Impact of Dual Credit Introduction to Engineering Course on Female High School Students' Self-Efficacy and Decisions to Follow a Career in Engineering (Evaluation)

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Abstract

ENGR 102 HS is a dual credit, introduction to engineering course offered in 38 high schools across Arizona and Southern California. ENGR 102 HS is taught by high school teachers in public, charter and private high schools. Since its pilot effort in academic year 2008-09, the ENGR 102 HS program has provided 2,131 high school juniors and seniors with three units of college credit while they explore the field of engineering as a possible career choice.

Many young people do not understand what engineering is and the creative work that engineers do. This is why a dual credit introduction to engineering course offered to high school students is so important. ENGR 102 HS curriculum focuses on presenting engineering as a helping profession that improves the human condition. Engineering service learning and biomedical projects are presented to pique the interest of a broad population of students. ENGR 102 HS allows students to try hands-on, design and build projects while still in high school where the risk is low and teacher scaffolding and contact time is high. This broad approach to an introduction to engineering course at the high school level is important to attracting the most diverse, brightest, and creative problem-solvers into the profession.

This paper will briefly describe the ENGR 102 HS course curriculum. Five years of student course evaluation survey data (2011-2012 to 2015-2016) for 1469 students both female (N= 289) and male (N=1180) were explored. Statistically significant differences were found in the overall engineering self-efficacy of male and female students using independent sample t-tests. Univariate Analysis of Variance also revealed gender differences in the importance of various elements of self-efficacy to a student's interest in becoming an engineer. Specifically, self-efficacy in traditional STEM coursework predicted interest in becoming an engineer for male but not female students. For female students, experience in the ENGR 102 HS course was found to predict interest in becoming an engineer. This finding demonstrates the positive impact the ENGR 102 HS course has on female students.

1. Introduction

In order to compete in the global market, the United States must continue to train the brightest students in Science, Technology, Engineering and Mathematics (STEM) fields. One way to increase the pool of students seeking engineering degrees is to reach out to those who are less inclined to choose an engineering degree program. Many high school students have no exposure to engineers or to the engineering profession. Additionally, some students might be uncomfortable with the academic challenges a university engineering degree could pose and are also unaware of the opportunities an engineering degree could provide. Many of these high school students lack the self-efficacy or an intrinsic belief that they have "what it takes" to succeed in engineering.

ENGR 102 HS is a dual credit, University of Arizona (UA) introduction to engineering course that is taught by high school teachers to high school students. It is unique in that this course is offered in the high school classroom, with a significantly reduced tuition and it is presented in 38 schools across Arizona and one in California. Unlike AP credit, upon successful completion of the ENGR 102 HS course, three units are bestowed by the university and students receive a university transcript. ENGR 102 HS is directly transferable for all Arizona engineering degree programs and typically transferable as an elective credit out of state. We train high school teachers to deliver the ENGR 102 HS core curriculum and they are then allowed the freedom and flexibility to present additional hands- on projects that interest their students and work in their high school environment.

Data on ENGR 102 HS student engineering self-efficacy is collected each spring as part of the course evaluation. In prior work, gender differences found in the engineering self-efficacy of the ENGR 102 HS students was explored [1]. The focus of this four year study was on the physiological aspects of self-efficacy to include anxiety caused by fear of failure and fixed mindset. Results showed that while female ENGR 102 HS students demonstrated a significantly lower self-efficacy than their male counterparts, there was no significant gender difference in the students' fear of failure, nor their tendency to have a fixed mindset. With fear of failure and fixed mindset ruled out as possible reasons for the gender difference in self-efficacy, a more in depth look at other aspects of efficacy is called for. This work looks to understand the impact of ENGR 102 HS course on the students' desire to pursue a career in engineering.

