122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #13238

Changes in Latino/a Adolescents' Engineering Self-efficacy and Perceptions of Engineering After Addressing Authentic Engineering Design Challenges

Dr. Joel Alejandro Mejia, West Virginia University

Joel Alejandro Mejia is an Assistant Professor of Engineering Education at West Virginia University. He is interested in research regarding underrepresentation of minority groups in Science, Technology, Engineering, and Mathematics (STEM), especially the use of culturally responsive practices in engineering education. He is particularly interested in the use of comprehension strategy instruction in linguistically and culturally diverse classrooms; physical and digital manipulatives and their application in engineering courses; engineering identity; cultures of engineering; retention, recruitment, and outreach for underrepresented minorities in STEM.

Mr. Dustin Drake, Utah State University

Dustin Drake is currently a graduate student at Utah State University. While being raised in a small town in southern Utah, Dustin had very few experiences with regards to diversity in his community. As a young adult, he had the opportunity to live in Guadalajara, Mexico, for a few years. He immersed himself in this new culture, learned the language, and loved experiencing new ways of seeing the world. Through this foreign experience, Dustin recognized a shift in his identity. These experiences also led him to become a language educator. He now teaches ESL courses to Spanish speakers, basic Spanish to English speakers, and English and Composition to fluent English speakers. Because of the interwoven nature of culture, language, and identity, Dustin studies explore identity development in different educational and cultural contexts.

Dr. Amy Wilson-Lopez, Utah State University - Teacher Education and Leadership

Amy Wilson-Lopez is an assistant professor at Utah State University who studies how literacy instruction can improve adolescents' engineering design thinking and activity.

Changes in Latino/a Adolescents' Engineering Self-Efficacy and Perceptions of Engineering After Addressing Authentic Engineering Design Challenges

Abstract

Community-based engineering design activities were used to provide Latino/a adolescents with authentic engineering experiences with the intention of increasing their engineering self-efficacy and changing their perceptions of engineering. Twenty five Latino/a adolescents (ages 14 to 17)–most of whom were either immigrants or English learners–were purposefully selected to work on different community-based engineering design activities, which are engineering experiences where the adolescents had the opportunity to research, analyze, and/or design solutions to problems affecting their community. The adolescents worked in teams of three or four members over the course of one school year to develop a solution to the problem they selected. Pre and post-interviews were conducted to determine the adolescents' perceptions of engineering and their self-efficacy in engineering. Data revealed that the participants' sense of engineering self-efficacy increased after participating in the project. In addition, the participants' perceptions of engineering changed over time. This exploratory study suggests that authentic engineering experiences, defined as experiences in which students identify real problems they want to solve for real clients, hold the potential to attract Latino/a adolescents to STEM.

Introduction

A major challenge for engineering education is the underrepresentation of minority students, particularly Latinos – one of the fastest growing ethnolinguistic groups in the United States.[1] Although the Latino school-age population is constantly increasing,[2] the number of students obtaining engineering degrees is stagnant.[3] Different scholars have offered reasons behind why Latinos do not pursue STEM careers.[4-6] Studies suggest that one particular powerful reason is that the cultures of underrepresented students do not fit with the cultures of engineering.[7]

For instance, research has emphasized how underrepresented students may find it difficult to identify with engineering.[8] Their unfamiliarity with the discipline creates the perception that engineering is not for them.[9] The National Academy of Engineering and National Research Council argued that in engineering education "curricular materials do not portray engineering in ways that seem likely to excite the interests of students from a variety of ethnic and cultural backgrounds" (p. 10),[10] perhaps because educators do not understand how engineering relates to the social, cultural, or historical contexts in which the students live.[11] Nonetheless, Latino students deserve substantive, quality opportunities to connect with engineering. Therefore, interventions are necessary to get Latino youth interested in engineering.

