Intervention to Improve Engineering Self-Efficacy and Sense of Belonging of First-Year Engineering Students

Dissertation

Presented in Partial Fulfillment of the Requirements for the degree Doctor of Philosophy in the Graduate School of The Ohio State University

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2014

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ABSTRACT

The percentage of bachelor's degrees in STEM awarded to women and underrepresented minority students needs to increase dramatically to reach parity with their majority counterparts. While three key underrepresented minority (URM) groups, African Americans, Hispanic/Latinos, and Native Americans constitute some 30 percent of the overall undergraduate student population in the United States, the share of engineering degrees earned by members of these groups declines as degree level increases. Underrepresented minority students accounted for about 12% of engineering bachelor's degrees awarded in 2009, 7% of master's degrees and 3% of doctorates (NSF Science Resource Statistics, 2009). The percent in engineering has been steadily decreasing, while overall participation in higher education among these groups has increased considerably.

Keeping those thoughts in mind it is important to examine the historical theories and frameworks that will help us not only understand why underrepresented minority students pursue and persist in STEM majors in low numbers, but to also develop interventions to improve the alarming statistics that hamper engineering diversity.

As indicated by our past two U.S. Presidents, there has been an increased discussion on the national and state level regarding the number of students entering engineering disciplines in general and underrepresented minority students in particular. Something happens between a student's freshman year and the point they decide to either switch their major or drop out of school altogether. Some researchers attribute the high

dropout rate of underrepresented minority students in engineering programs to low engineering self-efficacy (e.g. Jordan et al., 2011).

A student's engineering self-efficacy is his/her belief that he/she can successfully navigate the engineering curriculum and eventually become a practicing engineer. A student's engineering self-efficacy is formed by mastery experiences, vicarious experiences, his/her physiological state, and social persuasions, such as student-professor interaction. Increasing the awareness of a student's engineering self-efficacy could potentially improve sense of belonging and persistence for underrepresented minority students in engineering.

The hypothesis of this study is that an intervention during the first semester of an incoming freshman's tenure can help improve their engineering self-efficacy, sense of belonging, and overall retention in the engineering program. This study explored the following research questions:

1. What are the differences in engineering self-efficacy, and sense of belonging for first-year underrepresented minority engineering students compared to majority students?
2. What factors or variables should be considered and/or addressed in designing an intervention to increase engineering self-efficacy and sense of belonging amongst first-year underrepresented minority engineering students?
3. Can a small intervention during the beginning of the first semester improve a student's sense of belonging, engineering self-efficacy, and student-professor interaction?

Using the race, social fit, and achievement study by Walton and Cohen as a model, the author developed an intervention consisting of short compelling videos of upperclass engineering students from diverse backgrounds. In these videos, students discussed their pursuit of the engineering degree, what obstacles they faced in terms of sense of belonging and coping efficacy, and how they overcame those obstacles. Treatment groups of students watched the videos during the first few weeks of the semester, and pre and post tests were administered to measure mean gains in the student's engineering self-efficacy, sense of belonging, and other variables.

The results showed that underrepresented minority students had a lower sense of belonging than whites. The intervention used in the study contributed to mean gain increases in participants' engineering self-efficacy, which could ultimately improve persistence. A single intervention did not show a significant increase in students' sense of belonging; more work needs to be done to develop an effective intervention. The intervention is easily adaptable with insignificant cost, making it attractive for Minority Engineering Program (MEP) and other success program whose aim is to increase students' engineering self-efficacy.

Dedication

Dedicated to the past, present, and future members of the National Society of Black Engineers. Our mission is to increase the number of culturally responsible Black engineers who excel academically, succeed professionally, and positively impact the community.

Acknowledgements

I remember standing in the elevator of the Mechanical Engineering building at Michigan Tech. A faculty member stopped me to tell me that all of the faculty were waiting to see where I'd end up. Engineering Education was relatively new, and they didn't have confidence in my choice to switch from the Mechanical Engineering PhD program to Engineering Education. I can't say that I was too confident initially either. This field was new stomping ground for me and I was quite nervous. I'm proud to say that with the help of the Lord I'm finally ready to close this chapter of my life, but not before I thank a few people.

To the God of my salvation, the God who saved me as a young child, covered me in His blood, and filled me with the Holy Ghost: Jesus, I praise you for saving me, keeping me, and seeing me through this journey. You are the sole reason I exist.

To my parents: Albert and Myling Jordan. You have supported me through the ups and downs of my educational tenure. Thank you for holding me up, and holding me down. I love you, and don't worry—I'll start paying my tab soon!

To my siblings: Al-Jawaan, Niekeiya, BB, and Naomi. I still can't believe all four of you lived in Houghton, MI at some point! I'm beginning to think I have influenced you in some way. Thank you for making me laugh (and even making me cry). Where would you be without your "little big sister"?

To my best friend: Amanda Posey. God brought you into my life. We first connected on that long bus ride home to Detroit, and we've been singing and acting crazy ever since! Tell Jim and Jade they have a doctor in the family now!

To the advisors who gave me a fighting chance: Dr. John Sutherland, Dr. Sheryl Sorby, and Dr. Susie Amato. You could've left me behind a long time ago, but you didn't! Thank you for supporting me and seeing more in me than I sometimes saw in myself.

To a few good men: Isaiah Cunningham, Howard Reedy, Eric Befidi, Tony Howell, Alex and Sumo Mulbah, Joe Williams, Adrian Little, Godwin, Vincent, and Kingsley Iduma, Joe Johnson and Perry Wilson. Thank you for taking care of me as if I were your sister. You have been there for me through all of my crazy overseas excursions, my 10+ years at Michigan Tech, and my transition to Ohio State. I love you so much.

Tayloria Adams, Sade Ruffin, Taile Leswifi, Whitney Gaskins, and Renee Oats: See you at the finish line! We are finally going to be part of the club!

To those who came before me and pushed me to the finish line: Dr. Sharnnia Artis, Dr. Njema Frazier, Dr. Ebonee Williams, Dr. Crystal Smith, Dr. Jerrod Henderson, Dr. Michael Smith, Dr. Darryl Dickerson, Dr. Bevlee Watford, Dr. Howard Adams, and Dr. Stephanie Adams: Why didn't you tell me how hard this was going to be!? Just kidding.

Keisha Slaughter, you are the reason why I finished my dissertation proposal. You kept me on point during my final semester in the PhD program. I am forever in your debt.

Lisa Barclay, Kendra Allen, Shadya Yazback, Leslie Roston, Lori Hartrich, Kyra Watts, Charlene Dobbs, Yvette Lincoln, Brenda Nathan, Carolyn and Catherine Boyd, SherAaron Hurt, Kenisha Pope, and Layla Wilson: You all are my sisters for life.

To my therapist Daniel Goldstein: I'm still fighting and I'll never stop.

The National GEM Consortium and the King-Chavez-Parks Future Faculty Fellowship: Your funding allowed me to pursue my dream.

Dr. Robert Gustafson, Dr. Lin Ding, Dr. Mindy Rhoades, and Dr. Paul Post: Thank you for accepting me to the Buckeye family and advising me through the final stretch of my program.

Bishop Michael Jones and the Fountain of Truth Church: Thank you for showing me that faith without works is dead. Bishop Howard Tillman and the entire New Covenant Believers Church choir: Thank you for giving me a church home. Church of the Apostolic Authority: Thank you for giving me a church home away from home!

To my Doland: Thank you for holding on to see me graduate.

If your name is not listed it's because I'm exhausted and my brain is ready to shut down. I still love you!

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Publications

Jordan, Kari L., Pakzad, A., Oats, R., "Faculty and Student Perspectives on Internet-Based Engineering Education," Journal of Online Engineering Education, Vol. 2, No. 2, December 2011

Fields of Study

Major Field: Education: Teaching & Learning

Specialization: Engineering Education

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Chapter 1: Introduction

A degree in Science, Technology, Engineering, or Mathematics (STEM) allows students an open door to every major successful career opportunity known to man (Lent et al., 2005). Students majoring in STEM during their undergraduate tenure go on to pursue graduate school, medical school, law school, work for Fortune 500 companies and the government. Additionally, careers in STEM are proving especially profitable for high achieving underrepresented minority students according to an article in Research in Higher Education (Melguizo & Wolniak, 2012). Among the Gates Millennium Scholars sampled, scholars majoring in STEM fields earned starting salaries between $8,000 and $17,000 more per year compared with those majoring in the Social Sciences, Humanities, and Education. This career path would seem to be very attractive, yet the number of underrepresented minority students who major in and graduate from STEM fields is low. According to the National Science Foundation's Science Resources Statistics the number of Bachelor of Science degrees awarded in science and engineering in 1990 was 65,967 (10,130 of the graduates were women). Of those graduates there were 112 Native Americans, 2,173 African Americans, and 2,473 Hispanic students (NSF, 2009). A decade later, we see an increase: Native Americans accounted for 3,635 of the graduates, African Americans made up 3,635 graduates, and Hispanic Americans made up 6,063 of 79,528 total graduates (14,478 were women). However, there is still more work to be done.

Lack of Diversity in Engineering Degrees Awarded

The percentage of bachelor's degrees in engineering awarded to underrepresented minority students needs to increase dramatically to reach parity with their majority counterparts. While three key underrepresented minority (URM) groups, African Americans, Hispanic/Latinos, and Native Americans constitute some 30 percent of the overall undergraduate student population in the United States in general, the share of engineering degrees earned by members of these groups declines as degree level increases. Underrepresented minority students accounted for about 12% of engineering bachelor's degrees awarded in 2009, 7% master's degrees and 3% of doctorates (NSF Science Resource Statistics, 2009). The percent in engineering has been steadily decreasing, while overall participation in higher education among these groups has increased considerably. In 2007, the retention to graduation rate for underrepresented minority students in engineering was 37.8% compared to 46.1% for majority students, nationally (Marra and Bogue, 2006).

Table 1 illustrates the number of bachelor's degrees awarded in engineering in the United States (NSF, 2011). While the total number of bachelor's degrees has increased since 1990, the number of underrepresented minority students completing engineering degrees has remained stagnant. To address the engineering diversity gap, a considerable number of research projects are underway through organizations including the National Science Foundation (NSF) and the National Academy of Engineering (NAE).

		Sex		Race/ethnicity					
Year	All recipients	Female	Male	White	Asian American	African American	Hispanic American	Native American	Foreign national
1990	65,967	10,130	55,837	50,099	5,989	2,173	2,473	112	5,121
1991	63,986	10,016	53,970	48,028	6,305	2,304	2,663	146	4,540
1992	63,653	9,972	53,681	47,540	6,479	2,374	2,708	163	4,389
1993	65,001	10,453	54,548	47,976	6,764	2,637	2,845	175	4,604
1994	64,946	10,800	54,146	47,136	6,881	2,769	3,045	207	4,908
1995	64,749	11,303	53,446	46,264	7,056	2,897	3,409	230	4,893
1996	65,267	11,737	53,530	45,952	7,333	3,120	3,557	263	5,042
1997	65,091	12,160	52,931	44,976	7,625	3,203	4,005	265	5,017
1998	63,262	11,796	51,466	43,719	7,131	3,144	3,938	247	5,083
1999	62,500	12,360	50,140	42,650	7,226	3,171	4,073	328	5,052
2000	63,635	13,140	50,495	43,437	7,529	3,150	4,124	347	5,048
2001	65,195	13,195	52,000	44,407	8,340	3,182	4,152	275	4,839
2002	68,648	14,102	54,546	47,149	8,669	3,358	4,298	315	4,859
2003	75,031	15,114	59,917	51,297	9,705	3,429	4,652	388	5,560
2004	76,003	15,282	60,721	51,420	9,941	3,699	4,813	362	5,768
2005	76,003	14,868	61,135	51,302	10,033	3,756	4,890	378	5,644
2006	76,103	14,654	61,449	51,944	9,719	3,673	4,957	456	5,354
2007	75,823	14,101	61,722	51,911	9,466	3,735	5,133	426	5,152
2008	77,107	13,865	63,242	53,794	9,143	3,470	5,486	427	4,787
2009	75,320	13,432	61,888	52,850	8,743	3,392	5,488	328	4,519
2010	79,528	14,478	65,050	55,340	9,174	3,635	6,053	378	4,948

NOTES: These data differ from data collected by the National Center for Education Statistics (NCES) due to differences in population covered and taxonomy. The primary difference is that these data include some degrees that are counted as computer science by NCES. Race/ethnicity categories are those used in the survey's data collection.

SOURCE: Engineering Workforce Commission. 2011. *Engineering and Technology Degrees, 2010*. Washington, DC.

Table 1.1. Bachelor's degrees awarded in engineering by sex, race/ethnicity, and citizenship: 1990-2010

Diversity in engineering is extremely important, so important that the National Academy of Engineering (NAE) developed the NAE diversity program. Its mission is to "increase the diversity of the U.S. engineering workforce through developing a strong domestic talent pool." By convening stakeholders such as the American Indian Science and Engineering Society (AISES), Johns Hopkins University, and the Center for Advancing Science and Engineering Capacity, the NAE facilitates knowledge transfer, identifies undergraduate engineering program needs, and initiates actions to correct those needs.

The engineering diversity gap is caused by many socio-economic, historical, and even political factors; addressing the issue during a student's undergraduate tenure may actually be too late. Efforts such as Engineer Girl (http://www.engineergirl.org), a website dedicated to increasing young girls' interest in pursuing an engineering degree, address the lack of women studying engineering, but more efforts are needed.

Women are encouraged to pursue engineering careers in academia and industry because they have better career prospects in engineering than some other fields. Additionally, academia and industry can benefit from the perspectives of female employees. The National Science Foundation (NSF) created the ADVANCE program whose aim is to increase the participation and advancement of women in academic science and engineering careers. A joint program of the George Washington and Gallaudet Universities, "FORWARD to Professorship" (Focus on Reaching Women for Academics, Research and Development in Science, Engineering and Mathematics), prepares women in science, engineering, and mathematics fields for success. The goal of this program is to advance women, the deaf, and other underrepresented populations in STEM disciplines. This is accomplished through workshops, mentoring, and leadership development programs.