Self-efficacy beliefs are the thoughts or ideas people hold about their abilities to perform those tasks necessary to achieve a desired outcome [2]. The social cognitive construct of self-efficacy is not the same as the general idea of self-confidence or that of self-esteem. Confidence refers to only the strength of a belief in one's abilities. Self-esteem refers to an affective evaluation of the self, such as feelings of self-worth and self-like [3]. Efficacy is based on a level of achievement and the strength of one's belief that the desired level of achievement can be attained [4]. Female student self-efficacy in STEM has been shown to be lacking when compared to their male counterparts [5, 6, 7]. It is unfortunate that female students exhibit low self-efficacy considering that high self-efficacy in undergraduate STEM students has been linked to persistence [8, 9, 10], achievement [8, 10, 11, 12] and interest [13, 8, 11, 14].

1.1 ENGR 102 HS: Introduction to Engineering

ENGR 102 HS, a dual credit introduction to engineering course, is delivered to approximately 600 high school students each academic year. Of these 600 students, roughly 320 enroll in the three unit, University of Arizona course. The remaining students take the course for high school credit only. ENGR 102 HS students come from diverse, socioeconomic backgrounds and each academic year roughly 24% of the student population is female.

Figure 1. Teachers at the 2015 ENGR 102 HS workshop work with faculty and UA students to design a solar oven.

ENGR 102 HS appeals to students' academic interests and provides quality curriculum to high school teachers and students. In prior published work relating to the quality of the ENGR 102 HS program, survey results showed that out of 684 students, 513 of them or 75% of the students surveyed from a two year timeframe felt that their interest in becoming an engineer increased “significantly” or “somewhat” as a result of taking ENGR 102 HS. Additionally, a vast majority, or 81% from the past three years have rated ENGR 102 HS as “better than average” or “one of the best” courses they have taken in high school [15].

ENGR 102 HS was modeled after the on-campus ENGR 102: Introduction to Engineering course. The survey course introduces the undergraduate student to various fields of engineering through a main lecture and laboratory sections. The primary project in the university course is the iterative design, test and build of a solar oven. This framework is foundational to the high school version of ENGR 102.

A core curriculum, including the solar oven project, excel training and design of experiment (DOE) activities are presented to high school students in much the same way as the university course. This core content takes about 12 weeks to deliver in the high school classroom and assures continuity across the two programs. The key difference between the two versions of the course is the increased classroom time at the high school level. With the extra instructional time, high school ENGR 102 HS students enhance their learning through authentic, hands-on projects. Multiple opportunities are presented for high school students to draw from their prior knowledge and to hone new skills. High school teachers have time to scaffold learning; to reinforce basic skills and to introduce more complicated concepts. Students apply their math expertise, use hand tools, employ high level computer skills, work in teams and create unique items of their own design.

Teachers are free to provide their own project ideas to add to the core curriculum or to use assorted projects offered by the UA College of Engineering (COE) at the annual teacher training workshop (see Figure 1 and Table 1). This flexibility at the classroom level is key to the success of the ENGR 102 HS program because the final curriculum is developed according to the interests of students, teachers and the requirements of the school district and surrounding community. At the workshop, project ideas are presented by ENGR 102 HS partners in industry, UA College of Engineering faculty and staff and even the teachers themselves. This collaboration of stakeholders adds to the quality and success of the annual workshop. Towards the end of the academic year, high school ENGR 102 HS students prepare the solar oven project in much the same way as their undergraduate counterparts. For a sampling of the diverse project ideas presented at the ENGR 102 HS teacher workshop see Table 1 below.

Table 1. ENGR 102 HS curriculum/projects presented at the teacher workshop

Project Title	Year Introduced	Institution that Presented Project
Duct Tape Canoe	2011	Hamilton High School
EPICS- Engineering Service Learning Projects	2011	Purdue University
GC DELI- Online units focusing on the Grand Challenges in Engineering	2012	UA COE
PSA with “Alice” computer programming	2012	UA COE

