Gender and Self-Efficacy in Engineering: Embracing Failure and a Growth Mindset for Female High School Students (Fundamental)

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Abstract

Over the last decade much attention has been drawn to the lack of women in engineering careers and the need to attract and retain them in the field. This paper will discuss prior research focused on female student self-efficacy in engineering and the subsequent treatments that have been applied at various stages in the STEM pipeline. Then we will examine the ENGR 102 HS program and results from four years of student course evaluation surveys (n=1093).

ENGR 102 High School (HS) is an introduction to engineering course offered in 34 high schools in the Southwest. Students who enroll in the University of Arizona course receive three units of credit from the College of Engineering (COE) towards an engineering degree. Now in its eighth year of operation, the ENGR 102 HS program reaches diverse student populations around the state. ENGR 102 HS looks to fill the pipeline to undergraduate engineering degrees with diverse, capable, informed students of both genders. While gender parity is not our primary objective, we strive to create opportunity, diminish barriers and to deliver a curriculum with a broad appeal.

Data analysis for this paper concentrates on selected questions from the ENGR 102 HS course evaluations. Our results examine female (n=220) and male (n=873) high school student responses. Specifically, we explored the landscape of female ENGR 102 HS high school student self-efficacy in engineering to include attitudes towards failure, and mindset. Results demonstrated that female ENGR 102 HS students possessed a significantly lower engineering self-efficacy than male students. With respect to mindset and fear of failure, male and female students showed no statically significant difference.

1. Introduction

Despite attention to improving student engineering self-efficacy, high school and university engineering programs still struggle to attract and retain women into the engineering degree pipeline. Treatments such as female mentorship programs, all girls afterschool STEM programs, women's engineering clubs and marketing campaigns with smiling female faces of all races have emerged, and seem to help underrepresented students believe they can succeed and will "fit in" to the engineering culture. Recent reports and research measuring female student engineering self-efficacy assert the positive impact of these types of treatments (American Association of University Women Educational Foundation, 2002; Burger, Raelin, Reisberg, Bailey & Whitman, 2010; Corbett, Hill & Rose, 2008; Corbett, Hill & Rose, 2010; Fantz & Miranda, 2010; Marra, Rodgers, Shen & Bogue, 2009; Society of Women Engineers report, 2015).

Self-efficacy beliefs are the thoughts or ideas people hold about their abilities to perform those tasks necessary to achieve a desired outcome (Bandura, 1986). The social cognitive construct of self-efficacy is not the same as the general idea of self-confidence. Confidence refers to only the strength of a belief in one's abilities. Efficacy is based on a level of achievement and the strength of one's belief that the desired level of achievement can be attained [Pajares, 1996]. High self-efficacy in undergraduate STEM students has been linked to persistence (Lent et al., 2003; Margolis & Fisher, 2002; Besterfield-Sacre, Atman & Shuman, 1997) achievement (Besterfield-Sacre et al., 1997; Lent et al., 2003; Lent, Brown & Larkin, 1987; Schaefer, Epperson & Nauta, 1997) and interest (Hacket, Betz, Casas & Rocha-Singh, 1992; Lent et al., 2003; Lent et al., 1987; Lent, Lopez & Bieschke, 1991).

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. Roughly 24% of those students are female. This award-winning program 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 the majority (75%) of students (n = 513) over a two year timeframe felt their interest in becoming an engineer increased "significantly" or "somewhat" as a result of taking ENGR 102 HS. Additionally, over 81% of all students (n = 676) 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 (Rogers, J., Vezino, B., Baygents, J., & Goldberg, J, 2014).

Students in ENGR 102 HS are high school juniors and seniors who are at a critical point in their academic career. During this period, students turn their attention to college choice and consider a subject in which to major. One of the key focuses of the course is to provide these students, who are standing at the edge of the PK-12 pipeline, with a broad view of engineering. A range of hands-on activities and service learning opportunities are offered that demonstrate the diverse types of work engineers do. While ENGR 102 HS teachers are offered training and encouragement in recruiting more young women and members of under represented groups into the course, that is not the primary goal. Our 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.

ENGR 102 for high school was fashioned after the on-campus university ENGR 102 course. The survey course introduces the student to various fields of engineering through a main lecture and hands-on lab sections. The primary project in the course is the design, test and build of a solar oven. This inquiry/project based learning is carried over to the high school version of ENGR 102. The primary difference between the two versions of the course is increased classroom time at the high school level. With the extra instructional time, high school ENGR 102 students enhance their learning through multiple authentic and carefully planned projects. Towards the end of the school year, high school ENGR 102 students prepare the solar oven project in much the same way as their undergraduate counterparts.

