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# Measuring Community College Students' Self-Efficacy toward Circuit Analysis

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## Measuring Community College Student's Self-Efficacy toward Circuit Analysis

### Introduction

DC circuit analysis has been identified in the literature as being particularly difficult for students to learn[1,2,3]. Research on the difficulties students face regarding this topic focuses solely on 4-year university students, which neglects students studying this topic in alternative institutions like community colleges. The one common link between research on university and community college students is self-efficacy. This is rooted in the fact that many strategies to increase student interest, achievement, retention and persistence in both engineering and engineering technology programs are based on increasing self-efficacy. Self-efficacy has been used in studies as a measure of engineering design[4], persistence[5,6], success in mathematics[7,8], gender in engineering education[9,10], career choice[11], and more. Self-efficacy has been shown to be correlated with several key personal and academic characteristics, as outlined in Table 1. Students who have high self-efficacy for circuit analysis should have high confidence in their responses to an assessment of circuit analysis.

**Table 1. Characteristics Correlated with Self-Efficacy**

| | | |
|---|---|---|
| Hours worked each week[12] | Total time in program[13,14] | Number of college chemistry courses[15] |
| Gender[15,16] | Taken remedial Math[17] | Taken remedial English[17] |
| Race/Ethnicity[12] | Highest high-school Math course[15,18,19] | Marital status[17] |
| Percentage of tuition paid by financial aid[20] | Dependent children[21] | |

This paper extends the work of others by applying prior research on self-efficacy and circuit analysis to a community college engineering student population.

### Literature Review

Community college students are different from university students. Community college students, in general, have different educational goals and academic backgrounds than their university cohorts; the principal role of the community college is to be the provider of workplace and skill training. Most community colleges attract students who are underrepresented minorities, older, female, and those in search of education for a career change. Many of these students are ill-prepared for college[22]. Compared to their university counterparts, community college students generally arrive on campus with issues related to academics, family, finances, and personal issues. Specific demographic and personal characteristics related to these issues are highlighted in Table 2. What is not known is how the characteristics that define a community college engineering student population are related to their self-efficacy for circuit analysis.

**Table 2. Unique Characteristics of Community College Students**

| Category | Characteristics | |
|---|---|---|
| Academics | Require remedial Math[17,23] | Require remedial English[17,23] |
| | Less Chemistry, Physics & Math courses in high school[19] | Less Chemistry, Physics & Math courses in college[18] |
| | Lower high-school GPA[12] | Longer time working toward degree[23] |
| Family | Married[21] | Have dependent children[21] |
| | Less parental education[24] | |
| Finances | Dependent on Financial Aid[21] | Work full, or more than part-time[25] |
| Personal | Under-represented Minority[23] | Older than university students[23] |
| | Take time off from studies[25] | First-generation college student[24] |

## Methods

### *Study Context and Participant Population*

This study was conducted at a large community college in the southwestern United States. Students from three introductory circuit analysis courses in the Electronics program were studied. Participation was voluntary. There was a total pre-test population of 48, of which, 44 (n = 44) subjects participated. For the post-test, there was a total population of 41, with 37 (n = 37) subjects participating. Table 3 summarizes the three groups of participants for both the pre and post-test.

**Table 3. Section Sample Sizes for Pre- and Post-test**

| **Section** | **Pre-test Sample Size** | **Post-test Sample Size** |
|---|---|---|
| ELE 111 (morning) | 14 | 14 |
| ELE 100 | 12 | 10 |
| ELE 111 (evening) | 18 | 13 |
| **Total** | **44** | **37** |

Four students, all enrolled in ELE 111, were female. All four female students from the pre-test remained in the study. All participants were classified by the institution as freshmen or sophomores.

### *Data Collection*

An instrument was created to measure the relationships between self-efficacy for DC circuit analysis and personal and academic characteristics. The instrument asked students questions related to their confidence in each of their answers to a concept inventory. Questions were worded as “How confident are you about your answers given for parts 1 (multiple choice assessment of understanding) and 2 (written description of understanding)?” Responses were reported using a 100-point range on a Likert scale with 10-unit intervals. Prompts were provided at “0 - Not at all confident”, “40 - Maybe-Not Sure”, “70 - Pretty Confident”, and “100 - Completely Confident”. This was consistent with prior approaches in the literature [2,4,14]. Personal and academic characteristics were measured via demographic questions that had been found in the literature, as outlined previously in Tables 1 and 2. Sample items from the instrument are shown in Figures 1 and 2. The item in Figure 1 was the third item on the instrument, and it assessed conceptual knowledge of current and the subject’s confidence in their response. The item in Figure 2 was the fifth item on the instrument, and it assessed conceptual knowledge of voltage and the subject’s confidence in their response.