Build a Peroxide Bio-Sensor	2012	UA Bio5 Institute
Build a Titanium Dioxide (Raspberry) Solar Cell	2012	Canyon Del Oro High School
Bio-Mechanical Hand, design and build	2013	Ironwood Ridge High School
Artificial Heart Valve, design and build	2013	Sahuaro High School
Bio-Mimicry	2013	Salpointe High School
Build a Solar Cell Phone charger	2013	Texas Instruments
Racing the Sun- Solar car competition	2014	AZ Tech Park
Design and build a Guitar	2014	Hamilton High School
Bread Loaf- Design a Mine	2014	UA COE
F1 Racing- Design challenge for high schools	2015	Hamilton High School
Creative Projects with Arduino	2015	Palo Verde High School
Optics- 2 axis Solar Tracker	2015	UA COE
NeuroBytes- Reverse engineering the biological neuron	2016	NeuroTinker, Inc.
LEGO Robotics- Artificial service animal	2016	Sahuaro High School
Build a Quad Drone	2016	Salpointe High School
Aqualibrium – Aqueduct system design	2016	UA COE

The design and delivery of a high school introduction to engineering curriculum is important, as it is the first contact with the field of engineering for many students. Furthermore, pre-college, engineering programs have been shown to attract students to engineering and other STEM careers [16, 17, 18]. Program teachers offer varied, hands-on projects in their engineering classrooms that are practical, but also community minded, artful, or even musical. This approach to an introduction to engineering course is theorized to attract the creative problem solver needed to succeed in the field of engineering. See Appendix A for the ENGR 102 HS teaching objectives and learning outcomes. While the focus of this paper is gender and student self-efficacy, much more information about ENGR 102 HS in comparison to other dual credit programs, the quality of instruction and the logistics of the EPICS High community service program and the GC DELI online units can be found in previous work by the authors [1, 15, 19, 20, 21].

During a given academic year the percentage of female ENGR 102 HS students who enroll in the UA course is about 24%. ENGR 102 HS teachers are offered training and encouragement in recruiting more young women and members of underrepresented groups into the course, however, that is not the primary goal of the ENGR 102 HS program. Instead the goal is to develop and present the ENGR 102 HS curriculum in such a way as to inform and attract all the brightest, most creative young minds into the field of engineering. Nationally, gender aware strategies developed in the past decade have helped to increase the percent of engineering degrees earned by young women from 11% in 2000 to 21% in 2010, however there is much room for improvement [22]. In fact, some recent studies show female engineering self –efficacy overall, to be improving, except in certain areas such as engineering outcome expectations where female students still tend to show significantly lower scores [23, 24, 25]. Which brings the question; what unique characteristics of engineering student self-efficacy do engineering educators miss? The ENGR 102 HS program strives to improve student self-efficacy and desire to become an engineer through a broad engineering curriculum design that effects students, both male and female, in a positive way. Results presented in this paper will explore this topic.

1.2 *Evaluation Questions*

This paper applies Bandura's theories of self-efficacy and considers the impact of ENGR 102 HS course on student's interest in becoming an engineer. Using data collected from five years of ENGR 102 HS course evaluations; the following questions will be explored:

1. Is there a relation between self-reported self-efficacy and gender with ENGR 102 HS students?
2. What impact does the ENGR 102 HS course have on students' interest in becoming an engineer?

2. Framework and Literature Review

There are four sources of self-efficacy; 1) mastery of experience, 2) vicarious experience, 3) social persuasion and 4) physiological states [26]. Each of these sources helps define student self-efficacy, allow gender discrepancies in self-efficacy to be measured and inform educators how treatments to improve efficacy should be designed (see Figure 2). To better understand how Bandura's sources of self-efficacy inform practitioners, examples of approaches often used to increase female engineering student self-efficacy are provided.