The purpose of this study was to understand the perceptions of engineering of Latino adolescents, as well as their engineering self-efficacy, and how these perceptions changed over time. The adolescents were presented with an opportunity to collaboratively work in groups to find solutions to problems in their communities. Therefore, through community-based engineering design challenges, the participants engaged in authentic engineering experiences where they researched, analyzed, and/or designed solution to those problems. The participants were asked a series of questions before and after the project to identify how their perceptions of engineering changed after participating in different engineering experiences. The following sections outline how an intervention was used to improve the perceptions of Latino adolescents as engineers.

Engineering Identity and Perceptions of Engineering

The ability to build an engineering identity becomes an important factor when creating a sense of belonging to a group that practices engineering.[12] According to Godfrey and Parker, the beliefs and assumptions among students and faculty about the attributes an engineer must possess are a key factor when creating an engineering identity.[13] Godfrey and Parker indicated that one of the qualities of an engineer, as perceived by faculty and students, was the scientific and mathematical competency of the individual. Some of the attributes that described engineers also included being logical, practical, conservative, pragmatic, and not emotionally demonstrative.[13] In addition, engineers were also identified as individuals that make things, apply science and math, and problem solvers.[14]

Godfrey and Parker argued that self-identifying with these qualities was an indicator of becoming an engineer and being successful in an engineering program.[13] In fact, those students that self-identified as engineers were more persistent in their engineering programs.[15] Nonetheless, becoming an engineer involved not only self-identifying as an engineer but also being perceived by others as an engineer. Acceptance by other engineering students also created a sense of self-identification with engineering, while not being accepted as part of the engineering community jeopardized the students' retention in engineering.[13]

Unfortunately, professors and fellow students often do not identify students of color as being potential engineers.[16] Because underrepresented students are subject to predetermined engineering norms or beliefs (i.e., meritocracy, specific ways of knowing and doing, and accountable disciplinary knowledge), students do not get a chance to form engineering identities that recognize their diversity. Those individuals who are seen as "different" become "at risk" students in engineering environments (p. 17).[13] In addition, the norm of creating and participating in homogeneous groups can actively serve to marginalize underrepresented students.[17] Foor and colleagues argued that underrepresented students develop a feeling of alienation when students do not feel they are part of the group.[18] Some students become insiders while others become outsiders from the exacerbation of the "us" and "them" dynamics.[7, 18] Underrepresented students may struggle to create an engineering identity not only because they are not seen as potential engineers by others, but also because an engineering identity may contradict their social and cultural views.

For instance, Stevens and colleagues analyzed the internship experience of a female Mexican American engineering student. According to the study, the values and cultures of the student (i.e., helping other people) did not fit with the competitive environment of engineering,[13, 17, 18] or the idea that engineering is only applied mathematics and science and making things.[14] The student eventually was determined to leave the engineering program after the internship because it did not meet her expectations and being a "people person" clashed with engineering. The interaction and socialization with other members of the engineering community, as well as her own experiences during the internship, influenced how she saw herself in engineering and as part of that community.

Thus, it is important for the students to see themselves as being part of the engineering community and build a sense of belonging in order to stay in engineering. It is through identity that individuals understand the ways in which they are positioned, but also how they are situated socially.[7, 8, 18] The process of socialization and the experiences in engineering helps students develop their sense of belonging and the desire to continue in engineering.[19] Unfortunately, for many underrepresented students the social interactions and experiences in engineering may not lead to the development of an engineering identity, forcing underrepresented students to leave.

Creating an engineering identity for some underrepresented students may be daunting. Tonso argued that the lack of identification with engineering motivated students to leave engineering and pursue other degrees.[12] She also indicated that in order to fit in, underrepresented students, particularly women, "must appear to accept the existing norms and not openly resist or challenge them" (p. 224).[19] However, identifying with an engineering community may be significantly more difficult for underrepresented students.