Universities across the country house Women in Engineering (WIE) programs. They often include summer programs to attract young girls to pursue engineering careers. Industry leaders offer employee resource groups for women engineers as well to provide support and improve retention. Despite these efforts the number of bachelor's degrees awarded to women in engineering pales in comparison to men.

Keeping those thoughts in mind it is important to examine the historical theories and frameworks that will help us not only understand why women and underrepresented minority students pursue and persist in engineering in low numbers, but to also develop interventions to improve the alarming statistics that hamper engineering diversity.

There are a number of reasons why underrepresented minorities do not persist or even consider pursuing STEM degrees. For example, in Eris et al. study (2010) these students were found to have low confidence in their math and science skills. Their research also showed that non-persisters were encouraged to study engineering by their parents, and not having found their own desire to pursue engineering, they transferred out of those majors. Additionally, students of low socio-economic status tend not to major in engineering (Ware and Lee, 1988).

In the author's opinion, students feel an engineering career is not as rewarding as becoming a doctor, lawyer, teacher or veterinarian. Do institution size (small, medium, large), type (predominantly white, HBCU, public, private), and setting (urban, suburban, rural) have an effect as well? Could it be that these students do not have role models in engineering fields to look up to for mentorship? Do underrepresented minority students know what an engineer is or does? Does the perception that engineering majors must be excellent in math and science deter students who do not have confidence in their mathematical and scientific abilities? Moreover, what if there are underrepresented minority students who do not grow up in an atmosphere where hands-on learning is encouraged? Would that cause them to pursue options outside of engineering?

One of many factors deterring underrepresented minority students from pursuing an engineering degree is that K-12 math and science programs across the country lack the resources in their schools needed to prepare students to study engineering (PCAST, 2010). This fact can be summed up by Bandura's sentiments: "diversity in social practices produces substantial individual differences in the capabilities that are cultivated and those that remain underdeveloped" (Bandura, 1989).

Math and science skills are underdeveloped in urban communities. This leads many underrepresented minority students to pursue careers outside of engineering. Addressing this issue should actually take place prior to a student's undergraduate career; when they arrive to the university it is almost too late for them to develop the skills they need to be successful—especially in engineering. If a student *has* made the decision to study engineering, however, understanding the challenges he/she faces and providing resources to ensure persistence from freshman year to graduation should be the focus of engineering educators.

Sociocultural influences such as gender roles and other events often influence a student's decision to pursue or not to pursue engineering (Vygotsky, 1978). Vygotsky asserts that higher order functions develop out of social interaction, and social interaction plays a fundamental role in the development of cognition. Additionally, the path a student takes to pursue higher education is determined by the "nature of societal opportunity structures" (Bandura, 1989). Simply put, people select activities associated with their acquired preferences and competencies. These ideals support Social Cognitive Theory (SCT) (Bandura, 1989) which suggests that we are neither driven solely by an inner force or by outside influences.

Why is this situation worth examining? To quote William A. Wulf, former president of the National Academy of Engineering, "Our profession is diminished and impoverished by a lack of diversity." The United States ranks in the mid-teens in science and math, and the inability to compete in engineering has the potential to be a growing problem, especially for underrepresented minority students (NSF, 1996). Gaps in race/ethnicity at entry and in completion of engineering programs indicate the United States' struggle to develop a diverse workforce (NRC, 1999, 2003). As indicated by our past two U.S. Presidents, there has been an increased discussion on the national and state level regarding the number of students entering engineering disciplines in general and underrepresented minority students in particular. Something happens between a student's freshman year and the point he/she decides to either switch majors or drop out of school altogether. Some researchers attribute the high dropout rate of underrepresented minority students in engineering to low engineering self-efficacy (e.g. Jordan et *al*., 2011).

Purpose of the Study and Research Questions

A student's engineering self-efficacy is his/her belief that he/she can successfully navigate the engineering curriculum and eventually become a practicing engineer. A student's engineering self-efficacy is formed by mastery experiences, vicarious experiences his/her physiological state, and social persuasions, especially student-professor interaction. Increasing the awareness of a student's engineering self-efficacy could potentially improve persistence and sense of belonging for underrepresented minority students in engineering.

Do underrepresented minority students feel included in their courses and labs? Do their expectations of what will happen upon graduating with an engineering degree change at some point? Are they experiencing positive interactions with their professors? These questions are in fact related to their engineering self-efficacy.

The hypothesis of this study was that an intervention during the first semester of an incoming freshman's tenure could help improve their engineering self-efficacy, sense of belonging, and overall retention in the engineering program. This study therefore explored the following research questions:

1. What are the differences in engineering self-efficacy, and sense of belonging for first-year underrepresented minority engineering students compared to majority students?
2. What factors or variables should be considered and/or addressed in designing an intervention to increase engineering self-efficacy and sense of belonging amongst first-year underrepresented minority engineering students?
3. Can a small intervention during the beginning of the first semester improve a student's sense of belonging, engineering self-efficacy, and student-professor interaction?

Significance of the Study

We are long overdue for meaningful interventions to tackle the persistence issues that underrepresented minority students face in engineering (Lent et al., 2005). Pre-collegiate factors including participation in robotics, playing video games, and programming as a hobby influence these persisters (Fantz et al., 2011), but more can be done at the collegiate level to ensure these students are supported throughout their tenure in the engineering program.

There are certainly benefits of interventions designed to build support for, and mitigate barriers to, students' preferred career paths. This study tests an intervention that is intended to increase underrepresented minority student's engineering self-efficacy and sense of belonging, which could ultimately improve persistence. The intervention is meant to be easily adaptable with insignificant cost, making it attractive for Minority

Engineering Program (MEP) and other success program whose aim is to increase students' engineering self-efficacy.

Glossary of Terms

The following list provides definitions of terms pertinent to this study.

Engineering Self-Efficacy: A person's belief that he/she can successfully navigate the engineering curriculum and eventually become a practicing engineer (Jordan et al., 2011).

Engineering Self-efficacy 1: Measures a student's ability to reach academic milestones focusing on courses (Chemistry, Calculus, and Physics) as barriers.

Engineering Self-efficacy 2: Measures a student's ability to reach academic milestones facing all undergraduate engineering majors.

Persistence: An individual's efforts to overcome opposition (Reber, 1985).

Predominantly White Institution (PWI): A college or university whose student population is predominantly White (The Chronicle of Higher Education, 2000).

Self-Efficacy: A person's belief that he or she is capable of taking action to achieve a certain goal, such as completion of a college degree (Bandura, 1989).

Underrepresented minority (URM): In this study underrepresented minority students include African Americans (non-Hispanic), Hispanic/Latino(a) Americans, and Native Americans.

Organization of the Dissertation

This dissertation is organized into five chapters. Chapter 1 introduces the research topic, purpose of the study and research questions, and its significance. Chapter 2 provides an overview of the theoretical framework upon which the study is grounded. Chapter 3 describes the method in which the study was carried out including sampling method and procedures. Chapter 4 provides data analysis for the project. Chapter 5 provides research implications and next steps for the research.

Chapter 2: Review of Literature

Social Cognitive Theory

To understand the effect of self-efficacy and sense of belonging one must understand Bandura's Social Cognitive Theory (Bandura, 1989). Social cognitive theory posits that people are not driven by inner forces or controlled by their environments. Rather, they motivate their own behavior and development (Bandura, 1989).

Sociocultural influences and other events often influence a child's decision to pursue or not to pursue engineering (Bandura, 1989). In addition, the path a student takes to pursue higher education is also determined by the "nature of societal opportunity structures" (Bandura, 1989). These ideals support Social Cognitive Theory, which suggests that we are neither driven solely by an inner force or by outside influences.

There are several issues addressed within the social cognitive theory framework that help to explain the lack of interest and persistence of underrepresented minority students in engineering. For example, women face gender-role development, or "sex typing". Research shows that parents flood their male child's rooms with educational materials, sporting goods, machines, etc., while the female child's room acquires domestic items, baby dolls, etc. (Bandura, 1989). How then will a girl have the opportunity to show interest in engineering?

To be an engineer it is said that one must possess superb mathematical skills. It is also said that one must do well with hands-on learning. Women and underrepresented minority students may not grow up in atmospheres where they have the opportunity to "tinker" with things to learn how they work; there are rarely opportunities to enhance their vicarious capabilities (learning through watching others). Also, many K-12 math and science programs across the country lack the resources needed to prepare students to study engineering (PCAST, 2010). These are examples of the many challenge underrepresented minority students face when considering pursuing an engineering degree. This fact can be summed up as noted by Bandura (1989): “diversity in social practices produces substantial individual differences in the capabilities that are cultivated and those that remain underdeveloped.”

Social Cognitive Career Theory

Expanding Social Cognitive Theory, Lent at al. (2003) developed the Social Cognitive Career Theory (SCCT) framework. SCCT envelopes several environmental, behavioral, and person variables that develop a person’s academic interest. This theory has been widely accepted in counseling psychology and engineering education research, and has been used as a way to help predict students’ academic interests and goals in engineering (Lent et al., 2005). SCCT has three overlapping models aimed at understanding how people:

1. Develop basic academic and career interest
2. Make and revise their educational and vocational plans, and
3. Achieve performances of varying quality in their chosen academic and career pursuits.

Within these models, self-efficacy (described later), outcome expectations, goals, and other factors such as gender, race, and barriers help shape a student’s career path. An example of a barrier would be negative contextual influences, or adverse learning conditions (Lent et al., 2005). These theories are somewhat foundational when understanding the constructs of self-regulation and self-efficacy.

Addressing engineering diversity issues should actually take place prior to a student's undergraduate career; once they step foot on a college campus it is almost too late for them to develop the skills they need to be successful in engineering. If a student has made the decision to study engineering, however, resources and strategies must be put in place to ensure successful matriculate and graduation in an engineering program. Strategies that have proven successful stem from the theory of self-regulation.

Theory of Self-Regulation

Outside influences help shape a student's decision to pursue engineering, but once a student is capable of being self-directed, self-demands serve as their motivator (Bandura, 1991). This describes the theory of self-regulation—"the capacity to exercise self-influence by personal challenge and evaluative reaction to one's own attainments" (Bandura, 1991). Self-regulation provides a key cognitive mechanism of motivation and self-directedness, which could potentially lead to improved persistence of underrepresented minority students in engineering.

Two influential studies lead to understanding student success and persistence in engineering by way of self-regulation. French et al. (2005) note several cognitive (high school rank, SAT scores, cumulative grade point average) and non-cognitive (academic motivation and institutional integration) variables that are related to students' persistence in engineering, with motivation being significantly related to persistence. Their research showed reliable improvement in persistence ($p < 0.05$) when motivation was included as a factor. Vogt et al. (2007) measured self-variables including academic self-confidence and self-efficacy, as well as other environmental and behavior variables to learn what influences a student’s academic achievement. They found that academic achievement was influenced by self-efficacy (*p* <= 0.01) and academic self-confidence (*p* <= 0.01).

The results of these studies lead to a common conclusion. Self-regulation is essential in the persistence of not only underrepresented minority students in engineering, but also all students. Self-regulation has also been found to result in improved student self-efficacy.

Self-Efficacy

Self-efficacy refers to a person’s belief that he/she is capable of taking action to achieve a certain goal, such as completion of a college degree. Self-efficacy is formed by a person’s mastery experiences (previous success leads a person to believe he/she is capable of completing a similar task), vicarious experiences (when a person sees someone else completing a task and believes he/she could do the same), social persuasions (supportive people in a person’s life such as teachers, family, or mentors), and physiological state (anxiety, etc.). Engineering self-efficacy is a person’s belief that he/she can successfully navigate the engineering curriculum and eventually become a practicing engineer. Increasing engineering self-efficacy in women and underrepresented minority students could improve retention of these students in engineering. The following is a synopsis of several relevant studies.

In a survey administered to more than one thousand first-year engineering students in Purdue University's Engineering Problem Solving and Computer Tools course self-efficacy beliefs were analyzed (Hutchinson et al., 2006). The following factors were found to be important in a student's ability to succeed in the course:

1. Understanding or learning the material

2. Drive or motivation toward success
3. Teaming issues
4. Computing abilities
5. The availability of help and ability to access it
6. Issues surrounding doing assignments
7. Student problem-solving abilities
8. Enjoyment, interest, and satisfaction associated with the course and its material
9. Grades earned in the course

Of these factors, understanding or learning the material was cited by over 70% of the female survey respondents. Nearly 40% of the female respondents found the availability of help and ability to access it to be important, whereas not even 20% of the male respondents found that factor to be important. The results of this study were examined in light of Bandura's social cognitive theory and sources of self-efficacy beliefs.

This study helps one understand differences in gender related to persistence in engineering. Next steps should include understanding these factors as they relate to underrepresented minority students, and developing interventions to address these issues. This is where the current research is directed.

Self-efficacy relates to self-regulation as shown in a study where 102 ninth and tenth graders from two high schools were assessed regarding their perceived self-efficacy (Sheppard et al., 2010). Two subscales (self-efficacy for self-regulated learning and self-efficacy for academic achievement) were selected. Although the questionnaire was not aimed at engineering per se (the students were questioned about their social studies class), the results are notable. The research showed that self-motivational factors make a large contribution to academic attainment. Factors stemming from students' self-regulation were what fueled and influenced their achievement. Because of their belief in their efficacy for self-regulated learning, they showed improved self-efficacy for academic achievement, influencing their academic goals and overall achievement. These findings were true with underrepresented minority engineering students as well.

Upon uncovering factors influencing achievement, the current study addresses developing a research-based intervention to be implemented during the student's first semester to include these factors.

Measuring Engineering Self-Efficacy

This study utilizes three instruments to measure engineering self-efficacy and sense of belonging: The Longitudinal Assessment of Engineering Self-Efficacy (LAESE), the Academic Pathways of People Learning Engineering Survey (APPLES), and the Student-Professor Interaction scale. The following is a review of literature pertaining to each instrument.