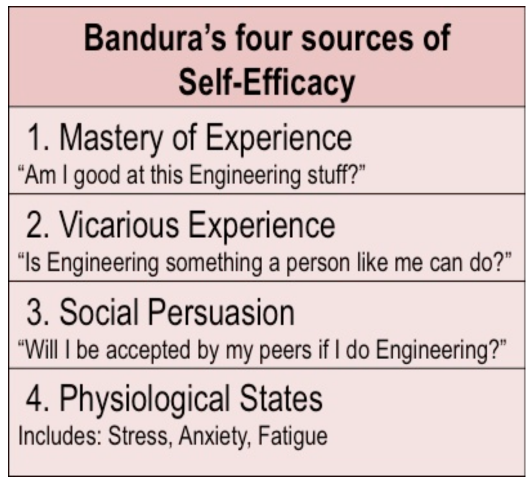

Figure 2. Bandura's four sources of self- efficacy

Strategies to increase a young girl's vicarious experience in engineering might include assigning her a female engineer as mentor or advertising engineering programs with posters of women doing engineering tasks. These commonly applied treatments might increase a student's self-efficacy via her vicarious engineering experiences. She is thus able to envision herself as an engineer through the female examples provided her. Undergraduate engineering mastery of experience is often enhanced through math tutoring, coursework in spatial relationships or remedial instruction in tool use. Low social persuasion self–efficacy for female students often is addressed via all girl clubs and gender segregated math courses where the environment is all female and not competitive, but rather supportive and nurturing. This allows the all-female group to encourage each other as they problem solve and work through the struggles of a rigorous curriculum or task.

Bandura's fourth source of self-efficacy, physiological states, is directly related to the other three. Physiological states include; anxiety, stress, fatigue and other emotions [7]. When female engineering students do not feel mastery of the subject matter, social acceptance and a feeling of belonging, heightened physiological stresses can occur that negatively affect student performance. When considering the causes of the stress and anxiety, others have observed stereotype threat brought on by gender bias [27, 28, 29] and fear of failure [30, 31, 32, 34]. These factors can be added to the list of attributors to negative physiological states affecting female engineering student self-efficacy.

Stereotype threat is a psychological event that occurs when an individual is doing a particular activity in which a negative stereotype about their group applies [28]. Factors such as a person's sex, race/ethnicity, age or socioeconomic status might cause the individual to experience an increase in stereotype threat due to negative societal bias. It is important to note that in many cases this is a *perceived* threat; making stereotype threat a very individualized phenomena that is felt in different intensities for each person, depending largely on their own life experiences. Students that feel high Perceived Stereotype Threat (PST) in a given situation naturally experience high levels of stress and anxiety.

2.1 Examining Environmental Factors

Self-efficacy and Perceived Stereotype Threat (PST) are complex concepts dependent on the individuals' perception. At the core of these variables as they relate to engineering student performance, is not simply the presence of gender differences but also the importance of the engineering educational environment and curriculum [33, 35, 28]. Environment is defined as elements and factors external to the individual. This includes variables like gender composition of the class, students' interactions with the instructor, and specifically for ENGR 102 HS; curriculum topics and design. By analyzing environment, education researchers can avoid an individual deficit approach which places undue emphasis on what ought to be "fixed" in the student rather than examining a system or structure that creates the deficit. When students are told to simply fit in and assimilate into existing curricular structures, the message received is that they do not "fit," which can provoke PST.

From the works of Bandura and many others one can make the following assumptions regarding women in engineering: 1) Women often lack the self-efficacy necessary to succeed in engineering courses, studies and careers. 2) This lack if self-efficacy is in part due to STEM educational methods, activities and products that are developed within our patriarchal society. 3) Perceived stereotype threat causes some female students to feel anxiety and stress when performing in the engineering classroom and those physiological states negatively effect the student's engineering self-efficacy.

3. Methods

3.1 Participants

Data analysis for this paper will concentrate on selected questions from the ENGR 102 HS course evaluations collected for Academic Years (AY) 2011-12, 2012-13, 2013-14, 2014-15 and 2015-16. Results will examine female (n=289) and male (n=1180) high school student responses. Data represent high school juniors and seniors from 37 diverse Southwestern American high schools, across 15 school districts, and taught by 39 instructors. We illustrate racial and gender composition in Table 2 to show the demographic distribution of the ENGR 102 HS student population over time.

