to determine the ability to retain underrepresented minorities through the use of these identified themes and factors. Future research would be directed at answering the following questions.

This study reported six factors that aid in the retention of URM students. A future study could investigate whether all six factors need to be implemented for URM retention success. This future study could also review the combinational effects between two or more of these activities to investigate if there is improved retention of the URMs. A separate study focus on these six factors and how they extend to those students who are studying engineering technology could be performed. The engineering technology students experience courses that are practical and hands-on oriented which could result in other factors becoming important.

Participants in this study mentioned that large universities (greater than 60,000 students) have a high opportunity for URM success because of a large number of support programs and organizations on campus. The effect of large institutions that graduate a higher percentage of URM engineering students could be studied to determine if different factors are important at a large institution. A study could focus on universities that cannot use race or ethnicity for admissions and whether there is a higher rate of women entering engineering programs vs. other URMs.

Participants mentioned that URM retention could be increased when URM students participate in a study abroad opportunity. The cohort that is formed during the study abroad helps to bind students to one another and support one another after the experience. Ascertaining the effects of the study abroad experience in retaining URMs would be interesting.

Summary

Studying engineering is not easy. Engineering is a difficult major for students to be successful; the engineering curriculum has many academic challenges. The first year programs contain physics, mathematics, chemistry, and general education courses. The engineering students in their first year often do not identify due to lack of contact with the engineering department and have difficulty understanding the connection of these courses to their major.

This study has P-20 implications with diversity being the primary area addressed within P-20. Innovative approaches to improving diversity have been addressed. Implementation of programs to address retention of URMs have been presented. The leadership provided by presenting these findings at conferences helps to improve the understanding of the P-20 concepts within engineering.

The role of faculty in the success of URM students is significant. A faculty participant in this study indicated that what is important for the student is the identification of their community and then to “love them hard.” The community, including the faculty, need to identify their URMs in their engineering departments and in turn, “love them hard.” A significant improvement to URM retention can be made by faculty and academic affairs personnel by simply letting students know that they are advancing well and their degree progression is important for faculty members. URM engineering students’ success will be enhanced by providing opportunities for community development and mentoring. This success is improved by aggregating the positive experiences of all six identified factors of focus. These six factors can be implemented with the goal of encouraging *all* engineering students at a university. However, the individual engineering student ultimately must decide that academic success is their personal goal, to participate in a community, and to utilize the provided university support services. For the URM engineering student, the need to find a group or community to belong to must happen early in the arrival at the university, the earlier that the URM engineering students find a home, or someone who cares about them, or an organization to become a part of, the higher the opportunity for the URMs’ retention.