In addition, the lack of compelling activities is one of the factors that push underrepresented students away from the STEM pipeline.[9] Aschbacher and colleagues argued that students involved in extracurricular activities, such as robotics clubs or summer research programs, expressed their disappointment with the type of experiences in which they participated. Students lost interest and eventually left the STEM pipeline because the project rationale was almost never explained and there was "little opportunity to discuss and see the relevancy of their work" (p. 573).[9] This example correlates with similar observations made by Stevens and colleagues indicating that underrepresented students lost interest in engineering due to the lack of relevancy and connectedness to their values and cultures.[8]

It is important for Latino students to see how engineering relates to their everyday lives. Values such as "caring" or being a "people person," [8] which are not reflected in engineering cultures, may be important to many minority students. Integrating information from a wide range of sources, including affective factors, cultivates the sense of relevance of engineering work of underrepresented students.[20]

Research Questions

To build the interest of Latino/a students in engineering, it is important that educators do two things. First, educators should work with Latino/a adolescents to help them develop positive perceptions of their ability to succeed at engineering. Second, educators should help them to develop perceptions of engineering that do not clash with their identities. Accordingly, we sought to develop an intervention that would improve Latino students' perceptions of themselves as engineers, and that would help them develop perceptions of engineering that did not clash with their identities.

In this exploratory study, we developed an after-school program in which we worked with Latino adolescents as they selected problems in their communities and tried to solve them through engineering design processes. We sought to make this engineering experience "authentic" in the sense that they worked in teams on ill-structured problems over an extended duration of time (9 months). We sought to answer the following two research questions: (a) Did their perceptions of engineering change, and if so, how? and (b) Did their perceptions of their engineering abilities change, and if so, how?

Context of the Study

We followed a group of 25 Latino/a adolescents (ages 14-17) throughout the course of two different school years. During the first year, a total number of ten adolescents participated in the study. Two different venues were used to introduce the project to the adolescents and ask for volunteers. The participants were recruited through the local MESA (Mathematics, Engineering, and Science Achievement) and LIA (Latinos in Action) clubs from one high school in a rural area in the Western United States. During the second year of the study, a total number of fourteen students participated in the study. The adolescents were recruited from two different high schools in the same area where the participants for the first year of the study were selected. Adolescents were recruited from one of the high schools through a program called Latino Discovery, while participants from the other high school were recruited from a physics course offered at that high school. The adolescents selected to participate in the study spoke Spanish at home and most of them had received English as a second language (ESL) services at their school. All participants came from working class families–most of the adolescents' parents had limited education and worked in farming or other manual labor activities.

The adolescents were divided into different groups of three or four adolescents per group. The adolescents were grouped according to their geographical location; in other words, participants who lived in the same neighborhoods were in the same groups. This strategy made it easier for the participants to work together in their respective projects and in the same community. Each group selected a problem in their community that was of interest to them, and used engineering design processes to solve the problem. The community-based problems selected by the participants in the first year of the study are shown in Table 1. All the names are pseudonyms to protect the identity of the participants.

The community-based problems were characterized as ill-structured problems because they were "not constrained by the content domains being studied in classrooms." [21] For example, the community-based problems selected by the students were dynamic, required collaboration, involved multiple solutions, and the constraints, both engineering and non-engineering, were identified by the students themselves.[21, 22] The main objective was to observe how students used engineering design processes, how they perceived engineering, how those perceptions changed over time, and how their perceptions of their abilities as engineers changed.

The purpose of these community-based engineering design challenges was to allow the students to provide the adolescents with an opportunity to work in problems they were familiar with. In addition, the participants had an opportunity to analyze practical real-life problems that were of interest to them. This paper describes how the community-based engineering design challenges influenced the students' perceptions of engineering.