Table 2. ENGR 102 HS Respondent Demographics by Gender, Race, and Academic Year						
	ENGR 102 HS Respondents by Academic Year					
Respondent Combined Race Variable & Student Gender	2011-12	2012-13	2013-14	2014-15	2015-16	Total
Hispanic/Latino-All Races						
Female	22	15	27	20	24	108
Male	62	58	87	74	98	379
American Indian/Alaska Native						
Female	2	1	1	2	0	6
Male	2	2	3	1	2	10
Asian						
Female	2	6	13	5	9	35
Male	11	41	18	25	28	123
Black/African American						
Female	1	0	0	0	0	1
Male	2	5	4	2	7	20
White						
Female	16	35	18	27	29	125
Male	77	136	122	112	147	594
Multi Racial						
Female	2	4	3	2	1	12
Male	2	9	8	12	12	43
Missing						
Female	0	1	0	0	1	2
Male	1	0	4	2	4	11

3.2 Instrument

At the end of the school year, ENGR 102 HS students fill out an online, 25 question course evaluation. The first four questions provide demographic data and the next 19 questions are built on a five point Likert scales and probe topics ranging from teacher effectiveness to satisfaction with the service learning program to college choice. The remaining two questions are open-ended and allow students to describe their favorite ENGR 102 HS design and build project and comments about their teacher. Many of the Likert scale questions for the online survey were obtained from the on-campus course evaluations handed out to undergraduates in the ENGR 102 course and deal with the quality of instruction and content. Additional questions, those dealing with self-efficacy, were selected from the Longitudinal Assessment of Engineering Self-Efficacy

(LAESE) instrument measuring student self-efficacy [36]. The LAESE instrument is a validated instrument that was developed with NSF funding as part of the Assessing Women in Engineering (AWE) project and can be found at www.aweonline.org . The whole LAESE instrument was not incorporated in the ENGR 102 HS course evaluation due to its length and the necessary focus on program evaluation. This lessens the validity of these results, however, paves the way for future research. The LAESE questions that were included in the course evaluation were chosen to allow program directors to informally monitor student efficacy, particularly underrepresented populations, as new curriculum is developed.

In this work, answers from the five questions relating to efficacy were averaged to create an Efficacy scale (α=.67). These questions included: How confident are you that you can succeed in a university engineering curriculum; How has your confidence in your ability to succeed in a university engineering curriculum been affected by ENGR 102 HS; How has your confidence in your ability to succeed in an engineering curriculum been affected by your math and science courses; Do you think you will feel like "part of the group" if you pursue a career in engineering; and How well can you cope with doing poorly (or not as good as you hoped) on a test.

4. Results

This evaluation first explored the relation between reported self-efficacy and gender and the effect of the ENGR 102 HS course. Gender differences in self-efficacy were found using an independent sample t-test comparing sores on the efficacy scale such that males (M= 4.02, SD= .59) reported higher levels of efficacy than females (M= 3.88, SD = .66), t(1467) = 3.52, p < .000. On three of the five efficacy questions that comprise the efficacy scale, males had significantly higher mean scores (see Table 3) including higher confidence because of ENGR 102 HS.

Table 3. Gender Differences in Efficacy Scale Item Scores

	Gender:	N	Mean	Std. Deviation	
How confident are you that you can succeed in a university engineering curriculum?	Male	1176	4.30	.799	t(1463) = 3.42, p = .001
	Female	289	4.12	.905	
How has your confidence in your ability to succeed in a university engineering curriculum been affected by ENGR 102 HS?	Male	1176	3.96	.818	t(404*) = 2.27, p = .024
	Female	289	3.83	.930	
How has your confidence in your ability to succeed in an engineering curriculum been affected by your math and science courses?	Male	1172	4.05	.863	t(1459) = 1.07, n.s.
	Female	289	3.99	.882	

Do you think you will feel like "part of the group" if you pursue a career in engineering?	Male	1175	4.13	.958	t(1461) = .84, n.s.
	Female	288	4.08	.956	
How well can you cope with doing poorly (or not as good as you hoped) on a test?	Male	1175	3.66	1.085	t(417*) = 3.58, p ≤ .000
	Female	288	3.39	1.169	