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Appendix A

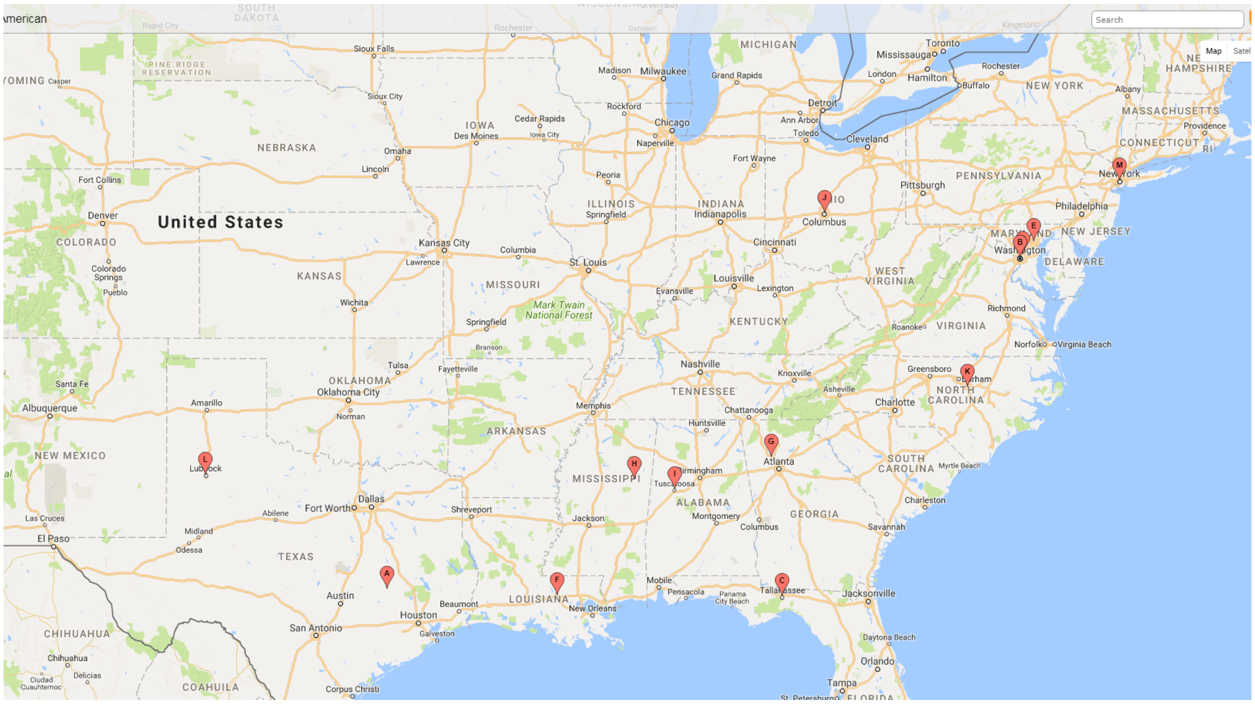
Count	University	Women	African American	Latino	Total URM Degrees	Total AA/H	Total Engineering Degrees	% of AA/H Degrees	% Women Degrees
1	Howard University	29	65	0	94	65	77	84.4	37.7
2	The University of Texas Rio Grande Valley	52	1	235	288	236	291	81.1	17.9
3	Florida International University	159	84	561	804	645	843	76.5	18.9
4	University of Texas, El Paso	97	5	281	383	286	383	74.7	25.3
5	North Carolina A&T State University	47	147	5	199	152	207	73.4	22.7
6	California State University	48	12	141	201	153	289	52.9	16.6
7	University of Texas, San Antonio	53	14	144	211	158	377	41.9	14.1
8	California State University, Long Beach	131	16	217	364	233	641	36.3	20.4
9	FAMU-FSU College of Engineering	111	62	68	241	130	413	31.5	26.9
10	University of Houston	100	12	129	241	141	449	31.4	22.3
11	University of Central Florida	202	98	326	626	424	1356	31.3	14.9
12	University of Arizona	145	8	145	298	153	579	26.4	25.0
13	City College of the CUNY	69	43	54	166	97	377	25.7	18.3
14	Kennesaw State University	33	52	17	102	69	285	24.2	11.6
15	University of Florida	281	40	221	542	261	1182	22.1	23.8
16	Massachusetts Institute of Technology	352	46	122	520	168	786	21.4	44.8
17	University of California, Irvine	148	9	132	289	141	690	20.4	21.4
18	Texas Tech University	118	45	100	263	145	730	19.9	16.2
19	Stanford University	234	40	93	367	133	701	19.0	33.4
20	California State Poly. U., Pomona	133	10	208	351	218	1178	18.5	11.3
21	Arizona State University	298	30	256	584	286	1554	18.4	19.2
22	Texas A&M University	336	29	246	611	275	1559	17.6	21.6
23	University of Texas, Austin	282	24	196	502	220	1559	14.1	18.1
24	George Mason University	147	42	53	242	95	705	13.5	20.9

25	University of California, San Diego	349	25	174	548	199	1541	12.9	22.6
26	Cornell University	345	24	84	453	108	864	12.5	39.9
27	University of Maryland, Baltimore County	118	55	23	196	78	635	12.3	18.6
28	Louisiana State University	158	52	48	258	100	824	12.1	19.2
29	University of Maryland, College Park	203	57	57	317	114	1011	11.3	20.1
30	Georgia Institute of Technology	594	124	117	835	241	2140	11.3	27.8
31	Mississippi State University	99	50	11	160	61	549	11.1	18.0
32	University of Michigan	415	33	122	570	155	1583	9.8	26.2
33	The University of Alabama	165	50	13	228	63	720	8.8	22.9
34	Colorado School of Mines	267	10	68	345	78	917	8.5	29.1
35	Virginia Tech	315	37	99	451	136	1635	8.3	19.3
36	University of Virginia	205	14	31	250	45	654	6.9	31.3
37	North Carolina State University	316	47	55	418	102	1489	6.9	21.2
38	University of California, Los Angeles	156	1	48	205	49	720	6.8	21.7
39	Ohio State University	267	47	49	363	96	1496	6.4	17.8
40	Univ. of Illinois, Urbana-Champaign	340	31	90	461	121	2111	5.7	16.1
41	Pennsylvania State University	325	22	67	414	89	1797	5.0	18.1
42	University of Washington	272	9	38	319	47	988	4.8	27.5
43	University of California, Berkeley	304	8	52	364	60	1273	4.7	23.9
44	Purdue University	409	23	48	480	71	1547	4.6	26.4
45	Missouri Univ. of Science and Tech.	112	21	22	155	43	1055	4.1	10.6