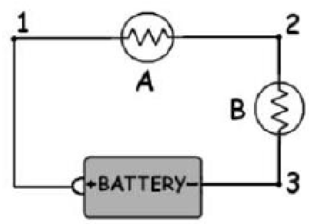


**Figure 1**

**3.1.** In Figure 3, compare the magnitudes of the currents at points 1, 2, 3 and 4, as well as the brightness of bulbs A and B. Circle the letter next to your answer.

| | Current | Brightness |
|---|---|---|
| a. | $i_1 = i_2 = i_3$ | Bulbs A and B are the same brightness |
| b. | $i_3 > i_2 > i_1$ | Bulb B is brighter |
| c. | $i_1 > i_2 > i_3$ | Bulb A is brighter |
| d. | $i_1 > i_2 > i_3$ | Bulbs A and B are the same brightness |

**3.2.** Which one of the following is the reason for your answer in the first part? Circle the letter next to your answer.

a. The closer the bulb is to the battery, the brighter it is.

b. In circuits in series, magnitude of the current is the same at any point.

c. Because the electric current is consumed by the bulbs, it diminishes.

d. ____________________________________________

**3.3.** How confident are you about your answers given for parts 1 and 2? Circle the number that best matches how confident you are.

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| Not at all confident | | | | Maybe/ Not Sure | | | Pretty Confident | | | Completely Confident |

**Figure 1. Sample Instrument Item Assessing Current and Confidence**

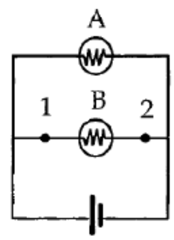


**Figure 1**

**5.1.** Referring to Figure 5, what happens to the potential difference between points 1 and 2 if Bulb A is removed? Circle the letter next to your answer.

a. Increases      b. Decreases      c. Stays the same

**5.2.** Which one of the following is the reason for your answer in the first part? Circle the letter next to your answer.

a. The battery provides the same amount of current to each circuit, regardless of the circuit arrangement.

b. Parallel connections have the same voltage.

c. Since the bulbs are equal, removing bulb A leaves twice as much current for bulb B.

d. By removing bulb A, there is more current in the circuit, and thus more voltage for bulb B.

e. ______________________________________________________________

**5.3.** How confident are you about your answers given for parts 1 and 2? Circle the number that best matches how confident you are.

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| Not at all confident | | | | Maybe/ Not Sure | | | Pretty Confident | | | Completely Confident |

**Figure 2. Sample Instrument Item Assessing Voltage and Confidence**

*Data Analysis*

Pre and post-test data were analyzed using SAS Enterprise Guide version 5.1. Internal reliability of the instrument was first checked for both the pre and post-test to ensure reliability. The instrument was found to be excellent ($\alpha = 0.935$). Face and content validity were established via research on past studies that used this approach for domains outside of circuit analysis[4,14,26]. Construct validity was not established due to the low number of subjects and the large number of characteristics measured.

To ensure consistency between pre and post-test, only those subjects who participated in both the pre and post-tests were included in the data set. Group effects for the population from the three separate classes was analyzed using Analysis of Variance (ANOVA). No differences were present for the pre-test [$F(2,36) = 0.50$, $p = 0.612$] or the post-test [$F(2,36) = 0.20$, $p = 0.817$].

Both pre- and post-test data sets were analyzed to investigate correlations between demographic data and self-efficacy for circuit analysis.

## Findings and Discussion

The literature identified eleven characteristics to be correlated with self-efficacy. Those characteristics were previously listed in Table 1. The results of the pre and post-test correlation analyses are shown in Table 4.

Examination of the pre-test correlations revealed that none of the demographics measured were significantly correlated with self-efficacy for circuit analysis. The post-test analysis revealed that subject's age and subject's father's education level were both significantly correlated with post-test self-efficacy for circuit analysis. Both age and father's education level combined to explain a total of 29.90% of the post-test variance in self-efficacy for circuit analysis. Neither was previously identified in the literature as correlating with self-efficacy.