*Equal variances not assumed

Students were also asked " How interested are you in becoming an engineer." To assess the impact of various elements of efficacy on interest in becoming an engineer, one important goal of the ENGR 102 HS program, a univariate analysis of variance was conducted. For both males and females, confidence to succeed in a university engineering curriculum (males $F(3)=15.51$, $p \leq .000$; females $F(3)=11.11$, $p \leq .000$) and feeling like "part of the group" if you pursue a career in engineering (males $F(4)=3.33$, $p = .01$; females $F(4)=7.45$, $p \leq .000$) were closely associated with interest in becoming an engineer. In addition confidence to succeed in engineering associated with math and science coursework was predictive of interest in being an engineer for males ($F(4)=4.11$, $p = .003$) but not females $F(4)=.975$, n.s.) Conversely confidence to succeed in engineering associated with ENGR 102 HS was predictive of interest in being an engineer for females ($F(3)=4.87$, $p = .003$) but not males $F(4)=.493$, n.s.). These results support the assertion that the ENGR 102 HS course positively affects female students in their decisions to become engineers but their other STEM courses do not.

5. Discussion and Future Work

Anticipated differences in overall efficacy of the sample were found, suggesting that additional efforts still are needed to address remaining gaps in engineering efficacy between males and females. The fact that ENGR 102 HS was related to interest in engineering for females but traditional STEM coursework was not, could guide the types of curriculum changes needed to narrow the gender gap. The ENGR 102 HS course illustrates the many ways engineers help improve the human condition and allows the student to actually participate in solving real world problems. This participation highlights the importance of math and science by allowing for abstract concepts to be put to practice. The many hands on projects and service learning opportunities allow students to practice and apply the skills needed to succeed in an engineering career.

An important element of the ENGR 102 HS curriculum is that it does not produce deficits in males' interest in engineering. Although traditional STEM coursework was more related to interest in engineering for males, their actual confidence related to ENGR 102 HS was still higher than that of the females. This juxtaposition suggests that programs like ENGR 102 HS can be an excellent way to promote engineering among females without dampening the interest of males.

Certainly many university and high school level, introduction to engineering courses exist that offer students hands on experiences. However, ENGR 102 HS is unique in that the high school teacher is allowed, in fact encouraged, to adapt and adjust elements of their curriculum according to community/school district requirements and student interests. This decentralized curriculum allows for flexibility and attention to the individual needs of the student. High school teachers have the opportunity to tackle varying degrees of negative gender bias and those who experience stereotype threat can be tended to on an individual basis. The nimble nature of one familiar high school teacher in a classroom with 20 student peers allows for a more individualized education experience that can be community focused and easily built on the students' prior knowledge. The results presented here suggest that female students are more inspired than their male counterparts to become an engineer, when exposed to the ENGR 102 HS approach. The specific elements of ENGR 102 HS that lead to this result should be examined completely. Such an examination could inform efforts to deploy a high school AP engineering course.

Attracting the best and brightest minds to engineering is important to the economic well being of the United States. Additional investigation is needed of programs, like ENGR 102 HS, that could increase the interest of underrepresented groups, including racial minorities. Future work will include studies on underrepresented minority respondents' self- efficacy as well as the implications for intersectional students.

6. Conclusion

There is no single solution for female engineering students when trying to address low self-efficacy. The negative effects of gender bias and perceived stereotype threat are difficult for educators to combat as each individual experiences these phenomena to varying degrees and the roots are embedded in the broader society. ENGR 102 HS, a dual credit, introduction to engineering course with a flexible curriculum, allows female students to work with familiar teachers as they apply prior knowledge to new engineering concepts. Students and their teachers can personally experience how engineering improves the human condition within their own school and community. Designing, building and creating may not be enough to strengthen self-efficacy and pique the interest of all students. To reach more diverse students, especially females, educators should also link coursework back to how these tasks can help people. It is possible that the altruistic nature of engineering is most important as we try to attract a wide range of young people into the field of engineering. It is this application of real engineering skills, motivated by helping others, which strengthened female student self-efficacy.