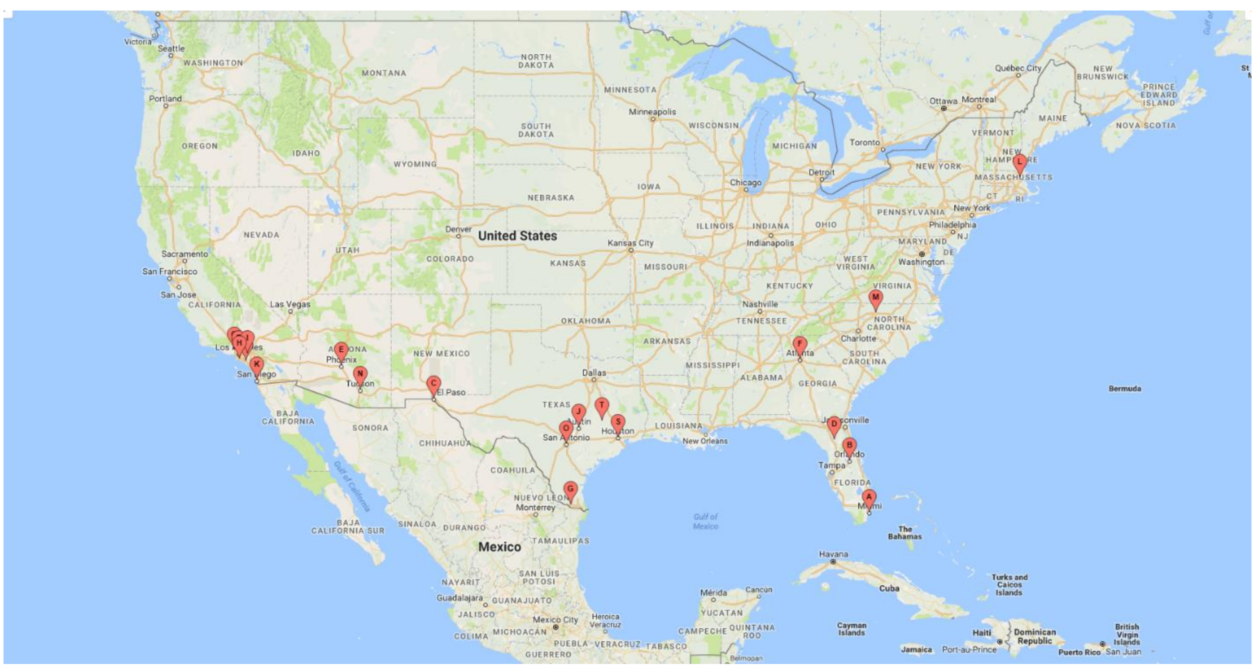
Highlighted text indicates that this university was visited by the researcher during this study.