Table 1

Description of Groups and Community-Based Engineering Design Projects

Team	Team Composition	Community-Based Project
Team 1	Eduardo (male, 16 years old) Francisco (male, 17 years old) Miguel (male, 16 years old)	Design an automatic set of doors for people with disabilities at their school
Team 2	Eva (female, 16 years old) Laura (female, 17 years old) Mateo (male, 15 years old)	Improve a local playground in their community
Team 3	Ana (female, 16 years old) Noemi (female, 17 years old) Silvia (female, 15 years old) Zoe (female, 17 years old)	Improve an existing device used by veterinarians to restrain feral cats during vaccinations
Team 4	Emiliano (male, 17 years old) Patricio (male, 14 years old) Samuel (male, 16 years old)	Design a water-resistant and good-traction shoe for playing and running during the winter
Team 5	Alejandra (female, 15 years old) Andrea (female, 14 years old) Paula (female, 16 years old) Clarisa (female, 14 years old)	Improve a water catchment system for underprivileged communities in Honduras affected by hurricane Mitch
Team 6	Carmen (female, 17 years old) Dulce (female, 17 years old) Felicia (female, 16 years old) Katy (female, 16 years old)	Improve a playground swing for children in wheelchairs
Team 7	Claudia (female, 17 years old) Sandra (female, 16 years old) Sofia (female, 17 years old) Tomas (male, 17 years old)	Improve headrest on a tub-based shower chair for children with muscular dystrophy

Method

The adolescents who wished to participate in the project went through a specific selection process, which involved a 30-minute screening interview. These interviews were used to ask different questions to the adolescents to make sure they fulfilled the selection criteria for the study. First, the adolescents had to identify themselves as part of the Latino ethnolinguistic group. Second, they had to be enrolled in high school at the time of the study. Third, they had to speak Spanish at home. Finally, the adolescents must have received ESL services for an extended period of time (at least 3 years). The participants also described their ethnic and educational backgrounds and their parents' occupations during screening interviews.

After the participants were selected, one-on-one interviews were conducted with every participant. These initial interviews included questions regarding the participants' perceptions of engineering (i.e., what does the word engineering mean to you? What kind of problems do you think engineers might solve? What does an engineer do on the job?). Then, interviews were conducted every month not only to track the changes in perceptions of engineering but also to establish a relationship between the participants and the researchers in order to build a certain level or "confianza" or trust.[23] Every interview, which ranged from 30 to 60 minutes in length, was audio-recorded. All questions asked during these interviews were open-ended questions.

In the initial interviews, participants identified a time they solved a problem similar to one an engineer might solve and they ranked their solution on a scale from 1 to 10. They also ranked themselves on a scale from 1-10 regarding how good they thought they were at engineering. In the final interviews, they ranked their solution to the community-based problem they addressed. They also ranked themselves again on a scale from 1-10 regarding how good they thought they were at engineering after providing a solution to their community-based project. The average of their scores from the before interviews were compared to their average scores in the after interviews.

In addition to collecting individual interviews, we observed the group meetings, which were held about once every three weeks, in which the participants discussed how they would address the problems they selected. These group meetings were facilitated by two of the researchers with a background in engineering. The researchers' role was to ask open-ended questions to prompt discussion if the students seemed unsure of what to do next. The transcripts obtained from these meetings were used to create protocols for upcoming group meetings. All meetings were recorded using audio and/or video sources.

Finally, exit interviews were conducted with every student in order to determine how the participants' perceptions changed after working on their community-based engineering design problems. Exit interviews consisted of the same questions asked during the initial interviews conducted at the beginning of the study. A modified version of constant comparative analysis was used to analyze the data.[24] The whole data set was later analyzed while mutually agreeing on each code. The following paragraphs describe the findings obtained from data analysis.

Changes in Perceptions of Engineering

Data analysis showed that most of the participants changed not only their perceptions of engineering, but also how they perceived their self-efficacy as they worked on their community-based engineering design challenges. Different codes were developed, which described how participants' perceptions evolved over time. The following sections highlight the common themes that emerged from the data.