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References

1. Rogers, J., Primreau, R., Hennessey, N., Baygents, J., (2016). Gender and Self-Efficacy in Engineering: Embracing Failure and a Growth Mindset for female high school students. *Proceedings of the 2016 American Society for Engineering Education Annual Conference & Exposition*. New Orleans, Louisiana.
2. Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*, Englewood Cliffs, N.J.: Prentice-Hall, 1986.
3. Gist, M. E., & Mitchell, T. R. (1992). Self-efficacy: A theoretical analysis of its determinants and malleability. *Academy of Management Review, 17*, 183–211.
4. Pajares, F., (1996). Self-efficacy beliefs in academic settings*. Review of Educational Research, 66(4), 543–578.*
5. Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. *Gender differences in mathematics: An integrative psychological approach*, 294-315.
6. 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.
7. Hutchison, M., Follman, D., Sumpter, M., Bodner, G. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education*, 95(1), 39-47.
8. Lent, R.W., Brown, S.D., Schmidt, J., Brenner, B., Lyons, H., and Treistman, D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Test of alternative social cognitive models. *Journal of Counseling Psychology*, *50*(4), 458–465.
9. Margolis, J., Fisher, A. (2002). *Unlocking the Clubhouse: Women in Computing,* Cambridge, Mass.: The MIT Press, 2002.
10. Besterfield-Sacre, M., Atman, C.J., and Shuman, L.J. (1997). Characteristics of freshman engineering students: Models for determining student attrition in engineering. *Journal of Engineering Education*, 86(2), 139–149.
11. Lent, R.W., Brown, S.D., and Larkin, K.C., (1987). Comparison of three theoretically derived variables in predicting career and academic behavior: Self-efficacy, interest congruence, and consequence thinking. *Journal of Counseling Psychology, 34*(3), 293–298.
12. Schaefer, K.G., Epperson, D.L., and Nauta, M.M., (1997). Women's career development: Can theoretically derived variables predict persistence in engineering majors? *Journal of Counseling Psychology*, 44(2), 173–183.
13. Hackett, G., Betz, N.E., Casas, J.M., and Rocha-Singh, I.A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology, 39*(4), 527–538.
14. Lent, R.W., Lopez, F.G., and Bieschke, K.J. (1991). Mathematics Self- Efficacy: Sources and Relation to Science-Based Career Choice. *Journal of Counseling Psychology, 38*(4), 424–430.

15. Rogers, J., Vezino, B., Baygents, J., & Goldberg, J. (2014), "ENGR 102 for high school: An introduction to engineering, AP type course taught in high schools by high school teachers. *Proceedings of the 2014 American Society for Engineering Education Annual Conference & Exposition.* Indianapolis, Indiana.
16. Crisp, G., Amaury N.,Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution." *American Educational Research Journal* (2009): 924-942.
17. Delci, M. (2002). Final Report of Women's Experiences in College Engineering (WECE) project. *National Science Foundation and Alfred P. Sloan Foundation Report.*
18. Yelamarthi, K., Mawasha, P. W. (2008). A pre-engineering program for the under-represented, low-income and/or first generation college students to pursue higher education. *Journal of STEM Education*: *Innovations & Research*, 9(4) 5-13.
19. Baygents, J., Goldberg, J., Hunter, J. (2011). Development of the supply chain: An AP engineering experience at the state level. Proceedings of the 2011 American Society for Engineering Education Annual Conference & Exposition.
20. Rogers, J., Baygents, J., & Goldberg, J. (2014), Best Practices in K12 and University Partnerships: ENGR 102 HS – An Introduction to Engineering, University Level Course for High School Students. Best Practices Panel and Award. *Proceedings of the 2014 American Society for Engineering Education Annual Conference & Exposition.* Indianapolis, Indiana.
21. Rogers, J., Hennessey, N., Buxner, S., Baygents, J., (2015), GC DELI: A collection of online/hybrid units for an introduction to engineering course, developed for high school and university level students. *Proceedings of the 2015 American Society for Engineering Education Annual Conference & Exposition*. Seattle, Washington.
22. National Science Foundation, Division of Science Resources Statistics. (2011). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011 (Special Report NSF 11-309). Arlington, VA. Retrieved from http://www.nsf.gov/statistics/wmpd/
23. Conncanon, J., Barrow, L. (2009). A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year and transfer status. *Journal of Science Education and Technology*, 18(2), 163-172.
24. Concannon, J, Barrow, L. (2010). A reanalysis of engineering majors' self-efficacy beliefs. *Journal of Science Education and Technology*, 21(2), 742-753.
25. Burger, C., Raelin, J., Reisberg, M., Bailey, M., Whitman, D. (2010). Self-efficacy in female and male undergraduate engineering students: Comparisons among four institutions. 2010 ASEE Southeast Section Conference.
26. Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Psychological Review*, 84(2), 191.
27. Mangels, J. A., Good, C., Whiteman, R. C., Maniscalco, B., & Dweck, C. S. (2012). Emotion blocks the path to learning under stereotype threat. *Social Cognitive & Affective Neuroscience, 7*(2), 230-241.

