AC 2012-3317: PILOT INTERVENTION TO IMPROVE ”SENSE OF BELONGING” OF MINORITIES IN ENGINEERING

Kari L. Jordan, Ohio State University

A Detroit native, Kari L. Jordan received her B.S. and M.S. degrees in mechanical engineering at Michigan Technological University and is now pursuing a Ph.D. in engineering education at the Ohio State University. She is a former GEM Doctoral Fellow and King-Chavez-Parks Future Faculty Fellow. Her research experience includes engineering for sustainability, and she is currently studying engineering self-efficacy of minority students at predominantly white institutions.

Dr. Sheryl A. Sorby, Ohio State University

Sheryl Sorby is Visiting Professor in the Engineering Education and Innovation Center at the Ohio State University and Professor Emerita of mechanical engineering-engineering mechanics at Michigan Technological University. She recently served as Program Director within the Division of Undergraduate Education at the National Science Foundation. She began her academic career on the faculty at Michigan Tech in 1986, starting first as an instructor while completing her Ph.D. degree and later joining the tenure-track ranks in 1991. Sorby is the former Associate Dean for Academic Programs in the College of Engineering and the former Department Chair of Engineering Fundamentals at Michigan Tech. Her research interests include graphics and visualization. She has been the Principal Investigator or Co-principal Investigator on more than $7 million in external funding, most from the National Science Foundation for educational projects. She is the author of numerous publications and several textbooks.

Dr. Susan L. Amato-Henderson, Michigan Technological University

Susan Amato-Henderson is an Associate Professor of psychology in the Department of Cognitive and Learning Sciences at Michigan Technological University, earning her Ph.D. in experimental psychology from the University of North Dakota. Her research focuses on assessment of educational outcomes in higher education as related to STEM learning, with a focus on the effects of various experiences on individuals' self-efficacy, entrepreneurial intentions, creativity, and other related constructs, as well as the effects of an individual's values and professional role orientation on STEM learning, retention, persistence, and ethics.

Pilot Intervention to Improve "Sense of Belonging" of Minorities in Engineering

Synopsis

During the fall 2010 semester the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) was administered to engineering students across several majors at three institutions. The purpose of this study was to examine if there were differences in engineering self-efficacy of minority students compared with majority students. The results of this initial assessment were that minority students had significantly lower feelings of inclusion, one subscale of engineering self-efficacy, than did their white counterparts. No differences in overall engineering self-efficacy were found.

Since inclusion contributes to self-efficacy, the authors addressed feeling of inclusion through a "sense of belonging" intervention consisting of a treatment group and two control groups piloted at a medium sized institution during the fall 2011 semester. To assess the effect of this intervention fall semester grades were collected and both the treatment and control groups were asked to complete the LAESE instrument during the beginning and at the end of the fall 2011 semester. Results and implications of the intervention are discussed.

Background and Theoretical Framework

One of many factors deterring minority students from pursuing an engineering degree is that K-12 math and science programs across the country lack the resources needed to prepare students to study engineering[1]. 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"[2].

Math and science skills are underdeveloped in urban communities which leads many minority students to pursue careers outside of Science, Technology, Engineering, and Mathematics (STEM). Sociocultural influences such as gender roles and other events often influence a student's decision to pursue or not to pursue engineering[2]. In addition, the path a student takes to pursue higher education is also determined by the "nature of societal opportunity structures"[2]. These ideals support **social cognitive theory** which suggests that we are neither driven solely by an inner force or by outside influences.

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 these students face and providing resources to ensure they persist from freshman year to graduation should be the focus of engineering educators.

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[2]. This describes the theory of self-regulation—"the capacity to exercise self-influence by personal challenge and evaluative

reaction to one's own attainments".[2] Self-regulation provides a key cognitive mechanism of motivation and self-directedness which could potentially lead to improved persistence.

To understand student success and persistence in engineering by way of self-regulation the authors point to two influential studies. French et al. note several cognitive (high school rank, SAT scores, cumulative grade point average) and noncognitive variables (academic motivation and institutional integration) that influence students' persistence in engineering, with motivation being significantly related to persistence[3]. Vogt et al. 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[4]. They found that academic achievement was influenced by self-efficacy and academic self-confidence.