The Longitudinal Assessment of Engineering Self-Efficacy (LAESE)

The current study measures engineering self-efficacy using the LAESE. The LAESE instrument was created, tested, and validated to measure self-efficacy, inclusion, and outcome expectations (Marra and Bogue, 2006). The following list provides a summary of the subscales measured by the LAESE instrument:

- Engineering career success expectations (7 items)
- Engineering self-efficacy (8 items)
- Feeling of inclusion (4 items)
- Coping self-efficacy (6 items)

- Math outcome expectations (3 items)

The questions related to each subscale were designed to identify support and barriers engineering students encounter while pursuing their degree, which ultimately determines their engineering self-efficacy. The expected outcome would be to see an increase in subscale averages as a student progresses through his/her academic tenure, indicating engineering self-efficacy, feeling of inclusion, etc., increases as they progress through their major.

Applying the LAESE

In their cross-sectional study of first-year engineering majors, Concannon and Barrow (2008) used the Longitudinal Assessment of Engineering Self-efficacy (LAESE) to survey 253 first-year engineering majors enrolled in an engineering course (211 men, 42 women) at a large Midwestern research extensive university. Their intent was to analyze differences in engineering self-efficacy by major, gender, ethnicity, participation in Freshman Interest Groups (FIGs), and participation in undergraduate engineering organizations. The dependent variables in the study were engineering self-efficacy, engineering career outcome expectations, and coping self-efficacy. Using a two-factor experiment with repeated measures for engineering self-efficacy, a multiple analysis of variance was used to determine differences among self-efficacy subscale scores and whether there were interactions. Results showed that freshmen men had statistically higher coping self-efficacy and engineering career outcome expectations than freshmen women. There were no statistically significant differences between freshmen involved with FIGs and those who were not, however, when women were separated from the sample it showed that women involved with FIGs had statistically significant higher engineering career outcome expectations than women who were not. Freshmen involved with undergraduate engineering organizations had statistically significant higher engineering career outcome expectations.

Concannon and Barrow (2010) used four of the six subscales in the LAESE to measure engineering self-efficacy, engineering career outcome expectations, and coping self-efficacy. The purpose of this study was to analyze undergraduate engineering majors' intentions to persist in their engineering program. They performed this analysis using the multiple analysis of variance technique to determine whether the sociocognitive predictors for persisting in engineering for women differ from those of men. Their sample consisted of 493 students (424 men and 69 women) at a Midwestern institution.

To determine whether engineering self-efficacy (1 and 2), coping self-efficacy, and engineering career outcome expectations predicted women's and men's persistence in engineering, multiple regression analysis was applied to the survey data. Results showed that engineering self-efficacy 1 and engineering career outcome expectations significantly predicted women's persistence in engineering. For men, engineering self-efficacy 2 and engineering career outcome expectations were significant predictors of men's persistence in engineering. Engineering self-efficacy 1 measures a student's ability to reach academic milestones focusing on courses (Chemistry, Calculus, Physics) as barriers. Engineering self-efficacy 2 measures a student's ability to reach academic milestones facing all undergraduate engineering majors. This tells us that, for this sample, mastering coursework (earning an A or B) is the most significant predictor for women's persistence in engineering, and completing coursework (not necessarily obtaining an A or B—merely completing the course) is the most significant predictor for men's persistence in engineering. For both men and women, persistence depends upon a student's career expectations.

In their comparison of women and men's engineering self-efficacy beliefs across grade levels, Concannon and Barrow (2012) surveyed 746 engineering students (635 men, 111 women) at a large research extensive university. Their goal was to identify statistically significant differences in engineering self-efficacy beliefs among first- through fifth-year engineering students (male compared with female). Using a repeated measures ANOVA the authors identified four variables: engineering self-efficacy 1, engineering self-efficacy 2, engineering career outcome expectations, and coping self-efficacy. These variables were used to measure whether mean differences in engineering self-efficacy (1 and 2) occur by year, gender, and year x gender. Using the LAESE (Marra and Bogue, 2006), differences in engineering self-efficacy were found by year. Fifth-year engineering students had significantly lower engineering self-efficacy than second-, third-, and fourth-year students. Significant interactions between year in school and all four subscales were found. A reanalysis was performed excluding fifth-year students, and significant differences in engineering self-efficacy 2 were found. First year students had significantly lower scores for engineering self-efficacy 2 compared to second-, third-, and fourth-year students. Lastly, the results showed that freshmen men had significantly higher engineering career outcome expectations compared to upper-class women.

The Academic Pathways of People Learning Engineering Survey (APPLES)

The Academic Pathways of People Learning Engineering Survey (APPLES) is an instrument that was developed by the Center for the Advancement of Engineering

Education at the University of Washington. It is one of many research tools developed by the Academic Pathways Study (Sheppard et al. 2010). The goal of using the instrument is to understand how students learn about engineering, what motivates students to study engineering, how confident they are in their choice of major, and what their post-graduation plans look like (Sheppard et al., 2010).

The APPLES instrument measures the following categories:

- Skills
    - Confidence in math and science skills
    - Confidence in professional and interpersonal skills
    - Confidence in solving open-ended problems
    - Perceived importance of math and science skills
    - Perceived importance of professional and interpersonal skills
- Motivation
    - Financial
    - Parental Influence
    - Social Good
    - Mentor Influence
    - Extracurricular Fulfillment
    - Intrinsic Motivation (Psychological)
    - Intrinsic Motivation (Behavioral)
- Education
    - Academic Persistence
    - Curriculum Overload

    - Financial Difficulties
    - Academic Disengagement (Liberal Arts Courses)
    - Academic Disengagement (Engineering)
    - Frequency of Interaction with Instructors
    - Satisfaction with Instructors
    - Overall Satisfaction with Collegiate Experience
    - Exposure to Project-Based Learning Methods (Group & Individual Projects)
    - Exposure to Project-Based Learning Methods (Group & Individual Projects)
- Workplace
    - Professional Persistence
    - Knowledge of the Engineering Profession

Applying the APPLES

In their first administration of the APPLES instrument, Sheppard et al. (2010) sampled over 900 students at four institutions. In their second administration of the APPLES instrument, Sheppard et al. (2010) sampled 4,266 students across 21 universities. Students were offered $4 to participate. In terms of demographics, women represented 35.8% of the first-year engineering student population, and underrepresented minority students (defined as Black/African American; Hispanic/Latino/a; American Indian/Alaska Native; and Native Hawaiian/Pacific Islander) comprised 19%. In their comparison of men versus women, women reported more frequent involvement in engineering extra-curricular activities than men. They also reported more frequent curricular overload and greater pressure to balance their social lives and academics. Lastly, women reported professional and interpersonal skills as being more important.

In terms of underrepresented minority students the authors made comparisons by gender. Underrepresented men were more psychologically motivated to study engineering than their majority. There were no other significant differences found.

In effort to improve retention, Eris et al. (2010) used the APPLES instrument to understand why students leave engineering. The instrument was administered to a cohort of 160 students (61% male, 39% female). Thirty-five percent of the students were underrepresented in engineering. Their small sample size did not allow extensive generalization, however, significant implications were observed. For example, their findings indicated that non-persisters' intentions to pursue engineering as a major decrease over time, and the decline begins a minimum of two semesters before they change their major.

The APPLES instrument has also been used to predict students' graduate school plans (Ro, 2011), and explore gender diversity in engineering (Knight et al., 2012).

The Student-Professor Interaction Scale

Cokley et al. (2004) developed the Student-Professor Interaction Scale to examine student-faculty interactions in terms of academic motivation, academic self-concept, and academic achievement. Steps taken to develop their scale included defining the constructs, identifying content, generating items, conducting a pilot study, refining the scale, item analysis, and validating the instrument. The results of the study indicated that there are 9 factors representing student-professor interaction:

1. Respectful interaction

2. Career guidance
3. Approachability
4. Validity
5. Caring attitude
6. Off campus interactions
7. Connectedness
8. Accessibility
9. Negative experiences

These studies provide support for the use of these instruments in the current study.

There have been several studies aimed at improving retention of first-year underrepresented minority engineering students. For example, Gregerman et al. (1998) evaluated the impact of a student-faculty research partnership. Their study targeted first- and second-year students, and findings showed that research partnerships were effective in retaining at-risk students, especially African Americans and students with low grade point averages.

Knight et al. (2007), found that hands-on, team based design projects during a student's first-year in the engineering program have the potential to improve retention. The authors measured engineering program retention at the third, fifth and seventh semesters for all students participating in the study. Results showed that those students participating in hands-on, team based design projects were retained at a significantly higher level into the third, fifth and seventh semesters ($p < .05$).

Waller (2009) used a mixed methods approach to investigate Summer Bridge Programs (SBP) for underrepresented minority engineering students in terms of the program’s strengths and weaknesses. The study called for program administrators to assess SBP outcomes to ensure support structures are in place for the enhancement of retention and graduation rates of at-risk students. The next chapter discusses the research design and methodology.

CHAPTER 3: Methodology

Introduction

An intervention used to mitigate doubts about students' sense of belonging [in engineering] could raise their academic achievement and improve retention, as observed in Walton and Cohen's (2007) study of race, social fit, and achievement. Their study housed two experiments, one of which "tested an intervention aimed at mitigating belonging uncertainty" (Walton and Cohen, 2007). The aim of the intervention was to normalize doubts about academic uncertainty to improve the academic motivation and achievement of first-year underrepresented minority students in computer science. During the intervention these students (18 Black, 19 White) were told that their doubts about belonging in school were not unique to their racial group, and that these doubts would decrease over time. The information was presented to the students in the form of survey results from upper-class students showing that all students, regardless of race, worried during their first year of school about whether they were accepted. As a result of the intervention, "Black students' sense of fit against academic adversity improved their achievement", their engagement in achievement behaviors (i.e. attending professors office hours) increased, and their grade point averages improved (Walton and Cohen, 2007). The aforementioned approach was used as a model for the current study's intervention.

Purpose of the Study

The purpose of this study was to assess engineering self-efficacy of underrepresented minority first-year engineering students, determine what variables to consider when developing an intervention to improve their engineering self-efficacy, and determine whether a small intervention will improve their engineering self-efficacy and sense of belonging in engineering. The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) instrument, Academic Pathways of People Learning Engineering Survey (APPLES), and Student-Professor Interaction Scale will be used for this study. The following questions were addressed in this research.

1. What are the differences in engineering self-efficacy and sense of belonging for underrepresented minority engineering students (across academic levels) compared to majority (White) students?
2. What factors or variables should be considered and/or addressed in designing an intervention to increase engineering self-efficacy amongst first-year underrepresented minority engineering students?
3. Can a small intervention during the beginning of the first semester improve a student's sense of belonging, engineering self-efficacy, and student-professor interaction?

This chapter provides a description of the research design and methodology used to address these research questions, including sample/sampling method, instruments used, and data collection procedures.

Research Design

This study featured a quantitative research design. A summary of the proposed approach and how the approach aligns with each research question is provided in Table 3.1. The institutions participating in the study were Michigan Technological University (Michigan Tech), New Jersey Institute of Technology (NJIT), Virginia Polytechnic Institute and State University (Virginia Tech), and The Ohio State University (OSU). These sites were selected based on their engineering program ranking and underrepresented minority student population in engineering. Additionally, the author had working relationships with faculty and staff at each institution. Having had personnel at each site was beneficial because these faculty and staff members had relationships with the students, which helped when recruiting participants for the study.

Research Question	**Participants/Location**	**Instruments/Method**	**Data Analysis**
RQ1	1043 students (freshmen through seniors) Michigan Tech, Virginia Tech and NJIT	LAESE, APPLES Demographic Data	2 (ethnicity) X 4 (class standing) ANOVA
RQ2	394 students (freshmen through seniors) Michigan Tech, NJIT, Virginia Tech	LAESE, APPLES	Means Independent groups t-tests
RQ3	406 students (freshmen) NJIT, Virginia Tech, The Ohio State	LAESE, Student Professor Interaction Scale	Means Independent groups t-tests (from pre and post tests

Table 3.1: Summary of research questions aligned with methods and data analysis

Summary of Data Collection Methods

The following is a synopsis of each research phase and the method used to answer each research question.

Phase One

- Requested permission for and obtain copies of instruments.
- Revised instruments as needed to fit needs of current study.
- Administered instruments to underrepresented minority students in engineering at each institution for baseline data.
- Administered instruments to a randomly selected sample of majority (White) engineering students for baseline comparison data.
- Analyzed data and revise instruments accordingly.
- Developed video footage of upper-class students at Michigan Tech for pilot intervention (treatment) and control videos.

Phase Two

- Pilot tested the intervention at Michigan Tech, Ohio State, and NJIT with underrepresented minority engineering students.
- Conducted near-term post assessment of those who participate in both conditions of the intervention.
- Analyzed data and make appropriate modifications for intervention strategy.
- Developed video footage of upper-class students at Virginia Tech, NJIT, and OSU for treatment and control videos.
- Edited and developed site-specific intervention videos.

- Conducted second intervention study at OSU and NJIT.

Phase Three

- Conducted revised intervention at Virginia Tech and OSU during the summer and/or first 4 weeks of the semester.
- Conducted post assessment of those who participate in both conditions of the intervention.
- Completed data analysis and dissertation preparation for dissemination of results

The following is a detailed description of each proposed phase including sampling method and procedures. For this research project, approval was obtained from the Institutional Review Board (IRB) at The Ohio State University (Appendix C). Data for the project was housed in a locked file in the author's office.

Phase One

To analyze differences in engineering self-efficacy and sense of belonging for underrepresented minority engineering students across academic levels compared to majority (White) students the LAESE and APPLES instruments were used. The researcher received permission to utilize both assessment tools from the instrument developers.

The LAESE and APPLES instruments were combined and revised into an 86-item survey. The LAESE instrument was created, tested, and validated to measure self-efficacy, inclusion, and outcome expectations (Marra and Bogue, 2006). The APPLES instrument measures how students studying engineering experience their education, gain knowledge of what engineering is, and what their plans after graduation are (Sheppard et al., 2010).