Appendix B

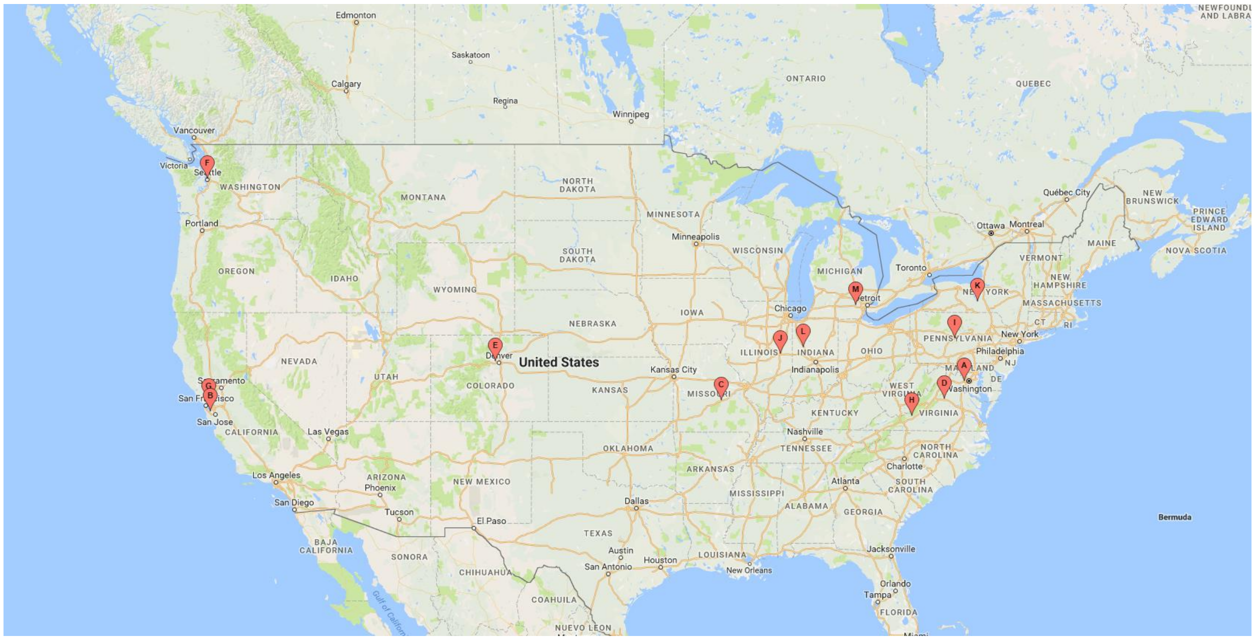
Location of High African American Diplomas Granted



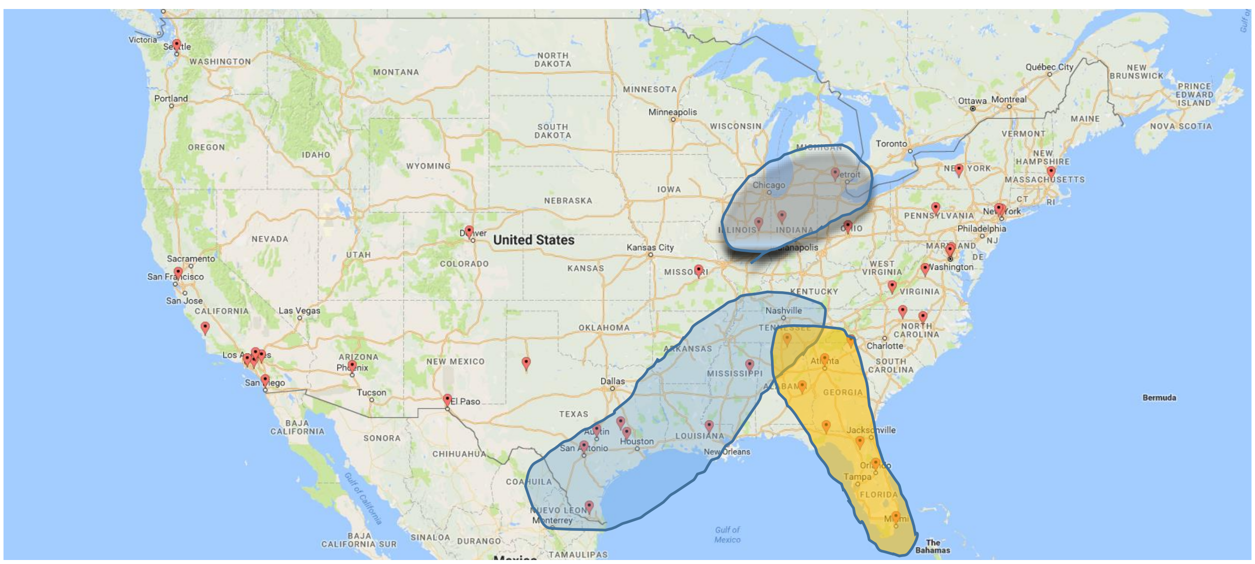
Location of High Latino Diplomas Granted