The design and delivery of an introduction to engineering curriculum is important as it is the first contact with the field of engineering for many students. Pre-college, engineering programs have been shown to attract students to engineering and other STEM careers (Crisp, Amaury & Taggart, 2009; Delci, 2002; Yelamarthi & Mawasha, 2008). Our goal is for our teachers to offer varied, hands-on projects in their engineering classrooms that are practical, but also community minded, artful, or even musical. See Appendix A for the ENGR 102 HS teaching objectives and learning outcomes. Much more information about ENGR 102 HS can be found in previous work (Baygents, Goldberg, Hunter, 2011; Rogers et al., 2014; Rogers, Baygents & Goldberg, 2014; Rogers, Hennessey, Buxner, Baygents, 2015).

While research informed treatments developed over the last 10 years have helped to increase the percent of engineering degrees earned by young women from 11% in 2000 to 21% in 2010, there is much room for improvement (NSF, 2011). In fact, some recent reports and studies in engineering student self-efficacy have reported no significant difference in many efficacy factors for female students when compared to males (Burger et al., 2010; Concannon & Barrow, 2009; Concannon & Barrow, 2010; Vogt, Hocevar & Hagedorn, 2007). Which brings the question; what other influences are in play? What unique characteristics of engineering student self-efficacy are we missing? An investigation into high school female student self-efficacy with a focus on physiological states to include stereotypic threat, mindset and fear of failure might lead to additional insight. Our results presented in this paper will explore these topics.

1.2 *Research Questions*

This paper looks at Bandura's theories of self-efficacy and offers an additional framework informed by the theories of Sandra Harding, Carol Dweck and others. Then using data collected from four years of ENGR 102 HS course evaluations, we will explore the following research questions:

1. Is there a relationship between self-reported self-efficacy and gender with ENGR 102 HS students?
2. Is there a relationship between self-reported fear of failure and gender with ENGR 102 HS students?
3. Is there a relationship between mindset and gender with ENGR 102 HS students?

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 (Bandura, 1977).

When designing treatments for those lacking in self-efficacy, the first three sources are commonly addressed and often center on a deficit approach; assuming that there is something missing from the individual with low self-efficacy, and that the missing element needs remediation. Under this assumption an appropriate strategy might be to increase a young girl's vicarious experience in engineering by assigning her a female engineer as mentor or by displaying colorful posters of women doing engineering tasks. These commonly applied treatments might increase her 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. These additive approaches focus on the subjects' lack of ability and its effect on their actual mastery of material, as well as their engineering self-efficacy. 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.

2.1 Physiological States- a source of self-efficacy

Bandura's fourth source of self-efficacy, physiological states, is harder for practitioners to address and may be the "missing piece" from the engineering self-efficacy treatments applied to girls and young women (See Figure. 1). Physiological states include; anxiety, stress, fatigue and other emotions (Hutchison et al., 2006). When considering the causes of the stress and anxiety, others have observed stereotypic threat brought on by gender bias (Mangels, Good, Whiteman, Maniscalco & Dweck, 2012; Scutt, Gilmartin, Sheppard & Brunhaver, 2013; Vogt, Hocevar & Hagedorn, 2007), fixed mindset (Dweke & Leggit, 1988; Dweck, 2009; Dweck, 2010; Scutt et al., 2013) and fear of failure (Lottero-Perdue & Parry, 2015; Nelson, 2012; Nelson, Newman, McDaniel & Buboltz, 2013; Stuart, 2013). These factors can be added to the list of attributors to negative physiological states affecting female engineering student self-efficacy.

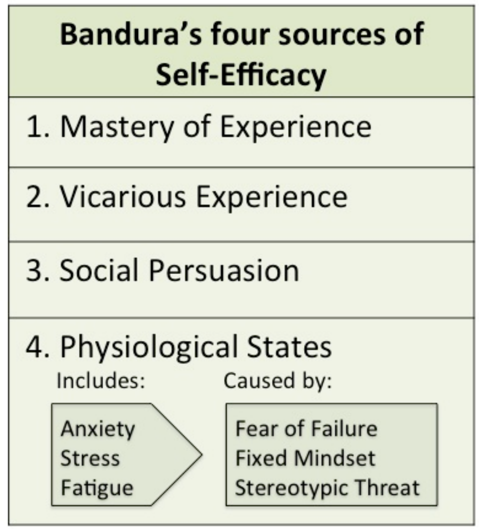

Figure 1. Bandura's four sources of Self-Efficacy. In this paper we explore fear of failure, fixed mindset and stereotypic treat and how they contribute to stress and anxiety.