Figure 3.1 shows a summary of the subscales measured by the LAESE instrument (Appendix E). The questions related to each subscale were designed to identify the supports and barriers that engineering students encounter while pursuing an engineering degree, which ultimately determines their engineering self-efficacy. The expected outcome would be to see an increase in subscale averages as a student progresses through his/her academic tenure, indicating engineering self-efficacy, feeling of inclusion, etc., increases as they progress through their major.

LAESE Subscales

1. Engineering career success expectations (7 items)
2. Engineering self-efficacy (8 items)
3. Feeling of inclusion (4 items)
4. Coping self-efficacy (6 items)
5. Math outcome expectations (3 items)

Figure 3.1: LAESE subscales

Of the 16 variables used in the original APPLES instrument to measure the factors influencing students' intentions to persist in engineering, 11 were identified as factors related to engineering self-efficacy. A summary of these items is shown in Figure 3.2.

APPLES Subscales

1. Motivation (Social Good) (3 items, alpha = 0.77)
2. Motivation (Financial) (3 items)
3. Motivation (Parental Influence) (2 items)
4. Motivation (Mentor Influence) (3 items)
5. Motivation (Intrinsic, Psychological) (3 items)
6. Motivation (Intrinsic, Behavioral) (2 items)
7. Confidence in Math and Science Skills (3 items)
8. Confidence in Professional and Interpersonal Skills (6 items)
9. Confidence in Solving Open-ended Problems (3 items)
10. Academic Disengagement (Liberal Arts Courses) (4 items)
11. Academic Disengagement (Engineering-related Courses) (4 items)

Figure 3.2: APPLES subscales

These subscales were used to determine what factors to consider when designing an intervention to improve sense of belonging and engineering self-efficacy.

Several avenues were taken to gather a pool of students to sample at Michigan Tech. The survey was administered to classrooms across the first year engineering program and upper level engineering courses across several majors within the college of engineering. These classes included but were not limited to Calculus II, Engineering Economics, Mechanical Engineering Laboratory, Circuits & Instrumentation, Introduction to Spatial Visualization, Chemical Engineering Fundamentals, Environmental Engineering Fundamentals and Introduction to Materials Science & Engineering. Students were given time to read the consent form (Appendix D) and were made aware that their participation was voluntary.

Some of the underrepresented minority students were not reached by surveying these courses. In order to attract more students a separate event was held on a Saturday. Minority students were asked to come to one of the dining halls on campus to have lunch and take the survey. Another opportunity for students to participate was held at the university library. It was impossible to survey 100% of the underrepresented minority students on campus, but the sample collected suited the needs of this research phase.

For data collection at Virginia Tech and NJIT, the author's advisor visited both institutions. An e-mail (Appendix A) was sent to all first-year underrepresented minority students asking that they attend a session where they would take a written survey via Scantron coding sheets.

The purpose of the research and procedures for opting out if they desired was explained at all three institutions. Additionally, each student who participated signed a consent form.

To develop treatment and control video footage for the pilot intervention at Michigan Tech the author developed the following protocol:

> Upper-class students selected to be filmed were given the following statement:
>
> We are trying to create a compelling video that will increase incoming student's sense of belonging, and increase their confidence in their ability to be successful in their major and their career. The questions we will ask you are related to these things – sense of belonging and self-confidence. Please speak of your experiences honestly, but be as positive as possible. We will start with asking you about when you may have questioned whether you belonged, or questioned your ability to be successful. Then we will focus on academic or social behaviors that helped you to cope, realize you belonged, or increased your confidence. In the end, we hope the video shows new students that it is perfectly normal to question whether they "belong", and for experiences to lower their confidence – but give them ideas for how to use those experiences to increase confidence and sense of belonging.

The treatment video addressed issues of belonging in the engineering program. The control video focused on extracurricular activities for students. The questions asked during the filming of each video are found in Table 3.2.

Treatment Video Questions
How did you feel when you first stepped foot on Michigan Tech's campus?
What types of friends have you met since your freshman year?
Why did you choose your major?
Describe your favorite faculty member. What do you like about him/her?
Have you ever done badly on a test? What do you do to cope with doing badly on a test?
Talk about friends you've made from different backgrounds/values.
Have you ever been the only person of your race or gender in your classes? Share your experience.
Control Video Questions
What extracurricular activities are you involved in on Michigan Tech's campus?
What types of friends have you met in your extracurricular activities
Why did you choose the clubs you're involved in?
Talk about friends you've made from different backgrounds in the clubs you're involved in.

Table 3.2: Treatment and control video questions

Michigan Tech's media department with the help of the author edited footage from the videos, and two videos (one treatment, one control) were developed.

Phase Two

Several adjustments were made to the research protocol in phase two:

- The order of the interview comments was rearranged such that the problem is brought to the front, and the social and academic strategies/advice, as well as coping mechanisms for environment follow.
- Aspects of engineering self-efficacy were added to the treatment video.

- Names of professors and dates were not included in the videos; however, students' first names along with their level (and engineering major) appeared in the video.
- Only engineering majors were included in the videos.
- Interviewees were provided with a survey to complete prior to the interview that provides questions they will be asked such that they can better prepare for the interview and make sure they address particular points.
- The control group video was replaced with a TED Talk about creativity in the educational system.
- Although the study initially considered both the APPLES and LAESE, it was determined that the LAESE provided the needed measures; hence the APPLES was removed from the study.
- The math outcome expectations and engineering career success expectation subscale items were removed from the instrument and the Student-Professor Interaction Scale was added.

Per the adjustments above, the interview prompts were revised as follows:

1. Introduce yourself (first name), tell us your major and year in school
2. Tell us a little about yourself. Where are you from?
3. Why did you choose your major?
4. Has your family always supported your decision to attend college, or your major? Is it important to them?
5. Talk about your experience when you first arrived to campus.
    a. Did you ever question your choice of major?

b. Did you ever question whether you could be successful in your major or career? (Lose confidence)?
c. Have you ever felt like you were the only one like you in your class? Share your experience.
d. Or: Have you ever felt alone in your classes? Share your experience

6. Have you ever done badly on a test? What do you do to cope with doing badly on a test?
7. What are some academic or social activities or behaviors you adopted to feel included (enhance your sense of belonging) on campus or in your major?
8. Without giving us the person's name, describe your favorite faculty member or another advocate on campus. What do you like about him/her?
9. Talk about friends you've made from different backgrounds/values.
10. What are specific behaviors that you engaged in that enhanced your confidence in your ability to be successful? (Scheduling meetings with faculty, seeking help when you need it, methods of coping with difficulties)
11. If you could tell incoming engineering students one thing to encourage them what would that be?

Using the prompts above, interviews of upper-class engineering students were conducted at OSU, Virginia Tech and NJIT. The author edited all of the videos using a MacBook Pro and Apple's iMovie software. One treatment video was developed for each institution.

The researcher conducted revised interventions at OSU and NJIT. Virginia Tech was not included in this phase due to low participant recruitment. At OSU an e-mail was sent to all first-year underrepresented minority engineering students inviting them to participate in the research study. Students were given the opportunity to sign up for a time where they would come to a conference room, take the pre-assessment via Scantron coding sheets, and watch either the treatment video or the TED Talk. They received a $15 gift card to Target as an incentive for their participation. Several weeks later the students were asked to come back to complete the post-assessment. At NJIT, the same procedure was conducted, however the students were not offered monetary incentives.

Phase Three

During the fall 2013 semester, the final attempt to implement the research protocol was conducted at Virginia Tech and OSU. At OSU, 8 sections of the first-year engineering program course ENGR1181 participated in the study. The revised LAESE and Student Professor Interaction Scale instrument was uploaded to an online software called Qualtrics, and a link to the assessment will be placed on the ENGR1181 course website. The survey opened for students to take on their own time between August 26th and September 4th.

Three sections of the ENGR1181 were selected at random watch the treatment video. The other 5 sections did not watch a video (so as to eliminate potential confounding variables).

The post-assessment (via the same survey link used to take the pre-assessment) opened October 7th through October 11th for all of the students to take, and a comparison of scores for those who watched the video and those who did not watch the video was completed by the author.

At Virginia Tech, students who participated in STEP (Student Transition Engineering Program) participated in the intervention. These students took the LAESE and Student Professor Interaction Scale instrument via Scantron coding sheets during their orientation. Half of the participants were randomly selected to watch the intervention video developed specifically for Virginia Tech. After 5 weeks, all of the students took the post-assessment via the Qualtrics web survey link.

The following chapter provides data analysis and results for the study.

Chapter 4: Results of the Study

Introduction

This chapter provides analysis and interpretation of data collected from a three-phase research study designed to assess engineering self-efficacy of underrepresented minority first-year engineering students. The study aimed to determine what variables to consider when developing an intervention to improve engineering self-efficacy, and determine whether a small intervention would improve sense of belonging in engineering, and ultimately retention.

Research Design

This study utilized a quantitative research design. The research was completed in three phases such that information in the first phase would inform the work completed in the second phase, and so on.

For the first phase the researcher used demographic data and the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) to determine the differences in engineering self-efficacy and sense of belonging for underrepresented minority engineering students across academic levels (freshman through senior) compared to majority (White) students. Three institutions participated in this phase: Michigan Tech, Virginia Tech, and NJIT.

For the second phase the researcher used the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) and Academic Pathways of People Studying Engineering Survey (APPLES) to determine what factors or variables to consider when designing an intervention to improve sense of belonging of first-year engineering students. The researcher also interviewed upper-class engineering students from diverse backgrounds to create a pilot intervention. The three institutions that participated in phase one also participated in phase two of the study.

For the third phase of the study the researcher used the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) and Student-Professor Interaction Scale to determine whether a small intervention implemented during the first semester can improve a student's engineering self-efficacy, sense of belonging, and student-professor interaction. Three institutions participated in this phase of the study: OSU, NJIT, and Virginia Tech.

Quantitative Findings: Phase 1

Introduction

During the fall 2010 semester several avenues were taken to gather a pool of students to sample for the first phase of the research. The LAESE and APPLES instruments were combined and revised into an 86-item survey that would serve the needs of this research phase. The LAESE instrument was created, tested, and validated to measure self-efficacy, inclusion, and outcome expectations (Marra and Bogue, 2006). A summary of the subscales (Appendix B) measured by the LAESE instrument is as follows:

1. Engineering career success expectations (7 items)
2. Engineering self-efficacy (8 items)
3. Feeling of inclusion/Sense of belonging (4 items)
4. Coping self-efficacy (6 items)

5. Math outcome expectations (3 items)

The questions related to each subscale were designed to identify the supports and barriers that engineering students encounter while pursuing an engineering degree, which ultimately determines their engineering self-efficacy. The expected outcome would be to see an increase in subscale averages as a student progresses through his/her academic tenure, indicating their engineering self-efficacy, feeling of inclusion, etc., increases as they progress through their major.

The APPLES instrument measures how students studying engineering experience their education, gain knowledge of what engineering is, and what their plans after graduation are (Sheppard et al., 2010). Of the 16 variables used in the original APPLES instrument to measure the factors influencing students' intentions to persist in engineering, 11 were identified as factors related to engineering self-efficacy. A summary of these items is shown below:

1. Motivation (Social Good) (3 items)
2. Motivation (Financial) (3 items)
3. Motivation (Parental Influence) (2 items)
4. Motivation (Mentor Influence) (3 items)
5. Motivation (Intrinsic, Psychological) (3 items)
6. Motivation (Intrinsic, Behavioral) (2 items)
7. Confidence in Math and Science Skills (3 items)
8. Confidence in Professional and Interpersonal Skills (6 items)
9. Confidence in Solving Open-ended Problems (3 items)
10. Academic Disengagement (Liberal Arts Courses) (4 items)

11. Academic Disengagement (Engineering-related Courses) (4 items)

These subscales were used to determine what variables to consider when developing an intervention to improve engineering self-efficacy of first-year underrepresented minority students.

For the current study, the survey was administered to classrooms across the first year engineering program and upper level engineering courses across several majors within the college of engineering during the Fall 2010 semester at Michigan Technological University. These classes included but were not limited to Calculus II, Engineering Economics, Mechanical Engineering Laboratory, Circuits & Instrumentation, Introduction to Spatial Visualization, Chemical Engineering Fundamentals, Environmental Engineering Fundamentals and Introduction to Materials Science & Engineering. Table 4.1 provides demographic data for the sample. The number of survey respondents was 1101. In terms of gender, 74.1% of the participants were male, and 25.9% of the participants were female. White respondents made up nearly half of the participants, while underrepresented minority students (African American, Native American, Hispanic/Latino(a)) combined made up about a third of the respondents. For the purposes of this research, Asian Americans are not considered underrepresented in engineering.

A variety of intended majors of study were represented in the sample. Chemical engineering students represented 20% of the population, while Mechanical and Civil engineering made up 13.7% and 11.3%, respectively. Students who had not decided their major made up 20% of the population.

In terms of institution, the Michigan Technological University respondents represent 38.8% of the population, the Virginia Tech respondents made up 14.4%, and NJIT respondents made up 46.8%.

Gender	**n**	**%**
Male	819	74.4
Female	282	25.6
Ethnicity/Citizenship	**n**	**%**
African American/Black	150	13.6
American Indian/Alaskan Native	18	1.6
Asian & Pacific American	141	12.8
Latino(a)/Hispanic American	196	17.8
Caucasian American	538	48.9
Foreign National on student visa	27	2.5
Foreign National/U.S. Resident (green card)	31	2.8
Major	**n**	**%**
Bachelor of Science in Engineering	42	3.8
Biomedical Engineering	106	9.6
Chemical Engineering	219	19.9
Civil Engineering	124	11.3
Computer Engineering	93	8.4
Electrical Engineering	77	7.0
Environmental Engineering	40	3.6

Table 4.1: Demographic Data (continued)

Table 4.1 continued

Materials Science & Engineering	26	2.4
Mechanical Engineering	151	13.7
Undecided	223	20.3
Institution	**n**	**%**
Michigan Tech	427	38.8
Virginia Tech	159	14.4
NJIT	515	46.8

Before further data analysis took place underrepresented minority students (African American, Native American, Hispanic/Latino(a)) were combined into one variable (underrepresented minority-***URM)***, and foreign students were removed from the sample. Thus, the sample size moving forward is as shown in Table 4.2.