The results of these studies support **social cognitive theory** and provide reasoning to explore self-efficacy.

Self-Efficacy and Self-Regulation

The lack of progress in retaining women and minorities in engineering is partially due to students' self-efficacy. Self-efficacy refers to a person's belief that s/he 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 s/he is capable of completing a similar task), vicarious experiences (when a person sees someone else completing a task and believes s/he could do the same), social persuasions (supportive people in a person's life such as teachers, family, or mentors), and physiological reactions to a task (anxiety, etc.).

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[5]. Two subscales (self-efficacy for self-regulated learning and self-efficacy for academic achievement) were selected in the study. Although the questionnaire was not aimed at engineering per se (the students were questioned about their social studies class), the results are notable. It was found that selected self-motivational factors make a large contribution to academic attainment. Factors stemming from students' self-regulation were what fueled and influenced their achievement. Self-regulatory factors solely contributed to students' academic attainment. Because of their belief in their self-efficacy for self-regulated learning, they showed improved self-efficacy for academic achievement. This improvement influenced their academic goals and overall achievement[6]. These findings will most likely hold true with minority engineering students as well.

Self-Efficacy and "Sense of Belonging"

394 undergraduate students studying engineering consented to participate in a research study to assess the differences in engineering self-efficacy between minority and majority students[7] in the fall 2010 semester[7]. There were 53 racially ethnic minority students (African American/Black, American Indian/Alaskan Native, Asian & Pacific American, Latino(a)/Hispanic American) in the sample, 326 Caucasian students, 12 Foreign National students and 3 students who did not specify either of these categories.

To assess these students, the LAESE (Longitudinal Assessment of Engineering Self-efficacy)-an instrument created, tested, and validated to measure self-efficacy, inclusion, and outcome expectations[8]-was administered. Figure 1 shows a summary of the subscales measured by the LAESE instrument. The questions relating to each subscale were designed to identify the supports and barriers 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.

LAESE Subscales

1. Engineering career success expectations (7 items, alpha = 0.84)
2. Engineering self-efficacy I (5 items, alpha = 0.82)
3. Engineering self-efficacy II (6 items, alpha = 0.82)
4. Feeling of inclusion (4 items, alpha = 0.73)
5. Coping self-efficacy (6 items, alpha = 0.78)
6. Math outcome expectations (3 items, alpha = 0.84)

Figure 1: LAESE subscales

To analyze the differences in engineering self-efficacy between this sample of minority and majority students, scores were computed and results showed that minority students had significantly lower feelings of inclusion than did their white counterparts. Additionally, seniors' feelings of inclusion were lower than first-year students—the opposite trend of what was found in majority students. No differences in engineering self-efficacy were found, but the implications regarding inclusion provided a basis and justification for further research (i.e. "sense of belonging" of first-year minority engineering students).

Research Question

Can a small intervention to address "sense of belonging" of first-year minority students contribute to their sense of belonging and ultimately improve retention? Research studies exist to assist the recruitment and retention of first-year engineering students such as Anderson-Rowland's first year engineering student survey[9], French et al. examination of engineering students' success and persistence[3], and Hutchison's look at the factors affecting the self-efficacy beliefs of first- and second-year engineering students[10]. These studies, though significant, provide only implications and not necessarily a solution or intervention to address first-year minority engineering student attrition.

A study conducted at Yale University, if adapted, could potentially be a low-cost and easily customizable solution that researchers at institutions across the country could adopt. In their study, Walton and Cohen studied the impact of social belonging on the performance of African-American computer science students. The researchers observed a relatively large impact for a small (1 hour) intervention. First-year students in the experimental group (both African-American and White) read about the findings from a survey among upperclassmen. The survey results presented dealt with how the upperclassmen had feelings of not belonging when they

arrived at Yale, but that eventually they adjusted and realized they belonged. The survey results showed that all students, regardless of race, gender, or ethnicity, had initial struggles at the university and feelings of not belonging, but were able to overcome them with time. A control group (both African-American and White students) was shown survey results indicating that upperclassmen had changed their political thinking over time.