28. Scutt, H., Gilmartin, K., Sheppard, S., Brunhaver, S. (2013). Research informed practices for inclusive science, technology, engineering and math (STEM) classrooms: Strategies for educators to close the gender gap. Paper presented at 2013 ASEE Annual Conference and Exposition, Atlanta, Georgia.
29. Vogt, C., Hocevar, D., Hagedorn, L. (2007). A social cognitive construct validation: Determining women's and men's success in engineering programs. *Journal of Higher Education*, *78*(3), 337-364.
30. Lottero-Perdue, P. S., & Parry, E. A. (2015). Elementary Teachers' Reported Responses to Student Design Failures. Paper presented at 2015 ASEE Annual Conference and Exposition, Seattle, Washington.
31. Nelson, K., Newman, D., McDaniel, J., Buboltz, W. (2013). Gender differences in fear of failure amongst engineering students. *International Journal of Humanities and Social Science, 16*(3), 10-16.
32. Stuart, E. M. (2013). The relation of fear of failure, procrastination and self-efficacy to academic success in college for first and non first-generation students in private non-selective institution. Dissertation, University of Alabama.
33. Beddoes, K., Borrego, M. (2011). Feminist theory in three engineering education journals: 1995-2008. *Journal of Engineering Education,* 100(2) 281-303.
34. Nelson, K. L. (2012). Examining the effects of fear of failure, self-efficacy and gender role conflict in male and female engineering students. Dissertation, Louisiana Tech University.
35. Sax, L. (2008). *The gender gap in college: Maximizing the developmental potential of women and men.* (1st edition). San Francisco: Jossey-Bass. (p. 61).
36. Assessing Women in Engineering. Longitudinal Assessment of Engineering Self- Efficacy Instrument (LAESE). Retrieved on January 3, 2011 from www.aweonline.org .

Appendix A

ENGR 102 HS Teaching Objectives

While providing high quality instruction ENGR 102 HS teachers will:

1) Show students that engineers use skills in mathematics and science to help people in a variety of global, economic, environmental, and societal contexts
2) Increase student self-efficacy in engineering — that is, increase students' belief in their ability to pursue and succeed in the engineering profession
3) Elevate the visibility of engineering as a viable and rewarding career path
4) Prepare students to make informed choices about their academic and career options by providing them with information regarding the vast number of engineering career paths
5) Help students identify "false positives"- that is, allow students who think they want to be engineers to explore the field and to figure out if engineering is for them with in the safe environment of their high school classroom

ENGR 102 HS benefits high school students by allowing them to:

1) Explore an introduction to engineering and the engineering profession without having to commit to a semester's worth of engineering courses at the University level
2) Gain a better understanding of what an engineer is and does and explore a variety of engineering disciplines through campus visits and lab tours
3) Become familiar with the demands and expectations of college-level courses
4) Receive credits for 3 units of required engineering coursework at significantly reduced tuition cost