From Building Things to Doing Research

The initial perception of the students regarding engineering was similar to that described by other studies, which indicates that engineers are commonly described as individuals that apply mathematics and science, build things, or solve problems.[7, 13, 14, 25] Interestingly, participants emphasized the idea that engineers "fix things" or "build and construct things" during the initial interviews. Nonetheless, their perceptions of engineering changed to the extent of including broader descriptions of engineering, such as "improving existing designs," "working with constraints," or "considering trade-offs." For instance, Miguel went from a convoluted definition of "building something" or "working on cars" to describing an engineer as someone who "designs a project or takes a project and makes it better." Miguel expanded his perception of an engineer by describing an engineer as someone that can improve designs and not only building or working on something more mechanical like a car. He also included other descriptors to his definition of an engineer by mentioning skills that aligned with engineering, such as "doing research, analyzing, and investigating."

One of the questions during the interviews was to describe what engineers do on a daily basis. Some of the participants' responses involved "working with cables," "construction," or even wide-ranging physical descriptions. For example, Zoe answered this question as follows:

> I think of, like, the guys that are out fixing the road or the train tracks. They wear their orange jackets, like the ones that are bright so you can see them…And I think of them holding the signs and – like to go or stop – and tractors. Yeah, that's how I think of them. They are probably not all like that – and their [hard] hat, but yeah.

As indicated by Zoe's description, engineers not only worked building stuff or in construction but they also were described as males wearing hard hats and "bright" jackets. Her description of an engineer was similar to that described by other participants. Nonetheless, her description changed and during her final interview she indicated that engineers "would probably set up a plan first, or set up a layout of what they are going to do, like their ideas, and then probably go from there."

Throughout the duration of the study, the participants had an opportunity to learn about the engineering design model. Zoe changed her perception of what engineers do and described engineers as individuals that created a plan to provide solutions to problems. Her description was aligned with the activities involved in in the engineering design process (i.e., problem scoping, brainstorming ideas, evaluating solutions, doing research, etc.). The community-based engineering design challenges provided the students with the context to change their perceptions about engineering and go from the idea that engineering is only the application of math and science or building things to completely different context that included “come up with solutions,” “do research,” “creating ideas,” or “helping people.”

From Individual Work to Teamwork

Another common topic of conversation among participants was their changes of perception regarding teamwork. In their interviews, participants rarely mentioned teamwork as one of the characteristics of being an engineer. In fact, most of the initial responses involved more individualist traits rather than working as members of a group or a team toward a common goal.

After the project was completed, all adolescents had a different perspective on engineering and teamwork. The participants listed different attributes as important for all engineers and engineering professions. Some of these characteristics included good communication skills, working well with others, collaboration, exchanging ideas, and listening to others. All these characteristics were representative of skills necessary when working in teams. The community-based challenges provided the participants with the opportunity to explore other dimensions of engineering, such as teamwork,[7, 13, 25] that are important for engineers.

For instance, Emiliano described how working in the community-based engineering design challenge helped him learn about collaboration. He indicated that this engineering experience was different from what he had thought:

> There was pretty much a lot of teamwork involved. We had to decide on a design and work together to actually get that one design done…Here it was like, “oh we get to work together,” and we all had different ideas that we brought to the design and the whole research because Samuel looked at things one way, Patricio another, and I looked at them differently too. It was kind of like mixing them together to come up with the best design that we could. Because on your own you can only look at it the one way you look at it. It’s just one way, but if you are working with multiple people, there are more than one way to see a problem.

This excerpt describes how Emiliano perceived the importance of teamwork when trying to come up with solutions to the problem. He also indicated that working with people from different backgrounds and with different points of view helped improve the solutions to their problem. Overall, the participants agreed that this experience expanded their perception of engineering as being a field where teamwork is important.