*Subject's Age*

The age of the subject was significantly correlated with post-test self-efficacy for circuit analysis ($R = 0.43$, $p = 0.008$). This represents a moderate correlation[27], accounting for 18.49% of the post-test variance in self-efficacy for circuit analysis. This positive correlation indicates that the older a student is, the higher their self-efficacy for circuit analysis.

This finding is different from the vast majority of the literature, which tends to indicate no relationship, or even an inverse relationship between age and self-efficacy. One recent study provides support for this finding. Whannell, et al.[28] studied a cohort of students enrolled in a university program intended to prepare those students for university-level studies. Prior to starting the program, age was inversely correlated with self-efficacy. The longer students stayed enrolled in the program, the more their self-efficacy increased. What is unique about this finding is that self-efficacy scores eventually increased so much that the final post-test relationship between age and self-efficacy was no longer inversely correlated. The authors of the study attributed this change in self-efficacy to older students becoming more familiar with professors' expectations and testing procedures. The work of Whannell, et al. may help to explain the findings of the present study because the two populations were of similar age, prior education level, and displayed the same trend. Unfortunately, details of these two similarities cannot be investigated further, as the authors did not provide information regarding the breakdown of age or education level other than ranges and mean values. While this finding is different from much of the literature regarding correlations between age and self-efficacy, it is possible that the subjects of the present study saw their self-efficacy increase between the pre and post-test as they became more familiar with their professors and their circuit analysis course.

**Table 4. Correlations Among Demographics and Pre- and Post-Test Self-Efficacy Scores**

| | Pre-Test | | Post-Test | |
|---|---|---|---|---|
| **Characteristic** | **R** | **(p)** | **R** | **(p)** |
| Self-Efficacy Score | 1 | -- | 1 | -- |
| Age | 0.19 | (0.259) | 0.43* | 0.008 |
| Gender | -0.13 | (0.454) | 0.01 | 0.969 |
| Ethnicity | 0.13 | (0.454) | -0.22 | 0.190 |
| Marital Status | 0.19 | (0.262) | 0.23 | 0.168 |
| Have Children | 0.18 | (0.286) | 0.28 | 0.097 |
| # Hours worked | 0.32 | (0.057) | 0.30 | 0.073 |
| % Tuition Paid by Financial Aid | 0.12 | (0.478) | 0.28 | 0.104 |
| Mother's Education | 0.08 | (0.634) | -0.11 | 0.519 |
| Father's Education | -0.28 | (0.098) | -0.34* | 0.042 |
| Student's Prior Education | -0.04 | (0.795) | -0.11 | 0.525 |
| 1st Generation Student | -0.18 | (0.300) | -0.12 | 0.462 |
| HS GPA | -0.15 | (0.419) | 0.05 | 0.782 |
| HS Chemistry | 0.15 | (0.365) | 0.02 | 0.917 |
| HS Physics | 0.18 | (0.285) | 0.03 | 0.853 |
| HS Math | -0.16 | (0.354) | -0.07 | 0.705 |
| College GPA | 0.00 | (0.987) | -0.02 | 0.934 |
| # Credits this Semester | -0.25 | (0.140) | -0.09 | 0.577 |
| Taken Remedial Math | 0.11 | (0.532) | 0.08 | 0.634 |
| Highest College Math | 0.02 | (0.894) | 0.27 | 0.135 |
| Highest College Math Grade | -0.05 | (0.802) | 0.08 | 0.701 |
| Taken ELE 100 | 0.25 | (0.137) | -0.04 | 0.818 |
| College Chemistry | -0.14 | (0.423) | 0.14 | 0.416 |
| College Physics | -0.11 | (0.533) | 0.09 | 0.577 |
| Taken Remedial English | -0.11 | (0.530) | -0.27 | 0.106 |
| Taken Semester Off | 0.06 | (0.715) | -0.01 | 0.954 |
| # Semesters In Current Program | 0.13 | (0.452) | -0.05 | 0.758 |
| Course Required for Major | -0.11 | (0.535) | -0.10 | 0.561 |
| 1st Semester in School | -0.21 | (0.219) | -0.08 | 0.650 |
| Currently Take Math Class | -0.06 | (0.720) | 0.09 | 0.591 |

*Father's Education Level*

The education level of the fathers of the study subjects was negatively correlated with post-test self-efficacy for circuit analysis ($R = -0.34$, $p = 0.042$). While this is statistically significant, it is considered a weak correlation[27], accounting for 11.56% of the post-test variance in self-efficacy for circuit analysis. This negative correlation indicates that the lower the education level of the student's father, the higher the student's self-efficacy for circuit analysis. Likewise, the higher the education level of the student's father, the lower the student's self-efficacy for circuit analysis.