After viewing the survey results, participants were told they could film a video message that would be shown to future incoming students at the university. Over the next week, experimenters surveyed the students in both groups daily to determine their levels of academic frustration and their participation in "achievement behaviors" (e.g. emailing questions to a professor, stopping by for advice during office hours, studying). As a result of participating in the 1-hour intervention, African-American first-year computer science students in the experimental group thought they fit into the university better than did those in the control group; rated their potential to succeed higher than did those in the control group; indicated they were willing to attempt more challenging courses than did those in the control group; sustained a student's sense of fit at the university on adverse days unlike the students in the control group; and engaged in more achievement behaviors (studying, emailing a professor, etc.) than did those in the control group.

Grade point averages (GPAs) were obtained for the students at the end of the first semester of their sophomore year. Through a regression analysis, experimental group participants' GPAs were compared to "expected GPAs" that were based on their GPAs at the end of the first semester of their freshman year. African-American students in the treatment group saw an average increase of +0.3 on their GPA compared to their expected GPA. For African-American students in the control group, the difference was -0.3. This difference was statistically significant.

Will this type of intervention be effective for engineering students at public universities? To explore this research question the authors piloted an adaptation of the Yale intervention at a medium sized Midwestern university.

Method

Pilot Intervention Synopsis

To assess and potentially improve first-year minority engineering students' feeling of inclusion/"sense of belonging" the authors adapted the "social belonging" intervention first introduced at Yale for African-American computer science students. 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 film 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 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 minority 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 non-minority 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 (figure 2).

"Sense of belonging" interview questions:

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 bad on a test? What do you do to cope with doing bad 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.

Figure 2: Treatment Video Interview Questions

The goal was to address the "feeling of inclusion" 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 may 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 from the treatment video. This video was a general video about how students are involved on campus via student organizations, volunteering, and campus jobs. The interview questions asked are in figure 3. The control video was also 16 minutes in length.

Campus involvement interview questions:

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.

Figure 3: Campus Involvement Interview Questions

Treatment and Control Group Subjects

A treatment and control group was created using first-year engineering students (6 male, 5 female) at a medium sized technological university in the Midwest. Ten of the students were first-year, first semester college students; 1 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 minority students.

Recruiting Participants

To recruit minority students for participation an e-mail blast was sent to all first-year 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 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, record via video camera their name and their intended major, and have their fall 2011 final grades seen by the authors. The entire session lasted 30 minutes and all students received a $10 iTunes gift card at the end of the session.

Control Group

Five minority students attended the "control" session and 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 1 provides the means of the subscales for all of the students (treatment group, control group (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.

Table 1: LAESE Subscale averages of all students (pre-test)

LAESE Subscale	**Mean (n=24)**
Engineering career success expectations	6.1667
Engineering self-efficacy I	5.9500
Engineering self-efficacy II	5.8125
Feeling of inclusion	5.2187
Coping self-efficacy	5.4097
Math outcome expectations	6.1806

Table 2 provides a breakdown of the subscale means comparing all of the minority students (both the treatment and control groups) with their white counterparts. There were no significant differences found.

Table 2: LAESE Subscale averages of all minority students vs. white students (pre-test)

LAESE Subscales	**Minority**	**White**
Engineering Career Success Expectations	6.1818	6.1538
Engineering Self-Efficacy I	5.9818	5.9231
Engineering Self-Efficacy II	5.8182	5.8077
Feeling of Inclusion	5.1364	5.2885
Coping Self-Efficacy	5.3636	5.4487
Math Outcome Expectations	6.1515	6.2051

Table 3 provides the subscale means for the treatment group of minority students compared with the control group (minority students) prior to the intervention. No significant differences were found.

Table 3: LAESE subscale averages of treatment vs. control group (pre-test)

LAESE Subscales	**Treatment**	**Control**
Engineering Career Success Expectations	6.1429	6.2286
Engineering Self-Efficacy I	5.8667	6.1200
Engineering Self-Efficacy II	5.5556	6.1333
Feeling of Inclusion	4.9583	5.3500
Coping Self-Efficacy	5.1944	5.5667
Math Outcome Expectations	6.0000	6.3333

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 shows the overall average gains for the students in the three groups on the LAESE subscales. As mentioned above, the LAESE assessment was administered at the beginning and end of the fall semester.