Location of High Percentage Women Engineering Diplomas Granted



Combined Map of all High URMs' Degrees Granted



Appendix C

MURRAY STATE UNIVERSITY

Institutional Review Board

328 Wells Hall
Murray, KY 42071-3318
270-809-2916 • msu.irb@murraystate.edu

TO: Ben Littlepage
Engineering

FROM: Institutional Review Board
Jonathan Baskin, IRB Coordinator

DATE: 8/23/2017

RE: Human Subjects Protocol I.D. – IRB # 18-004

The IRB has completed its review of your student's Level 1 protocol entitled *Engineering Education and effects of Active Learning*. After review and consideration, the IRB has determined that the research, as described in the protocol form, will be conducted in compliance with Murray State University guidelines for the protection of human participants.

The forms and materials that have been approved for use in this research study are attached to the email containing this letter. These are the forms and materials that must be presented to the subjects. Use of any process or forms other than those approved by the IRB will be considered misconduct in research as stated in the MSU IRB Procedures and Guidelines section 20.3.

Your stated data collection period is from 8/23/2017 to 7/6/2018.

If data collection extends beyond this period, please submit an Amendment to an Approved Protocol form detailing the new data collection period and the reason for the change.

This Level 1 approval is valid until 8/22/2018.

If data collection and analysis extends beyond this date, the research project must be reviewed as a continuation project by the IRB prior to the end of the approval period, 8/22/2018. You must reapply for IRB approval by submitting a Project Update and Closure form (available at murraystate.edu/irb). You must allow ample time for IRB processing and decision prior to your expiration date, or your research must stop until such time that IRB approval is received. If the research project is completed by the end of the approval period, then a Project Update and Closure form must be submitted for IRB review so that your protocol may be closed. It is your responsibility to submit the appropriate paperwork in a timely manner.

The protocol is approved. You may begin data collection now.

Opportunity afforded

murraystate.edu

Appendix D

Informed Consent Statement
A Case Study Understanding the Retention of Underrepresented Minorities

Principal Investigator:	You are being asked to participate in a case study administered by Sidney E Martin, III, Lecturer, Murray State University and Doctoral Student, Murray State University, under the guidance of Dr. Ben Littlepage, Assistant Professor for Postsecondary Education Administration.
Purpose:	The purpose of the study is to understand the actions that result in retention of underrepresented minorities in engineering.
Duration:	Data will be collected beginning August 2017 through May 2018.
Procedures:	If you agree to participate, you will participate in discussion with Mr. Martin that will last 45-60 minutes. Some discussions may be shorter or longer depending on your desire to participate.
Benefits:	These data will help faculty and institutions to make decisions on how to best offer instructional support for underrepresented minority student success.
Risks:	No risks are foreseen. Your interview is confidential. Responses will be provided in summary to faculty and administration without personally identifiable information.
Confidentiality:	All responses will be kept confidential within limits allowed by law.
Contact:	If you have questions about the study, please contact Dr. Ben Littlepage at 270-809-2796 or blittlepage@murraystate.edu. Participants can also contact the Institutional Review Board for the Protection of Human Subjects at msu.irb@murraystate.edu.
Voluntary Participation:	You are encouraged to inform Mr. Martin if you are uncomfortable about participating in the study. He is happy to offer a further explanation of the study as well as protecting your privacy and maintaining confidentiality. You can also elect to decline participation and not complete the survey.
Audio Recording:	The use of audio recording is planned for this interview. The audio recording is being used to ensure the accuracy of the recall of the interview. You must consent to the audio recording to participate.
Findings:	All participants may receive a copy of the research findings once the analysis is complete. Participants wishing to receive a copy must submit a request in writing to Dr. Ben Littlepage at the e-mail address previously listed.

Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study.

____________________ ____________________ ____________________ __________

My Signature Date Sidney Martin Date

____

My Printed Name

MURRAY STATE UNIVERSITY
Institutional Review Board
Approved: 8/23/17 Expires: 8/22/18

The dated approval stamp on this document indicates that this project has been reviewed and approved by the Murray State University Institutional Review Board (IRB) for the Protection of Human Subjects. Do not sign or agree to participate after the expiration date on the stamp. If you have any questions about your rights as a research participant, you should contact the MSU IRB Coordinator at (270) 809-2916 or msu.irb@murraystate.edu.