Ethnicity	**n**	**%**
URM	364	34.9
White	538	51.6

Table 4.2: Final sample size

Table 4.3 provides a t-test comparing underrepresented minority students and white students for each of the LAESE subscales to answer the following research question: What are the differences in engineering self-efficacy and sense of belonging for underrepresented minority engineering students (across academic levels) compared to majority (White) students? Significance levels (p-values) less than 0.05 are considered significant.

LAESE Subscale	**URM**	**White**	**t(df)**	**Sig.**
Coping Self-Efficacy	5.70	5.70	0.03 (884)	0.98
Math Self-Efficacy	5.69	5.51	2.45 (886)	0.02
Inclusion/Sense of Belonging	4.80	5.23	-5.82 (892)	0.00
Engineering Self-Efficacy 1	5.46	5.42	0.66 (891)	0.51
Engineering Self-Efficacy 2	5.72	5.79	-1.08 (890)	0.28
Engineering Career Success Expectations	5.88	5.84	0.83 (894)	0.41

Table 4.3: T-Test for Underrepresented Minority (URM) students vs. White students (all institutions)

The data shows a significant difference between underrepresented minority students and whites for the math self-efficacy and inclusion/sense of belonging subscales (p = 0.015 and 0.000, respectively). To gain better understanding of these differences we now compare these students by their academic level (freshman through senior). Table 4.4 provides the analysis of variance (ANOVA) table. Significant differences were found for coping self-efficacy, math self-efficacy, and inclusion/sense of belonging.

In terms of inclusion/sense of belonging all underrepresented minority students, regardless of year in school, had lower inclusion/sense of belonging than white students.

LAESE Subscale	SS	df	MS	F	Sig.
Coping Self-Efficacy					
Between Groups	17.65	2	8.823	12.5	0.00
Within Groups	721.82	1022	0.71		
Total	739.48	2024			
Math Self-Efficacy					
Between Groups	8.76	2	4.38	4.06	0.018
Within Groups	1105.5	1024	1.08		
Total	1114.26	1026			
Inclusion/Sense of Belonging					
Between Groups					
Within Groups	50.29	2	25.15	20.87	0.00
Total	1241.37	1030	1.21		
	1291.67	1032			

Table 4.4: ANOVA Table for Underrepresented Minority (URM) students vs. White students (all institutions) by year in school

Each institution was examined separately to gain a better understanding of variation across the three institutions. Table 4.5 provides a t-test of each LAESE subscale comparing underrepresented minority students with white students at Michigan Tech.

LAESE Subscale	URM (n = 56)	Whites (n=344)	t(df)	Sig.
Coping Self-Efficacy	5.90	5.69	1.19 (396)	0.23
Math Self-Efficacy	5.59	5.56	0.12 (398)	0.91
Inclusion/Sense of Belonging	4.93	5.23	-2.03 (400)	0.04
Engineering Self-Efficacy 1	5.60	5.29	1.88 (400)	0.06
Engineering Self-Efficacy 2	5.63	5.70	-0.65 (399)	0.52

Table 4.5: T-Test for Underrepresented Minority (URM) students vs. Whites (Michigan Tech) (continued)

Table 4.5 continued

Engineering Career Success Expectations	5.81	5.78	0.19 (400)	0.85

Underrepresented minority students' sense of belonging was significantly lower than white students (p = 0.04). Additionally, one could say that white students engineering self-efficacy 1 (p = 0.06) had a score approaching significantly lower than underrepresented minority students. As a reminder, engineering self-efficacy 1 measures a student's ability to reach academic milestones focusing on courses (Chemistry, Calculus, Physics) as barriers.

As shown in Table 4.6, underrepresented minority students feeling of inclusion/sense of belonging drops continually from Freshman to Junior year. It is worth mentioning that the highest score for the Likert items is 7, so the means for all students suggest their feeling of inclusion/sense of belonging could be improved.

	Freshman URM	**Freshman White**	**Sophomore URM**	**Sophomore White**	**Junior URM**	**Junior White**	**Senior URM**	**Senior White**
Inclusion	5.39	5.19	4.83	5.27	4.50	5.21	5.09	5.29

Table 4.6: Means of Underrepresented minority (URM) students Inclusion vs. Whites (Michigan Tech)

Table 4.7 provides a one-way analysis of variance (ANOVA) by year in school for Michigan Tech. Significant differences were found for the math self-efficacy subscale ($p < 0.01$).

LAESE Subscale	F	Sig.
Coping Self-Efficacy	0.98	0.42
Math Self-Efficacy	3.71	0.01
Inclusion/Sense of Belonging	0.48	0.75
Engineering Self-Efficacy 1	1.72	0.15
Engineering Self-Efficacy 2	1.78	0.13
Engineering Career Success Expectations	1.38	0.24

Table 4.7 One-Way ANOVA by Year in School (Michigan Tech)

From Table 4.8 one notices that as students progress by year in school from Freshman to Junior their math self-efficacy decreases. Additionally, math self-efficacy for underrepresented minority students is lower than for white students.

	Freshman URM	Freshman White	Sophomore URM	Sophomore White	Junior URM	Junior White	Senior URM	Senior White
Math SE	6.11	5.93	6.00	5.53	5.13	5.21	4.95	4.90

Table 4.8: Means of Math Self-Efficacy by Year in School and Ethnicity (Michigan Tech)

Turning our attention to Virginia Tech, Table 4.9 provides t-tests for each LAESE subscale comparing underrepresented minority students with white students. Significant differences were found for feeling of inclusion/sense of belonging ($p < 0.01$) and engineering career success expectations ($p = 0.03$).

LAESE Subscale	**URM (n = 48)**	**White (n ~ 96)**	**t(df)**	**Sig.**
Coping Self-Efficacy	5.71	6.09	-1.68 (142)	0.09
Math Self-Efficacy	5.45	5.67	-1.31 (142)	0.19
Inclusion/Sense of Belonging	4.78	5.56	-4.27 (142)	< 0.01
Engineering Self-Efficacy 1	5.62	5.79	-0.50 (142)	0.62
Engineering Self-Efficacy 2	5.76	6.01	-1.73 (142)	0.09
Engineering Career Success Expectations	5.89	6.17	-2.21 (142)	0.03

Table 4.9: T-Test for Underrepresented Minority (URM) students vs. Whites (Virginia Tech)

Comparing underrepresented minority and white students by year in school for these two subscales one notices the same trend for Virginia Tech that was apparent for Michigan Tech. Feeling of inclusion/sense of belonging decreases for underrepresented minority students from freshman to sophomore year. For white students the mean drops from freshman to sophomore year and increases from junior to senior year. For engineering career success expectations there is not a trend, however underrepresented minority sophomores and seniors have lower engineering career success expectations than white students.

	Freshman URM	Freshman White	Sophomore URM	Sophomore White	Junior URM	Junior White	Senior URM	Senior White
Inclusion	4.94	5.49	4.81	5.62	4.08	5.26	4.27	5.81
Eng Succ	6.07	6.12	5.53	6.39	5.92	5.95	5.59	6.31

Table 4.10: Means of Inclusion and Engineering Career Success Expectations by Year in School and Ethnicity (Virginia Tech)

Table 4.11 provides a one-way ANOVA by year in school for Virginia Tech. One would say the score for math self-efficacy is approaching significance ($p = 0.07$), however there were no significant differences found for the scores when year in school was factored. Table 4.12 shows that both groups of students math self-efficacy decreased from freshman to sophomore year and from junior to senior year.

LAESE Subscale	F	Sig.
Coping Self-Efficacy	1.07	0.37
Math Self-Efficacy	2.22	0.07
Inclusion/Sense of Belonging	1.39	0.24
Engineering Self-Efficacy 1	0.95	0.44
Engineering Self-Efficacy 2	0.42	0.79
Engineering Career Success Expectations	1.29	0.28

Table 4.11: One-Way ANOVA by Year in School (Virginia Tech)

	Freshman URM	Freshma n White	Sophomore URM	Sophomore White	Junior URM	Junior White	Senior URM	Senior White
Math SE	5.42	5.92	5.18	5.76	5.52	5.61	4.75	5.33

Table 4.12: Means of Math Self-Efficacy by Year in School (Virginia Tech)

Table 4.13 provides subscale comparisons for the NJIT. No significant differences were found when comparing underrepresented minority students against white students.

LAESE Subscale	**URM (n = 261)**	**White (n ~ 84)**	**t(df)**	**Sig.**
Coping Self-Efficacy	5.65	5.79	-1.29 (343)	0.20
Math Self-Efficacy	5.75	5.58	1.25 (343)	0.21
Inclusion/Sense of Belonging	4.81	4.91	-0.75 (347)	0.46
Engineering Self-Efficacy 1	5.49	5.57	-0.65 (346)	0.52
Engineering Self-Efficacy 2	5.76	5.93	-1.42 (346)	0.16
Engineering Career Success Expectations	5.88	5.86	0.23 (349)	0.82

Table 4.13: T-Test for Underrepresented Minority (URM) students vs. Whites (NJIT)

When comparing students across academic levels one finds significant differences in the coping self-efficacy and engineering self-efficacy 2 subscales (Table 4.14). Table 4.15 provides a breakdown of the coping self-efficacy subscale by ethnicity and year in school. One notices that underrepresented minority freshman sophomore, and senior students had lower coping self-efficacy than white students. Coping self-efficacy decreased for both underrepresented minority students and white students from the freshman to sophomore year.

LAESE Subscale	**F**	**Sig.**
Coping Self-Efficacy	9.03	< 0.01
Math Self-Efficacy	0.84	0.43
Inclusion/Sense of Belonging	0.79	0.46
Engineering Self-Efficacy 1	1.98	0.14
Engineering Self-Efficacy 2	4.01	0.02
Engineering Career Success Expectations	1.69	0.19

Table 4.14: One-Way ANOVA by Year in School (NJIT)

	Freshman URM	**Freshman White**	**Sophomore URM**	**Sophomore White**	**Junior URM**	**Junior White**	**Senior URM**	**Senior White**
Coping SE	5.54	5.99	5.48	5.69	5.75	5.65	5.77	5.97

Table 4.15: Means of Coping Self-Efficacy by Year in School (NJIT)

Summary of Quantitative Findings (Phase 1)

A summary of the quantitative findings from phase 1 is necessary to gain some perspective. For the combined sample (all institutions), underrepresented minority students had lower feeling of inclusion/sense of belonging scores than white students. When looking at each school separately, both Michigan Tech and Virginia Tech had underrepresented minority students with significantly lower feeling of inclusion/sense of belonging scores than white students. Underrepresented minority students had significantly higher math self-efficacy than whites. For all of the institutions combined, underrepresented minority students in their sophomore through junior year had higher math self-efficacy than white students. However, when singling out Michigan Tech one notices that as students progressed by year in school from Freshman to Junior their math self-efficacy decreased. Additionally, math self-efficacy for the underrepresented minority students was lower than for white students at Michigan Tech.

Lastly, underrepresented minority freshman, sophomore, and senior students at NJIT had lower coping self-efficacy than white students.

These findings provide reasoning to develop an intervention to be implemented during the first-year that will help improve feeling of inclusion/sense of belonging for underrepresented minority engineering students. We now move on to phase two of the study, which focuses on determining factors or variables to consider when designing an intervention to improve sense of belonging.

Quantitative Findings: Phase 2

The second phase of the research was designed to answer the following research question: What factors or variables should be considered and/or addressed in designing an intervention to increase engineering self-efficacy and sense of belonging amongst first-year underrepresented minority engineering students? To answer this question the author utilized the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) and Academic Pathways of People Studying Engineering Survey (APPLES). Table 4.16 provides those subscales with high means indicating these subscales could potentially be factors influencing underrepresented minority student sense of belonging in engineering. Focusing only on underrepresented minority engineering students, each ethnicity was separated out for better understanding. Additionally, the APPLES scores were on a scale of 1 to 4.

The results show relatively high means for *motivation for social good*, meaning students study engineering because they feel that engineers contribute to fixing the problems in the world. In terms of being motivated by *financial reasons*, there is variability in the means for the different ethnic groups with Latino(a)/Hispanic American students being less motivated to pursue engineering because of the financial outcome (μ=2.6078) compared with African American/Black students (μ=3.2593). Relatively high means for *intrinsic psychological motivation* show that underrepresented minority students study engineering because they think it is fun and interesting. The same holds true for *intrinsic behavioral motivation*; students study engineering because they like to figure out how things work. Students across the board have high confidence in their *professional and interpersonal skills*, and their *problem solving skills*. Variability in the means for students' *academic disengagement* in their liberal arts courses shows that Latino(a)/Hispanic American students are more engaged in their liberal arts courses than American Indian/Alaskan Native students. Lastly, students have relatively high confidence in their math and science abilities.

APPLES Constructs	**Ethnicity**	**Mean**
Motivation (Social Good)	African American/Black	3.50
	American Indian/Alaskan Native	3.39
	Latino(a)/Hispanic American	3.23
Motivation (Financial)	African American/Black	3.26
	American Indian/Alaskan Native	2.94
	Latino(a)/Hispanic American	2.61
Motivation (Intrinsic, Psychological)	African American/Black	3.72
	American Indian/Alaskan Native	3.42
	Latino(a)/Hispanic American	3.38
Motivation (Intrinsic, Behavioral)	African American/Black	3.75
	American Indian/Alaskan Native	3.50
	Latino(a)/Hispanic American	3.38
Confidence in Professional and Interpersonal Skills	African American/Black	3.93
	American Indian/Alaskan Native	3.61
	Latino(a)/Hispanic American	3.86
Confidence in Solving Open-ended Problems	African American/Black	5.20
	American Indian/Alaskan Native	5.00
	Latino(a)/Hispanic American	4.72
Academic Disengagement (Liberal Arts Courses)	African American/Black	3.25

Table 4.16: APPLES Constructs by Ethnicity (continued)

Table 4.16 continued

	American Indian/Alaskan Native	4.54
	Latino(a)/Hispanic American	2.39
Confidence in Math and Science Skills	African American/Black	3.57
	American Indian/Alaskan Native	3.39
	Latino(a)/Hispanic American	3.69

This information tells us that, in addition to addressing students' sense of belonging and coping self-efficacy, an intervention to improve engineering self-efficacy and sense of belonging for underrepresented minority students should include opportunities to appeal to their motivation for social good. It should also include reminders that engineering is fun and interesting.