Table 4: LAESE Mean Gains of all students

LAESE Subscale	Experimental Group (n=3)	Control Group 1 (Minority) (n=3)	Control Group 2 (Chem Lab) (n=8)
Engineering career success expectations	-0.143	-0.341	0.054
Engineering self-efficacy I	-0.278	-0.333	-0.119
Engineering self-efficacy II	-0.667	-0.733	-0.525
Feeling of inclusion	0.917	0.083	-0.031
Coping self-efficacy	0.222	0.222	-0.021
Math outcome expectations	-0.111	-0.444	-0.458

The number of students in each group was very low, making statistical inferences unreliable. Future plans include implementing the intervention and control conditions with larger sample sizes to determine if these results are repeatable. Despite the small sample sizes, the following observations are made in examining the data presented in Table 4:

- For the engineering career success expectations majority students showed no change, minority students in the intervention group showed a slight decrease, and minority 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 minority students. Further the minority 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 minority students in the intervention condition.
- Coping self-efficacy increased slightly for all minority 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 5 provides the average GPA for the treatment group (minority students), control group (minority 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 5.

Table 5: Average GPAs of all participants

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

From this data it appears 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 contributes to the fact that this group experienced a lower decrease in math outcomes 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.

Conclusion

The results from this pilot study are encouraging; however, due to small sample sizes, the results are not definitive and further exploration is required. Nonetheless, it does appear that the intervention designed to improve the feelings of inclusion for minority engineering students at a predominantly white institution had a positive impact. The group that participated in the intervention had an increased sense of belonging over the semester compared to minority students in the control group. The impact of the pilot intervention on grades appears to be mixed. Future plans include extending the intervention to a larger group of students to see if these preliminary results are repeatable and if statistical inferences can be drawn from the results we obtain.

In addition, further research into the feeling of inclusion and how first-year minority engineering students' feeling of inclusion is shaped is needed. The authors plan to pursue a qualitative study using techniques such as interviews and observations to understand ***how*** these students sense of belonging is shaped.

References

1. President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future.
2. Bandura, A. (1989). Social Cognitive Theory. Annals of Child Development, Vol. 6, 1-60.
3. French, B., Immekus, J., Oakes, W (2005). An Examination of Indicators of Engineering Students' Success and Persistence. *Journal of Engineering Education*, Vol. 94, No. 4, 419-425.
4. Vogt, C., Hocevar, D., Hagedorn, L. (2007). A Social Cognitive Construct Validation: Determining Women's and Men's Success in Engineering Programs. *The Journal of Higher Education*, Vol. 78, No. 3, 337-364.

5. Sheppard, S., Gilmartin, S., Chen, H., Donaldson, K., Lichtenstein, G., Özgür, E., Lande, M., Toye, G. (2010). Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES).
6. Zimmerman B.J., Bandura, A., Martinez-Pons, M. (1992). Self-Motivation for Academic Attainment: The Role of Self-Efficacy Beliefs and Personal Goal Setting. *American Educational Research Journal*, Vol. 29, No. 3, 663-676.
7. Jordan, K.L., Donahue, T., Amato, S., Sorby, S., "Are There Differences in Engineering Self-Efficacy Between Minority and Majority Students Across Academic Levels?" *Proceedings of the 118th Annual ASEE Conference and Exhibition*, Vancouver, BC, Canada, June 2011.
8. Marra, R., Bogue, B. (2006). Women Engineering Students' Self Efficacy – A Longitudinal Multi-Institution Study. *Proceedings of the 2006 WEPAN Conference*.
9. Anderson-Rowland, A. (1996). "A First Year Engineering Student Survey to Assist Recruitment and Retention." *Proceedings of the Frontiers in Education Conference*.
10. Hutchison, M. (2007). *Factors Affecting the Self-Efficacy Beliefs of First- and Second-year Engineering Students.* Dissertation, Purdue University. West Lafayette
11. Walton, G., and Cohen, G. (2007). "A Question of Belonging: Race, Social Fit, and Achievement." *Journal of Personality and Social Psychology*, Vol. 92, No. 1, 82-96.