Parental education level is one measure of socioeconomic status (SES)[29,30]. Parental education level as a measure of SES has been shown to directly influence children's academic self-efficacy[31,32]. One study by Weiser & Riggio[33] found that students from low SES families had higher academic self-efficacy than students from high SES families. The authors determined that many of the students in that study were first-generation college students, and simply attending the university was considered an achievement for them. They also determined that many of the students considered lower family SES as motivation for higher achievement. This finding is consistent with the results of a study on Hispanic high school students[34] who viewed their lower-educated parents as "an example of what life would be like if they did not pursue higher education (pg. 91)". For the present study, this same inverse relationship between subject's father's education level and self-efficacy was found. Just under 20% of the subjects self-identified as being first-generation students, and the same percentage self-identified as being Hispanic.

Since there is similarity between the subjects used by Weiser and Riggio and those subjects in the present study, Weiser and Riggio's results partially explain the relationship between a lower-educated father and a child with high self-efficacy. They do not explain why the child of a higher-educated father would have lower self-efficacy. One explanation may have to do with parental expectations and the stigma associated with attending a community college. Parents who attended prestigious colleges and universities tend to expect the same for their children[35,36], and will use their influence over their children to guide them toward meeting those expectations[37]. This may occur even if the children are unprepared or otherwise not ready to attend college[30]. The stigma associated with community colleges is that the general public does not consider them "college", but instead "high school, Part 2"[38,39]. This stigma continues to be perpetuated by low tuition, general lack of knowledge about community colleges, and inaccurate portrayals on popular television shows[39]. In short, community colleges do not have the same level of prestige as most universities. The findings from the present study regarding highly-educated fathers and their children who have low self-efficacy for circuit analysis may possibly be explained as an issue of higher SES students who might feel unprepared to take a difficult course such as circuit analysis, or perhaps feel as though they have disappointed their higher-educated parents by attending a community college.

## Conclusions and Recommendations

As the primary source of technical and workplace training, community colleges play an important role in educating a highly skilled engineering and technical workforce. This has not impacted the focus of research in engineering education as most research has focused on university students. There are extremely few studies on the community college engineering population, and most of what does exist tends to focus on retention, transfer, or the larger STEM fields. Community college engineering students are different from university engineering students, which require different approaches and solutions to their unique problems.

This study contributes two findings to the body of knowledge. The age of a community college engineering student is directly correlated with their self-efficacy for circuit analysis, and student's father's education level is inversely correlated with the student's self-efficacy for circuit analysis. Older community college engineering students had higher self-efficacy for circuit analysis than their peers, which contradicts much of the literature. This significant finding should be further investigated given its rarity in the literature. Perhaps one consideration for future research is to include an intermediate assessment between the pre and post-tests. Whannell et al. noted that the change in self-efficacy was gradual over the course of a semester. There is no indication from the present study of when this change in self-efficacy for circuit analysis occurred. This information could have direct applications in the community college engineering classroom. Instructors could identify students with low self-efficacy in order to offer additional assistance or scaffolding for a sufficient period of time that would allow those students to build their confidence.

The second finding this study contributes to the body of knowledge is the relationship between student's father's education level and the student's self-efficacy for circuit analysis. Community college engineering students who have lower-educated fathers were found to have higher self-efficacy for circuit analysis, and those who have higher-educated fathers had lower self-efficacy for circuit analysis. This finding is new to the literature, but can be reasoned. Additional research of this novel finding should be performed, particularly with regard to the relationships between SES, first generation students, and self-efficacy. One recommendation for future research is to modify the demographic portion of the survey instrument to include additional questions pertaining to respondent SES. More information will only help to clarify and possibly support this unique finding.

Future studies should be conducted to confirm these findings as well as to identify additional links between personal characteristics and self-efficacy of community college engineering students. One avenue for future research includes extending the study into a longitudinal study to collect data over time. This study and Whannell et al.'s study had similar outcomes with subject samples that had similar characteristics, but there does not appear to have been a follow-up to Whannell's work. Without additional information, the results of both studies may be considered anomalies. If the positive correlation between age and self-efficacy is confirmed, this would not only further support the assertion that community college engineering students are different from university engineering students, but could also identify other characteristics that differentiate community college engineering students from each other in regard to their individual self-efficacy. This could lead to personalized education, which is also one of the 14 Grand Challenges for Engineering proposed by the National Academy of Engineering[40].