With this information in mind we move on to developing the pilot intervention. For this experiment, the null hypothesis would be that the intervention video has no effect on students' sense of belonging in engineering. The author is attempting to reject the null hypothesis. The author performed power analysis to calculate the minimum sample size required to detect an effect because of the treatment video. For a desired statistical power of 0.8 (considered adequate by Kenny (1987)) and a medium effect size ($d = 0.5$), the sample should be 64 participants. For a small effect size ($d = 0.2$), a sample size of 393 is required. The author therefore aimed for a sample of participants between 64 and 393.

Pilot Intervention Synopsis

To assess and potentially improve first-year underrepresented minority engineering students' feeling of inclusion/sense of belonging the author modeled the “social belonging” intervention first introduced at Yale for African-American computer science students. For the current study, upper division students of diverse backgrounds were videotaped describing how they overcame feelings of non-inclusion over time. The video footage was edited to produce a compelling short video showing that all first-year students regardless of race, ethnicity, or gender, experience the same feelings of not belonging, but that they overcome these feelings over time. A second control video was produced as well with the same group of students sharing ideas about how to get involved on campus.

A treatment group of underrepresented minority students viewed the video footage and discussed it as a group. They also completed the LAESE instrument and filmed a testimonial for future students. A control group of underrepresented students also viewed the control video footage and discussed it as a group and completed the LAESE instrument as well. The LAESE instrument was administered to a group of white first-year engineering students to gather baseline data of majority students for comparison.

Video Footage Participants

Nine (9) upper class students (5 women, 4 men—3 African-American, 2 Native American, 2 Caucasian, and 2 Hispanic/Latino(a)) were selected to film the video footage. The students were paid $50 for their participation.

“Sense of Belonging” (Treatment) Video

To capture video participants’ opinions about their sense of belonging, the students were asked questions related to how they first felt when arriving to campus, friends they have made from different backgrounds, and questions about faculty members. The sense of belonging (treatment) interview questions were as follows:

1. How did you feel when you first stepped foot on [INSTITUTION]'s campus?
2. What types of friends have you met since your freshman year?
3. Why did you choose your major?
4. Describe your favorite faculty member. What do you like about him/her?
5. Have you ever done badly on a test? What do you do to cope with doing badly on a test?
6. Talk about friends you've made from different backgrounds/values.
7. Have you ever been the only person of your race or gender in your classes? Share your experience.

The goal was to address the feeling of inclusion/sense of belonging and coping self-efficacy subscales of the LAESE instrument. In these subscales students were asked to indicate to what degree they agree with the following statements:

Feeling of inclusion

- I can relate to the people around me in my class.
- I have a lot in common with other students in my classes.
- The other students in my classes share my personal interests.
- I can relate to the people around me in my extra-curricular activities.

Coping self-efficacy

- I can cope with not doing well on a test.
- I can make friends with people from different background and/or values.
- I can cope with friends' disapproval of my chosen major.
- I can cope with being the only person of my race/ethnicity in my class.
- I can approach a faculty or staff member to get assistance.

- I can adjust to a new campus environment.

Responses to the questions were captured and edited to produce a video that showed that all students might feel as if they do not belong when first arriving to campus. For example, when asked how she felt when first stepped foot on campus, a female respondent stated:

> *"When I first got to campus I was honestly really terrified because I came from a really small rural area—tiny classes sizes. I graduated with 54 people."*

A male respondent stated the following:

> *"When I first step foot on [INSTITUTION]'s campus I was extremely nervous. I didn't really know too many people here. I didn't know what to expect. I knew that there was something called "orientation", but I didn't know who was going to be in my group. I just—was extremely nervous and I knew my parents were nervous and that made me more nervous, and I was just extremely overwhelmed."*

Providing students with a sense that nervousness can accompany excitement, a male responded with the following:

> *"The first time I step foot on [INSTITUTION]'s campus I felt a little concerned because, honestly, it was my first day away from home you know, big move, that kind of thing, and then as soon as I got into my hall…it was so much fun. Everyone in the hall was a giant family and got to know people really quickly. We all pretty much hung out and honestly as soon as my parents left I was actually kind of happy to see them go."*

The final video included these sorts of snippets accompanied by "techno" music and was about 16 minutes in length.

Campus Involvement (Control) Video

A video was created using responses from the same students who helped develop the treatment video. This video was a general video about how students are involved on campus via student organizations, volunteering, and campus jobs. The control video was also 16 minutes in length. The interview questions asked are as follows:

1. What extracurricular activities are you involved in on [INSTITUTION]'s campus?

2. What types of friends have you met in your extracurricular activities?

3. Why did you choose the clubs you're involved in?

4. Talk about friends you've made from different backgrounds in the clubs you're involved in.

Treatment and Control Group Subjects

A treatment and control group was created using first-year engineering students (6 male, 5 female) at Michigan Tech. Ten of the students were first-year, first semester college students; one student transferred from a community college. The students' racial/ethnic composition was as follows:

- 3 African American
- 1 Asian
- 2 Hispanic/Latino, and
- 5 multiracial students.

For comparison, a second control group of 13 first-year engineering students (11 male, 2 female) were used. 12 of the students were white and one student was multiracial. The LAESE instrument was administered to these students solely for the purpose of gathering baseline data to compare their survey responses with those of the underrepresented minority students.

Recruiting Participants

To recruit underrepresented minority students for participation an e-mail blast was sent to all first-year underrepresented minority students at the institution. Students self-selected into the treatment and control conditions through their choice of attending 1 of 2 available time slots for participation.

Treatment Group

Six underrepresented minority students attended the treatment session. Students were introduced to the research and it was explained to them that their participation was voluntary. All of the students consented to take the LAESE assessment, watch the treatment video, be recorded via video camera their name and their intended major, and have their fall 2011 final grades shared with the author. The entire session lasted 30 minutes and all students received a $10 iTunes gift card at the end of the session.

Control Group

Five underrepresented minority students attended the "control" session. These students were told that their participation was voluntary as well. They were not told that they would be watching a different video than the first group. These students consented to take the LAESE assessment and watch the control video. They did not video record their intended major. They did consent to have the authors pull their final grades for the fall 2011 semester.

Data Analysis and Results

To compare the results of the LAESE assessment, subscale means were computed and a series of t-tests were performed.

Pre-Intervention Results

Table 4.17 provides the means of the subscales for all of the students (treatment group, control group (underrepresented minority students), and second control group). The highest score attainable for each subscale is 7. The data shows that on average students have the highest means for engineering career success expectations and math outcome expectations.

LAESE Subscale	Mean (n=24)
Engineering Career Success Expectations	6.17
Engineering Self-efficacy I	5.95
Engineering Self-efficacy 2	5.81
Inclusion/Sense of Belonging	5.22
Coping Self-Efficacy	5.41
Math Outcome Expectations	6.18

Table 4.17: LAESE Subscale averages of all students (pre-test)

Table 4.18 provides a breakdown of the subscale means comparing all of the underrepresented students (both the treatment and control groups) with their white counterparts. There were no significant differences found.

LAESE Subscales	URM	White
Engineering Career Success Expectations	6.18	6.15
Engineering Self-Efficacy 1	5.98	5.92
Engineering Self-Efficacy 2	5.81	5.80
Inclusion/Sense of Belonging	5.14	5.28
Coping Self-Efficacy	5.36	5.44
Math Outcome Expectation	6.15	6.20

Table 4.18: LAESE Subscale averages of all underrepresented students vs. white students (pre-test)

Table 4.19 provides the subscale means for the treatment group of underrepresented students compared with the control group (underrepresented students) prior to the intervention. No significant differences were found.

LAESE Subscales	**Treatment**	**Control**
Engineering Career Success Expectations	6.14	6.22
Engineering Self-Efficacy 1	5.86	6.12
Engineering Self-Efficacy 2	5.55	6.13
Inclusion/Sense of Belonging	4.95	5.35
Coping Self-Efficacy	5.19	5.56
Math Outcome Expectations	6.00	6.33

Table 4.19: LAESE subscale averages of treatment vs. control group (pre-test)

Post-Intervention Results

Of the original participants, 3 from the treatment group, 3 from the control group, and 8 from the second control group (white students) volunteered to take the post assessment. Table 4.20 shows the overall average gains for the students in the three groups on the LAESE subscales. As aforementioned, the LAESE assessment was administered at the beginning and end of the fall semester.

LAESE Subscale	**Experimental Group (n=3)**	**Control Group 1 (URM) (n=3)**	**Control Group 2 (White) (n=8)**
Engineering career success expectations	-0.14	-0.34	0.05
Engineering self-efficacy I	-0.28	-0.33	-0.12
Engineering self-efficacy 2	-0.67	-0.73	-0.53
Inclusion/Sense of Belonging	0.92	0.08	-0.03
Coping self-efficacy	0.22	0.22	-0.02
Math outcome expectations	-0.11	-0.44	-0.46

Table 4.20: LAESE Mean Gains of all students

The number of students in each group was very low, making statistical inferences unreliable. Despite the small sample sizes, the following observations were made in examining the data presented in Table 4.20:

- For the engineering career success expectations, underrepresented students in the intervention group showed a slight decrease, and underrepresented students in the non-intervention group showed a slightly higher decrease.
- For both self-efficacy subscales, all three groups showed a decrease over the course of the semester. The decrease was slightly less for majority students than it was for underrepresented students. Further the underrepresented students in the non-intervention group showed the largest decrease in self-efficacy.
- For the feeling of inclusion, there was essentially no change for either of the control groups; however, there was a seemingly large increase for the underrepresented students in the intervention condition.
- Coping self-efficacy increased slightly for all underrepresented students; for majority students there was no change.
- Interestingly, the math outcome expectations for both control groups decreased by about the same amount. The decrease in math outcomes expectations for students in the intervention group was less than either of the two control groups.

Final Grades and Grade Point Averages (GPAs)

The students consented to have their grades assessed, so student grades were also compared in this analysis. Table 4.21 provides the average GPA for the treatment group (underrepresented students), control group (underrepresented students), and second control group (white students). It should be noted that not all students were enrolled in the same math, science and engineering courses; however, for this analysis, all grades earned in those subjects were combined. The overall Math/Science/Engineering (MSE) GPA was computed for each group as well as the overall GPA earned by that student for the semester as presented in Table 4.21.

Course	**Treatment**	**Control 1**	**Control 2**
Chemistry	1.67	2.00	2.13
First-Year Engineering	2.00	2.40	1.92
Math	3.00	1.70	2.69
MSE GPA	2.35	2.03	2.24
Overall GPA	2.27	2.27	2.48

Table 4.21: Average GPAs of all participants

From this data it appeared that the students in the treatment group did slightly worse in chemistry courses, about average in engineering courses, and much better in their math courses than did the students in the two control groups. The better performance in math for this group likely contributed to the fact that this group experienced a lower decrease in math outcome expectations on the LAESE instrument. Interestingly, the treatment group appeared to have earned better grades on average in math/science/engineering courses compared to students in control group1 even though their average overall GPAs were identical.

Summary of Quantitative Findings (Phase 2)

The results from this phase are encouraging; however, due to small sample sizes, the results were not definitive and further exploration was required. Nonetheless, it did appear that the intervention designed to improve sense of belonging for underrepresented engineering students had a positive impact. The group that participated in the intervention had an increased sense of belonging over the semester compared to underrepresented students in the control group. The impact, if any, of the pilot intervention on grades appeared to be mixed. The next phase of the research included extending the intervention to a larger group of students to see if these preliminary results were repeatable and if statistical inferences could be drawn from the results.

Quantitative Findings: Phase 3

To improve this research protocol the author assembled a panel of advisory board members during the summer of 2012. The advisory board consisted of practicing engineering educators with experience in instrument construction and statistical analysis. These advisors made several suggestions to improve the intervention. They are as follows:

- Moving forward, another representative engineering school with a population of minority engineering students to sample from needed to be added to the study. With only the large rural institution as a representative school, the research would not have the same impact to the engineering education community.
- It was suggested that the order of the interview comments be rearranged such that the problem is brought to the front, and the social and academic strategies/advice, as well as coping mechanisms for environment follow.
- It was suggested that even though issues of belonging were the only significant element, it would be beneficial to have aspects of engineering self-efficacy in the video. Additionally, all names of mentioned professors

or dates should be removed, however, include students' first names along with their level and engineering major in the video.

- There was concern that in the pilot video there were two people who did not have engineering degrees. Videos moving forward should only including engineering majors.
- It was suggested to provide interviewees with a survey to complete prior to the interview that provides questions they will be asked. Doing so will better prepare them for the interview and make sure they address particular points.
- It was suggested to remove the control group video because it may have given a similar message as the treatment video.
- It was suggested to keep the large urban institution in the study as it serves as a model engineering school for diversity (i.e. no majority or minority groups).
- It was suggested to add items from the Student-Professor Interaction Scale to the LAESE. Further it was suggested that the reflection questions regarding students' aspirations should be removed, as they are not in concert with the research questions.

The intervention was attempted at OSU and NJIT during the 2012-2013 academic school year. It was attempted at Virginia Tech, however key personnel at this institution were not able to gather enough students to participate.