From Male Engineers to Female Engineers

The majority of the participants in this study were females–only 8 out of the 25 participants were males. The boys in the study didn’t use gendered terms nearly as much as the girls, so the shift from before working on the project to after working on the project was much more indicative of a change in the girls’ perceptions of engineering. The girls constantly used the terms “he” or “guy” to describe engineers or engineering in general. For instance, when asked to describe an engineer and what an engineer does on a daily basis, Noemi answered the following:

> *He* looks at the problem and *he* thinks about it and *he* comes up with different options… Yeah, like multiple tests. And then *he* will learn from *his* mistakes and keep going and going and going, *he* is very perseverant and it works. Like I've never seen an engineer fail ever.

Noemi's answer highlights her idea that engineering is a male-oriented field. In addition, she described the engineer as an individual with attributes such as "perseverant." Nonetheless, her descriptions at the beginning of the study were never associated with females. Interestingly, during her exit interview, Noemi talked about engineering in more gender-neutral terms and when asked to describe an engineer she indicated, "he is smart–no, *she* is smart."

Similarly, other female participants talked about engineering in gender-specific terms before the project, but used no gendered terms after the project, or included the term "she" when referring to engineers. For example, Sara described an engineer with the following words:

> I feel like *she* would try any material *she* thinks would work. *She* would also test it out a lot. *She* would write a lot of notes, so when other people look at *her* experiments or when *she* tries to show it to someone, *she* could show *she* did trial and error. And be like "This is why this is the best one I did, this is why I think it's a better material to use."

Sara changed her perception of engineering as being male-oriented to a field were females are also active participants. Her perception of engineering included activities where women had engineering dispositions and participated in engineering activities. These examples illustrate how the engineering experience provided the girls with the opportunity to see engineering as a field that was not only for males. Overall, the community-based engineering design challenges influenced the participants' perceptions of engineering in terms of teamwork, gender, and characteristics of engineers.

Self-Perceptions of Engineering

Every participant was asked to rank themselves, on a scale from 1 to 10, regarding how good they thought they were at engineering and their final solution to their community-based engineering design problems. We found a 2.2 point increase for each category, indicating that, overall the participants thought they were better engineers than they were before the project. Although the purpose of this study was not to prove statistical significance, this pattern indicates a general improvement in students' self-perceptions as engineers.

A thematic analysis of the students' answers to these questions also indicated that (a) the participants felt like they had developed a better sense of whether or not they were good at engineering, and (b) they thought they were moderately good at engineering. The data below illustrate these two findings.

Before the project, 43% of participants were uncertain whether they were good at engineering. When asked "are you good at engineering," they gave responses such as, "I don't know" or "I'm not sure." Other students (36%) said they were "new," "beginners," or "haven't done it." Finally, 14% of students held low self-perceptions of themselves as engineers, using phrases such as, “I’m not very good,” or “I don’t think I’m good at engineering.”

By contrast, after the project, nobody believed that they were bad at engineering. Instead, 72% said they thought they were “pretty good” at it. Of these respondents, only four participants stated unequivocally that they were good at engineering, while the rest of them qualified their answer with “I’m pretty good” or “fairly good.” We interpret this finding to mean that, although the participants’ engineering self-perceptions generally improved after participating in the project, they still expressed a degree of tentativeness in how they perceived their engineering skills.

Interestingly, of the four respondents who expressed that they were definitely good at engineering, three of them used the term “we” rather than “I” to describe their engineering skills. For instance, one participant said, “We’re pro; we’re so pro,” while a second participant said, “As a team, I think we did good as engineers.” In other words, the participants who developed the most positive perceptions of their engineering abilities did so in the context of their collective engineering skills as a team, rather than in the context of their engineering skills as individuals.