A final consideration for continuing this research is to expand the study to include other populations. The community college engineering population is different from the university engineering population. Given the role the community college plays in educating a skilled workforce, those differences require educational approaches that match the needs of the population being served. Expanding the scope of this study may help to further identify the characteristics and subsequent needs of a larger population, and possibly help more of those students complete their technical education goals.

**Bibliography**


[1] Engelhardt, P. V., & Beichner, R. J. (2004). Students' Understanding of Direct Current Resistive Electrical Circuits. *American Journal of Physics, 72*(1), 98-115.

[2] Streveler, R., Geist, M., Ammerman, R., Sulzbach, C., Miller, R., Olds, B., & Nelson, M. (2006). Identifying and Investigating Difficult Concepts in Engineering Mechanics and Electric Circuits. *Proceedings of the 2006 ASEE Annual Conference.* Chicago: American Society for Engineering Education.

[3] Peşman, H., & Eryilmaz, A. (2010). Development of a Three-Tier Test to Assess Misconceptions About Simple Electric Circuits. *The Journal of Educational Research, 103*, 208-222.

[4] Carberry, A. R., Lee, H.-S., & Ohland, M. W. (2010). Measuring Engineering Design Self-Efficacy. *Journal of Engineering Education, 99*(1), 71-79.

[5] Brown, S. D., Lent, R. W., & Larkin, K. C. (1989). Self-Efficacy as a Moderator of Scholastic Aptitude - Academic Performance Relationships. *Journal of Vocational Behavior, 35*, 64-75.

[6] Concannon, J. P., & Barrow, L. H. (2010). Men's and Women's Intentions to Persist in Undergraduate Engineering Degree Programs. *Journal of Science Education Technology, 19*, 133-145.

[7] Khezri azar, H., Lavasani, M. G., Malahmadi, E., & Amani, J. (2010). The Role of Self-Efficacy, Task Value, and Achievement Goals in Predicting Learning Approaches and Mathematics Achievement. *Procedia Social and Behavioral Sciences, 5*, 942-947.

[8] Bonham, B. S., & Boylan, H. R. (2011). Developmental Mathematics: Challenges, Promising Practices, and Recent Initiatives. *Journal of Developmental Education, 34*(3), 2-10.

[9] Concannon, J. P., & Barrow, L. H. (2009). A Cross-Sectional Study of Engineering Students' Self-Efficacy by Gender, Ethnicity, Year, and Transfer Status. *Journal of Science Education Technology, 18*, 163-172.

[10] Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women Engineering Students and Self-Efficacy: A Multi-Year, Multi-Institution Study of Women Engineering Student Self-Efficacy. *Journal of Engineering Education, 98*(1), 27-38.

[11] DiLisi, G., McMillin, K., & Virstek, M. (2011). Project WISE: Building STEM-Focused Youth-Programs that Serve the Community. *Journal of STEM Education, 12*(5 & 6), 38-45.

[12] Kane, M. A., Beals, C., Valeau, E. J., & Johnson, M. J. (2004). Fostering Success Among Traditionally Underrepresented Student Groups: Hartnell College's Approach to Implementation of the Math, Engineering, and Science Achievement (MESA) Program. *Community College Journal of Research and Practice, 28*, 17-26.

[13] Spellman, N. (2007). Enrollment and Retention Barriers Adult Students Encounter. *The Community College Enterprise, 13*(1), 63-79.

[14] Pajares, F. (2009). Motivational Role of Self-Efficacy Beliefs in Self-Regulated Learning. In D. H. Schunk, & B. J. Zimmerman (Eds.), *Motivation and Self-Regulated Learning: Theory, Research and Applications* (pp. 111-139). New York, NY, USA: Taylor & Francis.

[15] Buchanan, D. G. (2006). *An Exploration of the Gateway Math and Science Course Relationships in the Los Angeles Community College District.* University of Southern California, Rossier School of Education. Ann Arbor, MI: ProQuest Information and Learning Company.

[16] Besterfield-Sacre, M., Moreno, M., Shuman, L. J., & Atman, C. J. (2001, October). Gender and Ethnicity Differences in Freshmen Engineering Student Attitudes: A Cross-Institutional Study. *Journal of Engineering Education, 90*(4), 477 - 489.