The author developed intervention videos for both OSU and NJIT. Upper-class students from diverse backgrounds were solicited to have themselves video recorded, and they received $10 Target gift cards. The treatment video protocol was as follows:

> **Overview**: We are trying to create a compelling video that will increase incoming students' sense of belonging, and increase their confidence in their ability to be successful in their major and future career. The questions we will ask you are related to sense of belonging and self-confidence. Please speak of your experiences honestly, but be as positive as possible. We will start with asking you about when you may have questioned whether you belonged, or questioned your ability to be successful. Then we will focus on academic or social behaviors that helped you to cope, realize you belonged, or increased your confidence. In the end, we hope the video shows new students that it is perfectly normal to question whether you "belong", and for experiences to lower your confidence – but give them ideas for how to use those experiences to increase confidence and sense of belonging.
>
> **Probing Questions:**
> 1. Introduce yourself (first name) by telling us your major and year in school.
> 2. Tell us a little about yourself. Where are you from?
> 3. Why did you choose your major?
> 4. Has your family always supported your decision to attend college, or your major? Is it important to them?
> 5. Talk about your experience when you first arrived to campus.
>   a. Did you ever question your choice of major?
>   b. Did you ever question whether you could be successful in your major or career? (lose confidence)?
>   c. Have you ever felt like you were the only one like you in your class? Share your experience.
>   d. or: Have you ever felt alone in your classes? Share your experience.
> 6. Have you ever done badly on a test? What do you do to cope with doing badly on a test?
> 7. What are some academic or social activities or behaviors you adopted to feel included (enhance your sense of belonging) on campus or in your major?
> 8. Without giving us the person's name, describe your favorite faculty member or another advocate on campus. What do you like about him/her?
> 9. Talk about friends you've made from different backgrounds/values.
> 10. What are specific behaviors that you engaged in that enhanced your confidence in your ability to be successful? (Examples: Scheduling meetings with faculty, seeking help when you need it, methods of coping with difficulties)
> 11. If you could tell incoming engineering students one thing to encourage them what would that be?

Type of Students:

- ~10 students
- Upper-class students (juniors and seniors)
- Diverse backgrounds (African American, Hispanic/Latino(a), Asian, Native, White)
- Engineering majors only (diverse majors across the college of engineering)

Location:
Videos should be recorded in a comfortable area such as a lounge or waiting area with couches where the student will feel comfortable.

During the 2012-2013 academic school year the author implemented the intervention at both OSU and NJIT. At OSU the author sent an e-mail to underrepresented first-year engineering students asking that they sign-up to attend a session where they would watch a video, take a survey, and have a short discussion. At NJIT the author hosted the session during the school's "common hour". Students chose between two times to participate and did not know whether they were in the treatment or control group.

The treatment group took the LAESE instrument in person via Scantron coding sheets (including questions from the Student-Professor Interaction Scale) and watched the video that was developed for that institution. The control group took the instrument and watched a TED Talk about creativity in schools. All of the groups were asked to complete the post-assessment via an online Qualtrics survey at the end of the semester.

There were no significant differences found in any of the subscales between the intervention and control groups at each institution. Table 4.22 provides mean gains for each institution's treatment and control group. A summary of the data is found below the table.

OSU Treatment (n=13)	Pre Test	Post Test	Gain
Engineering Self-Efficacy 1	5.36	5.41	0.05
Engineering Self-Efficacy 2	5.26	6.04	0.78
Inclusion/Sense of Belonging	5.30	5.30	0.00
Coping Self-Efficacy	5.76	5.87	0.11
Student Professor Interaction	5.56	4.88	-0.68
OSU Control (n=13)	**Pre Test**	**Post Test**	**Gain**
Engineering Self-Efficacy 1	5.12	4.72	-0.41
Engineering Self-Efficacy 2	6.26	5.71	-0.56
Inclusion/Sense of Belonging	5.34	4.96	-0.39
Coping Self-Efficacy	5.77	5.19	-0.57
Student Professor Interaction	5.50	4.38	-1.12
NJIT Treatment (n=17)	**Pre Test**	**Post Test**	**Gain**
Engineering Self-Efficacy 1	5.062	5.25	0.19
Engineering Self-Efficacy 2	5.86	5.55	-0.31
Inclusion/Sense of Belonging	5.53	5.34	-0.19
Coping Self-Efficacy	5.56	5.64	0.08
Student Professor Interaction	5.44	5.28	-0.17
NJIT Control (n=20)	**Pre Test**	**Post Test**	**Gain**
Engineering Self-Efficacy 1	5.37	5.14	-0.23
Engineering Self-Efficacy 2	5.97	5.74	-0.22
Inclusion/Sense of Belonging	5.59	5.29	-0.29
Coping Self-Efficacy	5.58	5.5824	0.00
Student Professor Interaction	5.775	5.2528	-0.52

Table 4.22: Mean Gains of OSU and NJIT

To summarize these findings:

- The students who participated in the treatment at OSU showed positive gains for the engineering self-efficacy 2 and coping self-efficacy subscales.
- The students who participated in the control group at OSU showed negative gains for each subscale measure.
- The students who participated in the treatment group at Virginia Tech showed a positive gain for the engineering self-efficacy 1 subscale.
- The students who participated in the control group at Virginia Tech showed negative gains for all but the coping self-efficacy subscale.

There were several issues that occurred during the implementation of this intervention. These issues could have affected the outcome of the results. More on this topic will be discussed in chapter 5.

The final attempt to implement the intervention took place during the Summer 2013 and Fall 2013 semesters at OSU and Virginia Tech. At Virginia Tech students who participated in the summer bridge program were subjects in the study. Table 4.23 provides demographic data about the students participating in the study.

Gender	**n**	**%**
Male	36	58.1
Female	26	41.9
Ethnicity/Citizenship	**n**	**%**
African American/Black	11	17.7
American Indian/Alaskan Native	3	4.8
Asian & Pacific American	11	17.7
Latino(a)/Hispanic American	3	4.8
Caucasian American	29	46.8
Foreign National on student visa	1	1.6
Foreign National/U.S. Resident (green card)	4	6.5
Major	**n**	**%**
Bachelor of Science in Engineering	5	8.1
Biomedical Engineering	3	4.8
Chemical Engineering	5	8.1
Civil Engineering	1	1.6
Computer Engineering	20	32.3
Electrical Engineering	1	1.6
Environmental Engineering	2	3.2
Materials Science & Engineering	3	4.8
Mechanical Engineering	12	19.4
Undecided	9	14.5

Table 4.23: Demographic Data of Virginia Tech Participants

At Virginia Tech a total of 90 students took the survey initially. Sixty-two students took the post-test. Of the students who took the post-test, 27 watched the video and 35 did not watch the video. There were no significant differences in the two groups.

All 62 participants took the paper version of the instrument during one of their required bridge program sessions. Two weeks later, key personnel at the institution invited the random sample of students to watch the treatment video. At the end of the bridge program all students were asked to take the post-assessment online.

Table 4.24 provides mean gains for each subscale. The results show that those in the treatment group had increases in their mean gain scores for engineering self-efficacy 2. The control group showed slightly higher negative mean gains for student-professor interaction.

Subscale	**Experimental Group (n=27)**	**Control Group (n=35)**
Engineering Self-Efficacy 1	0.07	-0.11
Engineering Self-Efficacy 2	0.36	0.00
Inclusion/Sense of Belonging	0.06	0.13
Coping Self-Efficacy	0.01	-0.01
Student Professor Interaction	-0.04	-0.14

Table 4.24: Mean Gains for Virginia Tech

At the OSU during the third week of the semester the author visited 8 sections of the first-year engineering program course to introduce herself and the purpose of the research. The students were asked to take the online version of the instrument and complete the consent form electronically.

During the fourth week of the semester 3 sections were chosen at random to watch the treatment video of upper-class students sharing their experiences in engineering.

During the seventh week of the semester all 8 sections were asked to complete the survey instrument again (electronically).

Students who opted to participate in the research study received extra credit points in the form of one journal grade. Students who did not opt to participate in the research study also were given a chance to receive extra credit. They had the option of watching a 15 minute TED Talk about creativity in school and to submit a critique of the video. The TED Talk can be found via the following link:

https://www.ted.com/talks/lang/en/ken_robinson_says_schools_kill_creativity.html

No students chose to receive extra credit in this manner.

The initial pool of participants was 1,048. Three sections of the first year engineering program (n=216) were shown the treatment video. Not all of the students who watched the treatment video took the post-assessment. The number of students who took the pre-assessment and post-assessment, and watched the video was 172. A random control sample of 172 students who took the pre and post-assessment will be used for comparison.

Summary of Quantitative Findings (Phase 3)

Table 4.25 provides the mean gains for each group (experimental and control). The data shows significant increases in the mean scores for students in the experimental group for engineering self-efficacy 1 and 2, and a slight increase in student professor interaction (based on a desired effect size of 0.2). Hence, a small intervention could potentially improve students' engineering self-efficacy during their first-year in the engineering program. The next chapter provides discussion and conclusions for this study.

LAESE Subscale	**Experimental Group (n=172)**	**Control Group 1 (n=172)**	**Sig.**
Engineering Self-Efficacy 1	0.34	-0.19	0.015
Engineering Self-Efficacy 2	0.45	0.03	
Inclusion/Sense of Belonging	0.04	-0.04	
Coping Self-Efficacy	0.01	-0.04	
Student Professor Interaction	0.19	-0.24	

Table 4.25: Mean Gains for OSU

Chapter 5: Discussion and Conclusions

Introduction

The purpose of this study was to understand engineering self-efficacy and sense of belonging for underrepresented minority students compared with majority (White) students. With that information in mind the author sought to determine what factors to include to develop an intervention that could improve engineering self-efficacy and sense of belonging for first-year underrepresented minority engineering students. Ultimately, the author sought to determine whether a small intervention implemented during student's first semester of their first academic year could potentially improve engineering self-efficacy and sense of belonging for first year engineering students.

Discussion of Findings

Combining data from three institutions of varying characteristics showed that underrepresented students had lower feeling of inclusion/sense of belonging than white students. Per Walton and Cohen (2007), belonging uncertainty can lead to racial disparities in achievement. Additionally, inclusion has been shown to be a significant factor in predicting minority student persistence in engineering (Bainard, 1997). If the engineering education community is calling for a diverse engineering workforce, addressing sense of belonging for underrepresented students in engineering should be a high priority.

Knowing that underrepresented students had lower feeling of inclusion/sense of belonging than whites, it was the author's goal to determine what factors or variables would be important when developing an intervention to improve these students' sense of belonging and engineering self-efficacy. The data in this study showed that an intervention to improve engineering self-efficacy and sense of belonging for underrepresented students should include opportunities to appeal to their motivation for social good. This means that students need to see how an engineering degree will help them give back to their community and society as a whole. The intervention should also address the fact that engineering is fun and interesting.

From this information the author developed a small intervention in the form of compelling short videos that first-year engineering students watched that were meant to increase their engineering self-efficacy and sense of belonging. To address social good as well as showing engineering to be fun and interesting, the author made it a point to have video interviewees highlight opportunities such as studying abroad, internships, undergraduate research, etc. when speaking of their undergraduate experience. Comparing means from the pre- and post-tests the students took showed that a small intervention during the beginning of the semester could potentially help improve students' engineering self-efficacy. Although it will take more than a short video to see students, especially underrepresented minority students, from their freshman to their senior year, the intervention seemed to have a positive effect.

Although the students who watched the intervention video showed positive mean gains in their engineering self-efficacy, underrepresented minority students at OSU still showed significantly lower scores for engineering self-efficacy 2, sense of belonging, and student-professor interaction when compared to majority (White) students (Table 5.1).

This means there is still work to be done to ensure underrepresented minority students feel included in the engineering program.

LAESE Subscales	**URM**	**White**	**Sig.**
Engineering Self-Efficacy 1	5.59	5.75	0.11
Engineering Self-Efficacy 2	5.62	5.84	0.04
Inclusion/Sense of Belonging	5.01	5.49	0.00
Coping Self-Efficacy	5.65	5.78	0.14
Student-Professor Interaction	5.19	5.53	0.03

Table 5.1: LAESE subscale averages of underrepresented students vs. Whites (OSU post-test)

Limitations

There were a number of noteworthy limitations to the study. The primary limitation was the sample size of underrepresented minority students at each phase of the research. Although several avenues were used to recruit students, and several incentives were offered, it was still extremely difficult to get underrepresented students to participate in the study. It seems that these students are "over-surveyed", especially in their first year in the engineering program.

A second limitation was the chronological time, which required tracking students from their freshman to senior year in the engineering program. Ideally, this type of study would be longitudinal, but for the purposes of the research questions addressed here, a different set of students was assessed at various stages of the research.

Being unable to travel to each institution to collect data was a limitation. Depending on personnel at the various institutions proved difficult as data collection was pushed back several times due to key personnel's schedules. Ideally, the researcher would travel to each institution to ensure data collection takes place properly.

A last area of concern is what is known in educational research as the "survivor's effect". The purpose of the study was to help improve engineering student's sense of belonging, which could ultimately lead to retention. One could argue that students who are still in the engineering program are "surviving" and that they do not necessarily need interventions to keep them retained.

Areas for Future Research

The results from this study are encouraging. It does appear that the intervention designed to improve engineering self-efficacy and sense of belonging had a positive impact. The group that participated in the intervention had increased engineering self-efficacy over the semester compared to those in the control group. However, first-year underrepresented students still have significantly lower feeling of inclusion/sense of belonging than Whites in engineering.

Further research into how first-year underrepresented engineering students' feeling of inclusion/sense of belonging is shaped is needed. The author plans to pursue a qualitative study using techniques such as interviews and observations to understand how these students sense of belonging is shaped.

Other ideas for future research include the following:

1. Assessing engineering self-efficacy of first-year students at Historically Black Colleges and Universities (HBCUs).
2. Assessing engineering self-efficacy of female engineering students by year in school and ethnicity.

3. Comparison of Asian American students' engineering self-efficacy with Whites
4. A mixed-methods approach to understanding engineering self-efficacy of underrepresented minority engineering students.

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Appendix A: OSU Recruitment E-mail

Eat Free!
Help a PhD!

Video and discussion with Kari

Kari L. Jordan, Engineering Education PhD Student • jordan.722@osu.edu • (313) 908 - 0453

Save a swipe…FREE FOOD

Date
Sunday, September 23, 2012

Time
2pm **OR** 3pm

Location
Hitchcock 206

Register TODAY:
Visit http://goo.gl/k4Enp to register.