Although most participants thought they were good at engineering to some degree after participating in the project, 22% classified their engineering skills as “average.” Specifically, they used phrases such as, “I’m not bad but I’m not the best,” “I think that I’m kind of in the middle,” “I’m all right; I wouldn’t say good, just all right,” and “I don’t know if I could say I am good, but I feel like I did grow as a person. I feel medium, not really good, but not as bad.” Several of these answers indicated that the participants did not necessarily saw themselves as “good” at engineering, but they at least felt they had grown so that they were no longer “as bad” as they were before the project began. None of the participants called themselves “beginners,” as they did at the beginning of the project, and only one participant still indicated she was “not sure” about whether she was good at engineering or not.

Lastly, we noted that several of the participants stated at the end of the project that “Anyone can be an engineer if they really wanted to,” because they defined engineering more in terms of problem solving, teamwork, and helping others, and as one student said, “I definitely have those traits.”

Discussion and Implications

In an effort to provide transcendental engineering experiences for Latinos, this intervention was intended to give students an opportunity to work in authentic engineering experiences where students could provide solutions to problems affecting their communities. These experiences promoted a sense of independency and self-empowerment with respect to engineering.[25] For instance, participants were able to relate some of their everyday lives to engineering practices. For example, Felicia mentioned during an interview, “I thought we were going to be told what to do.” Instead, the participants engaged in practices where they had the power to select their own projects and were able to connect with their communities. Consequently, one implication for future research is to make the participants active and to give them agency or self-determination because multiple participants reported that empowerment was one thing they liked about the project.

Not only was the engineering experience relevant for the adolescents, but it also helped the participants change their perceptions of engineering. As mentioned earlier, participants indicated that engineering was not only making things or applying mathematics, but their perceptions changed to include other traits, elements, dispositions, or practices that were important in engineering such as working in teams. Moreover, the participants in some ways identified with engineering after the project was finalized. According to Stevens and colleagues, identifying with engineering is a key factor in retaining students in engineering, particularly underrepresented students, because those who are perceived as engineers by their peers can determine who would fit or be successful in engineering.[7, 8, 13]

Surprisingly, only a few participants mentioned that engineering was about helping others after the project even though every project they selected was intended to help a disadvantaged population. Nonetheless, before the project, the participants often mentioned that engineering was "building," whereas after the project they thought more of engineering in term of problem solving, considering trade-offs, and working with constraints. Although other studies have indicated that students do not see engineering as a field used to "help others," [7, 8] interventions like the one described in this study can help high school students change their overall perception of engineering and make it more relatable to their lives. Community engagement and giving students autonomy in different engineering activities allows for an increase in inclusiveness and increases the motivation of students and their self-perception as engineers.[26]

Finally, this study suggests that the intervention helped female participants change their perceptions of engineering. Females in the study changed their descriptions of engineers as being male to descriptions that involved females. Effective practices, such as providing engaging activities or cooperative learning experiences, increase and promote the retention and persistence of females in engineering.[3] In this case, the participants engaged in engineering practices while shifting their perceptions of engineering because there was a venue for them to feel empowered and see engineering from a different lens where they had autonomy.[25] This environment allowed for a change in the girls perception of engineering and, therefore, see themselves as individuals with the same characteristics that are usually perceived as descriptive of a male-oriented or exclusive profession.

Bibliographic Information

[1] U.S. Census Bureau. (2012). *Hispanic heritage month 2012: Sept. 12 – Oct. 15*. Retrieved from http://www.census.gov/newsroom/releases/pdf/cb12ff-19_hispanic.pdf

[2] Fry, R., & Gonzales, F. (2008). *A profile of Hispanic public school students: One-in-five and growing fast* [PDF document]. Retrieved from: http://www.pewhispanic.org/2008/08/26/one-in-five-and-growing-fast-a-profile-of-hispanic-public-school-students/

[3] Lichtenstein, G., Chen, H. L., Smith, K. A. & Maldonado, T. (2014). Retention and persistence of women and minorities along the engineering pathway in the United States. In A. Johri & B. M. Olds (Eds.), *Handbook of engineering education research* (pp. 311-334). New York, NY: Cambridge University Press.