[17] Chatman, L. M. (2007). *Persistence of Community College Engineering Science Students: The Impact of Selected Cognitive and Noncognitive Characteristics.* Wilmington College, Educational Innovation and Leadership. Ann Arbor, MI: ProQuest Information and Learning Company.
[18] Adleman, C. (1998). *Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers.* U.S. Department of Education. Washington, DC: U.S. Department of Education.
[19] Tyson, W. (2011). Modeling Engineering Degree Attainment Using High School and College Physics and Calculus Coursetaking and Achievement. *Journal of Engineering Education, 100*(4), 760-777.
[20] Hayden, D. C., & Holloway, E. L. (1985). A Longitudinal Study of Attrition Among Engineering Students. *Engineering Education, 75*(7), 664-668.
[21] Packard, B. W.-L., Gagnon, J. L., & Senas, A. J. (2012). Navigating Community College Transfer in Science, Technical, Engineering, and Mathematics. *Community College Journal of Research and Practice, 36*, 670-683.
[22] Hagedorn, L. S., & Purnamasari, A. V. (2012). A Realistic Look at STEM and the Role of Community Colleges. *Community College Review, 40*(2), 145-164.
[23] Cohen, A. M., & Brawer, F. B. (2008). *The American Community College.* San Francisco, CA, USA: Jossey-Bass.
[24] Cassidy, T. (2004). Mapping Variables Related to Social Identity, Distress and Perceived Health in an Undergraduate Student Population. *Social Psychology of Education, 7*, 339-352.
[25] Alfonso, M. (2006, Spring). Hispanic Educational Attainment in Sub-Baccalaureate Programs. *New Directions For Community Colleges, 133*, 17 - 25.
[26] Bong, M. (2001). Role of Self-Efficacy and Task-Value in Predicting College Students' Course Performance and Future Enrollment Intentions. *Contemporary Educational Psychology, 26*, 553-570.
[27] Taylor, R. (1990). Interpretation of the Correlation Coefficient: A Basic Review. *Journal of Diagnostic Medical Sonography, 6*(1), 35-39.
[28] Whannell, P., Whannell, R., & Allen, B. (2012). Investigating the Influence of Teacher Strategies on Academic Self-Efficacy ansd Study Behaviour of Students in a Tertiary Bridging Program. *Australian Journal of Adult Learning, 52*(1), 39-65.
[29] Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic Status and Child Development. *Annual Review of Psychology, 53*, 371-399.
[30] Wells, R. S., & Lynch, C. M. (2012). Delayed College Entry and the Socioeconomic Gap: Examining the Roles of Students Plans, Family Income, Parental Education, and Parental Occupation. *The Journal of Higher Education, 83*(5), 671-697.
[31] Inman, W. E., & Mayes, L. (1999). The Importance of Being First: Unique Characteristics of First Generation Community College Students. *Community College Review, 26*(4), 3-22.
[32] Horn, L., & Bobbitt, L. (2000). *Mapping the Road to College: First Generation Students' Math Track, Planning Strategies, and Context of Support (NCES Publication No. 2000-153).* Washington, DC: US Government Printing Office.
[33] Weiser, D. A., & Riggio, H. R. (2010). Family Background and Academic Achievement: Does Self-Efficacy Mediate Outcomes? *Social Psychological Education, 13*, 367-383.
[34] Ojeda, L., & Flores, L. Y. (2008). The Influence of Gender, Generation Level, Parent's Education Level, and Perceived Barriers on the Educational Aspirations of Mexican American High School Students. *The Career Development Quarterly, 57*(1), 84-95.
[35] Hearn, J. C. (1991). Academic and Nonacademic Influences on the College Destinations of 1980 High School Graduates. *Sociology of Education, 64*(3), 158-171.
[36] Karen, D. (2002). Changes in Access in Higher Education in the United States. *Sociology of Education, 75*, 191-210.
[37] Ma, Y. (2009). Family Socioeconomic Status, Parental Involvement, and College Major Choices - Gender, Race/Ethnic, and Nativity Patterns. *Sociological Perspectives, 52*(2), 211-234.
[38] Blankenship, M. (2010). Is Community College Really College? *The Hispanic Outlook in Higher Education, 20*, 20-21.

39 Miranda, M. E. (2014, Mar 13). The Old Community College Try. *Diverse Education*, pp. 60-62.
40 National Academy of Engineering. (2008, Feb 16). *Introduction to the Grand Challenges for Engineering*. Retrieved from NAE Grand Challenges for Engineering: http://www.engineeringchallenges.org/cms/8996/9221.aspx