Join Me! Join me and other first-year engineering students for FREE FOOD, a short film and discussion.

Why? I am pursuing a PhD in Engineering Education and **NEED** your help! I'd like to know how your first semester in engineering is going.

How? At this event you will watch a 20 minute film, take a 15 minute survey, and participate in a discussion with other first-year engineering students. It's going to be a great time!

Questions? Want more info? Shoot me an e-mail or text!

Kari L. Jordan
jordan.722@osu.edu
313.908.0453

Appendix B: LAESE Subscales

LAESE Subscales– LAESE v3.0

Numbers in parentheses correspond to item numbers from the LAESE survey (v 3.0).
The following item subscales are for a total of 31 items (from items 16 – 46 in the LAESE survey).

Items 1 – 12 are items that gather background data, and data about how students have chosen their majors. Items 12 – 15 are "scenario" items that examine how students would choose to act in typical barrier situations.

1) Engineering career success expectations – 7 items, alpha = .84
   1) Someone like me can succeed in an engineering career (16)
   2) A degree in engineering will allow me to obtain a well paying job (25)
   3) I expect to be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter engineering (27)
   4) A degree in engineering will give me the kind of lifestyle I want (30)
   5) I expect to feel "part of the group" on my job if I enter engineering (33)
   6) A degree in engineering will allow me to get a job where I can use my talents and creativity (37)
   7) A degree in engineering will allow me to obtain a job that I like (42)

2) Engineering self-efficacy I – 5 items, alpha = .82
   1) I can succeed in an engineering curriculum (14)
   2) I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g. extra curricular activities, family, sports) (18)
   3) I will succeed (earn an A or B) in my physics courses (20)
   4) I will succeed (earn an A or B) in my math courses (21)
   5) I will succeed (earn an A or B) in my engineering courses (22)

3) Engineering self-efficacy II – 6 items, alpha = .82
   1) I can complete the math requirements for most engineering majors (23)
   2) I can excel in an engineering major during the current academic year (26)
   3) I can complete any engineering degree at this institution (28)
   4) I can complete the physics requirements for most engineering majors (34)
   5) I can persist in an engineering major during the next year (39)
   6) I can complete the chemistry requirements for most engineering majors (43)

4) Feeling of inclusion – 4 items, alpha = .73
   1) I can relate to the people around me in my class (13)
   2) I have a lot in common with the other students in my classes (15)
   3) The other students in my classes share my personal interests (17)
   4) I can relate to the people around me in my extra-curricular activities (19)

5) Coping self-efficacy – 6 items, alpha = .78
   1) I can cope with not doing well on a test (29)
   2) I can make friends with people from different backgrounds and/or values (31)
   3) I can cope with friends' disapproval of chosen major (36)
   4) I can cope with being the only person of my race/ethnicity in my class (38)
   5) I can approach a faculty or staff member to get assistance (40)
   6) I can adjust to a new campus environment (41)

6) Math outcome expectations – 3 items, alpha = .84
   1) Doing well at math will enhance my career/job opportunities (24)
   2) Doing well at math will increase my sense of self worth (32)
   3) Taking math courses will help me to keep my career options open (35)

Appendix C: IRB Amendment Approvals

THE OHIO STATE UNIVERSITY

Behavioral and Social Sciences Institutional Review Board

Office of Responsible Research Practices
300 Research Administration Building
1960 Kenny Road
Columbus, OH 43210-1063

Phone (614) 688-8457
Fax (614) 688-0366
www.orrp.osu.edu

September 26, 2013

Protocol Number:	**2011B0441**
Protocol Title:	**RESEARCH IN ENGINEERING SELF EFFICACY OF MINORITY STUDENTS, Sheryl Sorby, Kari Jordan, Engineering**
	Request to amend the protocol dated 08/05/2013--Add Steven Nozaki as key personnel; add 1900 participants (n+ 2,000); conduct survey at universities in Hawaii
Type of Review:	Amendment #03—Expedited
Approval Date:	September 17, 2013
IRB Staff Contact:	Michael Donovan Phone: 614-292-6950 Email: donovan.6@osu.edu

Dear Dr. Sorby,

The Behavioral and Social Sciences IRB **APPROVED** the above referenced research.

Note that if applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University's OHRP Federalwide Assurance #00006378. All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Michael Edwards, PhD, Chair
Behavioral and Social Sciences Institutional Review Board

Association for the Accreditation of Human Research Protection Programs, Inc. Full Accreditation

hs-017-03 Approval Amend
Version 05/18/10

Behavioral and Social Sciences Institutional Review Board

Office of Responsible Research Practices
300 Research Administration Building
1960 Kenny Road
Columbus, OH 43210-1063

Phone (614) 688-8457
Fax (614) 688-0366
www.orrp.osu.edu

January 4, 2013 (revised 01-04-2013)

Protocol Number:	**2011B0441**
Protocol Title:	**RESEARCH IN ENGINEERING SELF EFFICACY OF MINORITY STUDENTS, Sheryl Sorby, Kari Jordan, Introduction to Engineering**
Type of Review:	Continuing Review & Amendment—Expedited - Expedited
Approval Date:	January 3, 2013
IRB Staff Contact:	Michael Donovan Phone: 614-292-6950 Email: donovan.6@osu.edu

Dear Dr. Sorby,

The Behavioral and Social Sciences IRB **APPROVED** the Continuing Review of the above referenced research.

Date of IRB Approval:	**January 3, 2013**
Date of IRB Approval Expiration:	**December 6, 2013**
Expedited Review Category:	**7**

In addition, the IRB **APPROVED** the request to amend the protocol dated 10/27/2012-- Add raffle incentive for post-assessment participation; change recruitment e-mail; revise survey instrument on December 6, 2012.

If applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

This approval is valid for **one year** from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of all investigators and research staff to promptly report to the IRB any serious, unexpected and related adverse events and potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University's OHRP Federalwide Assurance #00006378. All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Steve Beck, PhD, Co-Chair
Behavioral and Social Sciences Institutional Review Board

hs-017-07 Exp Approval CR/AM
Version 05/18/10

Appendix D: Consent Form

THE OHIO STATE UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

You are asked to participate in a research study conducted by Dr. Sheryl Sorby and Kari L. Jordan from the Engineering Education Innovation Center (EEIC) at The Ohio State University (Ohio State). This research is funded by the National Science Foundation. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

You have been asked to participate in this study because you are majoring in engineering.

If you have completed this survey already please do not re-take it.

- **PURPOSE OF THE STUDY**

The purpose of this study is to identify factors associated with retention which will be used to develop an intervention designed to assist first year students and better enable them to remain in their chosen engineering major.

- **PROCEDURES**

If you volunteer to participate in this study, you will be asked to take a survey containing items regarding your feelings about your major, your experiences at your school, and your intentions regarding pursuing a career. It is anticipated that the survey should take no more than 20 minutes to complete.

You may also be asked to watch a short video of current students discussing their experiences. To help the researchers understand your journey thus far as an engineering student, you also have the option to participate in a one-on-one interview and/or group discussion with other engineering students.

Lastly, you are consenting to allow the investigators to track your Fall 2013 and Spring 2014 grades.

- **POTENTIAL RISKS AND DISCOMFORTS**

There are no known risks for participation in this study.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

While we anticipate that you will not receive direct benefit from participation in this study, future engineering students may benefit from the information we gather in this study and the intervention we design.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. The confidentiality of all survey responses will be maintained via a password protected electronic database in the researchers' password-protected computer. All participants will be assigned a code number, and once information is taken from the survey by researchers for use in data analysis, it will only be affiliated with this code number, not your name. All paper copies of surveys will be kept in a locked file cabinet by Kari L. Jordan. Publications or presentations that result from this research will describe group data only – the identity of individuals will not be disclosed.

- **PARTICIPATION AND WITHDRAWAL**

You can choose whether or not to participate in this study. If you volunteer to participate in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer on the survey. There is no penalty if you withdraw from the study.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about this research, or if you feel you have been harmed by participation, please contact:

Dr. Sheryl Sorby	Kari L. Jordan
EEIC	EEIC
225 Hitchcock Hall	324 Hitchcock Hall
sorby.1@osu.edu	jordan.722@osu.edu
614-292-7923	313-908-0453

- **RIGHTS OF RESEARCH SUBJECTS**

The Ohio State University Institutional Review Board has reviewed my request to conduct this project. If you have any concerns about your rights in this study, please contact Sandra Meadows in the Ohio State University Office of Responsible Practices at 1-800-678-6251. The OSU IRB protocol number for this study is 2011B0441.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____

Printed Name of Subject

________________________ ________________________

Signature of Subject Date

Appendix E: LAESE Instrument

An Adaptation of the AWE Engineering Student Annual Survey (www.aweonline.org), NSF Grant # 0120642

Engineering Student Survey

Before&completing&the&survey,&please&complete&your&name&and&birth&date&on&the&scantron&form.

1) Major or intended major as of today: (Select one)

1 Aeronautical/Astronautical Engineering
2 Biomedical Engineering
3 Chemical Engineering
4 Civil Engineering
5 Computer/Electrical Engineering
6 Environmental Engineering
7 Industrial and Systems Engineering
8 Materials Science Engineering
9 Mechanical Engineering
10 Other/Undecided

2) Gender

1 Male
2 Female

3) Ethnicity/Citizenship: (Select all that apply)

1 African American/Black
2 American Indian/Alaskan Native
3 Asian & Pacific American
4 Latino(a)/Hispanic American
5 Caucasian American
6 Foreign National on student visa
7 Foreign National/U.S. Resident (green card)

4) As of today, I am a:

1 First-year student
2 Second-year student
3 Third-year student
4 Fourth-year student
5 Fifth-year student or above

5) Where were you immediately before starting at this institution?

1 High School
2 4-year college
3 Vocational/Technical School
4 2-year/Community College
5 Military
6 Working a full-time job
7 Working a part-time job

6) My experience of the work required in high school classes was: (Select one)

1 It was very easy for me to get the grade I wanted in all my classes.
2 With a few exceptions, it was easy for me to get the grade I wanted in my classes.
3 I had to work some, but not all that hard to get the grade I wanted in my classes.
4 I had to work hard to get the grade I wanted in my classes.

7) In college, I expect: (Select one)

1 I will have to work less than I did in high school to get the grades I want.
2 I will have to work the same amount as I did in high school to get the grades I want.
3 I will have to work harder than I did in high school to get the grades I want.

8) What was your overall GPA when you graduated high school?

1 0.00-0.99
2 1.00-1.49
3 1.50-1.99
4 2.00-2.49
5 2.50-2.99
6 3.00-3.24
7 3.25-3.49
8 3.50-3.74
9 3.75-4.00

9) Presently, how satisfied are you with your decision about your specific engineering major?

1 Very dissatisfied
2 Dissatisfied
3 Neither Satisfied nor Dissatisfied
4 Satisfied
5 Very satisfied

10 Presently, how confident are you that you will keep your <u>current</u> engineering major through college?

1 Not at all confident; I am already planning to change my major.
2 Not very confident; it is highly likely that I will change my major.
3 There is about a 50% chance that I will change my major.
4 I am fairly confident that I will keep my current choice as my major
5 I am very confident that I will keep my current choice as my major.

11) The following is a list of academic preparation activities. Select all the activities that you participated in at least once this past year:

1 A professional engineering society (such as American Society of Mechanical Engineers).
2 A social sorority or fraternity.
3 Activities sponsored by your department or major.
4 An intramural or university sports team.
5 A minority engineering society (such as SWE, SHPE, NSBE or AISES).
6 A summer bridge program.

An Adaptation of the AWE Engineering Student Annual Survey (www.aweonline.org), NSF Grant # 0120642

Directions: Please indicate to what degree you agree with the following statements.	Strongly Disagree	Disagree	Slightly Disagree	Neither Disagree nor Agree	Slightly Agree	Agree	Strongly Agree
12) I can relate to the people around me in my classes.	1	2	3	4	5	6	7
13) I can succeed in an engineering curriculum.	1	2	3	4	5	6	7
14) I have a lot in common with the other students in my classes.	1	2	3	4	5	6	7
15) I will succeed (earn an A or B) in my physics courses.	1	2	3	4	5	6	7
16) I will succeed (earn an A or B) in my math courses.	1	2	3	4	5	6	7
17) I will succeed (earn an A or B) in my engineering courses.	1	2	3	4	5	6	7
18) The other students in my classes share my personal interests.	1	2	3	4	5	6	7
19) I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g. extracurricular, activities, family, sports).	1	2	3	4	5	6	7
20) I can relate to the people around me in my extracurricular activities.	1	2	3	4	5	6	7

Directions: Please indicate your level of confidence in the following statements.	Strongly Disagree	Disagree	Slightly Disagree	Neither Disagree nor Agree	Slightly Agree	Agree	Strongly Agree
21) I can complete the math requirements for most engineering majors	1	2	3	4	5	6	7
22) I can complete any engineering degree at this institution.	1	2	3	4	5	6	7
23) I can cope with not doing well on a test.	1	2	3	4	5	6	7
24) I can make friends with people from different backgrounds and/or values.	1	2	3	4	5	6	7

Directions: Please indicate your level of confidence in the following statements.	Strongly Disagree	Disagree	Slightly Disagree	Neither Disagree nor Agree	Slightly Agree	Agree	Strongly Agree
25) I can complete the physics requirements for most engineering majors.	1	2	3	4	5	6	7
26) I can cope with friends' disapproval of my chosen major.	1	2	3	4	5	6	7
27) I can cope with being the only person of my race/ethnicity in a class.	1	2	3	4	5	6	7
28) I can persist in an engineering major during the next year.	1	2	3	4	5	6	7
29) I can approach a faculty or staff member to get assistance.	1	2	3	4	5	6	7
30) I can adjust to any campus environment.	1	2	3	4	5	6	7
31) I can complete the chemistry requirements for most engineering majors.	1	2	3	4	5	6	7
32) I feel that one or more professors are supportive of me.	1	2	3	4	5	6	7