[4] Carter, D. F. (2006). Key issues in the persistence of underrepresented minority students. *New Directions for Institutional Research, 130*, 33-46.

[5] Chapa, J., & De La Rosa, B. (2006). The problematic pipeline: Demographic trends and Latino participation in graduate science, technology, engineering, and mathematics programs. *Journal of Hispanic Higher Education*, *5*(3), 203-221.

[6] Rochin, R., & Mello, S. (2007). Latinos in science: Trends and opportunities. *Journal of Hispanic Higher Education, 6*(4), 305–355.

[7] Stevens, R., O'Connor, K., Garrison, L., Jocuns, A., & Amos, D. M. (2008). Becoming an engineer: Toward a three dimensional view of engineering learning. *Journal of Engineering Education, 97*(3), 355-368.

[8] Stevens, R. O'Connor, K., & Garrison, L. (2005). Engineering student identities in the navigation of the undergraduate curriculum. In *Proceedings of the 2005 American Society for Engineering Education Annual Conference*. Portland, OR: ASEE.

[9] Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation, and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching, 47*, 564-582.

[10] National Academy of Engineering and National Research Council. (2009). *Engineering in K-12 education: Understanding the status and improving the prospects.* Washington, DC: National Academies Press.

[11] Wertsch, J. V. (1998). *Mind as action*. New York, NY: Oxford University Press.

[12] Tonso, K. L. (2014). Engineering identity. In A. Johri & B. M. Olds (Eds.), *Handbook of engineering education research* (pp. 267-282). New York, NY: Cambridge University Press.

[13] Godfrey, E., & Parker, L. (2010). Mapping the cultural landscape in engineering education, *Journal of Engineering Education, 99*, 5-22.

[14] Pawley, A. L. (2009). Universalized narratives: Patterns in how faculty describe "engineering." *Journal of Engineering Education, 98*(3), 309-319.

[15] Meyers, K. L., Ohland, M. W., Pawley, A. L., Siliman, S. E., & Smith, K. A. (2012). Factors relating to engineering identity. *Global Journal of Engineering Education, 14*(1), 119-131.

[16] McGee, E. & Martin, D. (2011). You would not believe what I have to go through to prove my intellectual value! Stereotype management among successful Black college mathematics and engineering students. *American Educational Research Journal, 48*(6), 1347-1389.

[17] Tonso, K. L. (2006). Teams that work: Campus culture, engineer identity, and social interactions. *Journal of Engineering Education*, *95*(1), 25-37.

[18] Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education*, *96*(2), 103-115.

[19] Tonso, K. L. (1996). The impact of cultural norms on women. *Journal of Engineering Education, 85*(3), 217-225.

[20] Adams, R., Evangelou, D., English, L., Dias de Figueiredo, A., Mousoulides, N., Pawley, A., Schifellite, C., Stevens, R., Svinicki, M., Trenor, J. M., & Wilson, D. M. (2011). Multiple perspectives on engaging future engineers. *Journal of Engineering Education, 100*, 48-88.

[21] Jonassen, D. H. (2014). Engineers as problem solvers. In A. Johri & B. M. Olds (Eds.), *Handbook of engineering education research* (pp. 103-118). New York, NY: Cambridge University Press.

[22] Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of Engineering Education*, *95*(2), 139-151.

[23] Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*, 132-141.

[24] Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). Thousand Oaks, CA: Sage.

[25] Riley, D., Slaton, A. E., & Pawley, A. L. (2014). Social justice and inclusion: Women and minorities in engineering. In A. Johri & B. M. Olds (Eds.), *Handbook of engineering education research* (pp. 335-356). New York, NY: Cambridge University Press.

[26] Swan, C., Paterson, K., & Bielefeldt, A. R. (2014). Community engagement in engineering education as a way to increase inclusiveness. In A. Johri & B. M. Olds (Eds.), *Handbook of engineering education research* (pp. 357-372). New York, NY: Cambridge University Press.