2.2 Perceived Stereotypic Threat (PST)

In order to better understand how a fixed mindset and fear of failure might negatively affect the physiological aspects of engineering self-efficacy, it is instructive to first explore the phenomenon of perceived stereotypic threat (PST). Stereotypic threat is a physiological event that occurs when an individual is doing a particular activity in which a negative stereotype about their group applies (Scutt et al., 2013). Factors such as a person's sex, race/ethnicity, age or socioeconomic status might cause the individual to experience an increase in stereotypic threat due to negative societal bias. It is important to note that in many cases this is a *perceived* threat; making stereotypic 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 PST in a given situation naturally experience high levels of stress and anxiety.

Empirical evidence shows that stereotypes for women in STEM exist. Finson (2002) conducted an extensive literature review based on Mead and Metraux's seminal work " Draw a Scientist," (1957), and examined countless studies conducted since (Fort & Varney, 1989; Mason, Kahle & Gardner, 1991). In this experiment participants are asked to draw a scientist on a blank sheet of paper. Drawings are then analyzed for common themes such as gender, attire, and type of activity. The research shows that a majority of society expects individuals who are leading research or making scientific discovery to be nerdy, social pariahs in lab coats and glasses and for the most part- male. Finson reports "…strong evidence exists that such a stereotypical perception is persistent and pervasive across grade levels, gender, racial groups, and national borders" (2002, p. 335).

2.3 Growth versus Fixed Mindset

When looking at how PST leads to stress and anxiety an exploration into the advantages of a "growth" mindset should be investigated. A report published by the American Association of University Women (AAUW) outlines Carol Dweck's ideas about fixed vs growth mindset (Hill, Corbett & Rose, 2010). Dweck argues that individuals with a fixed mindset believe that all intelligence is innate, a gift with which people are born. These individuals believe that when a task is difficult for them, it must mean that they are not smart enough. Fixed mindset individuals tend to value "looking smart" above all else (Dweck, 2010). On the other hand, an individual with a growth mindset feels that difficult tasks are a challenge. People with a growth mindset relish difficult tasks and assume that if they keep trying they will achieve mastery (Dweck, 2009). Individuals who are victims of negative gender stereotype and bias are much more likely to exhibit a fixed mindset because they believe their personal gender history puts a limit on their intelligence (Blackwell et al., 2007).

In an empirical study based on Dweck's mindset theory, Mangels et al. demonstrated how a gender based stereotypic threat can induce stress and negative emotions that then block new learning and even the expression of known content (2012). Female college students were asked to complete forty-eight computerized math problems while electroencephalography (EEG) recordings were taken to measure event related potentials (ERP) in their brains. The ERPs measured included activity in medial frontal lobe feed-back related negativity, the anterior P3 lobe (P3a) and the posteriorly- maximal lobe, late positive potential (LPP). Both groups were pre-tested for their perception of environmental stereotype threat, self-reported math ability and math SAT scores and controls for these variables were applied to the collected data. Just before the test, the treatment group was given instructions that were subtly gender biased. The instructions included information about how men usually do better on the test than women.

In this Mangels et al. study the control group performed better on the math test than the gender biased, treatment group (2012). Additionally, the females under the highest stereotypic threat were the most sensitive to automated feedback/tutorials provided within the math test and at times did not even attempt to correct errors or complete the most difficult problems. This result was consistent across all high stereotypic threat individuals, regardless of the test subject's actual math ability.

2.4 Fear of Failure

In their 2015, ASEE Best Paper award publication, Lottero-Perdue and Parry describe the misalignment between PK-12 education and the field of engineering with regard to the concept of *failure*. When examining middle school teachers' response to students' design failures it became apparent that even the use of the word "failure" was unpleasant for them. The research showed that teachers associated failure with defeat, dropping out, "failing schools", etc., and so they did all they could to detract from and diminish the impact of failure in their students' designs. While these teacher's actions were empathetic, the fact remains that "testing to failure, " and attempting difficult, if not impossible tasks are core premises of engineering education and the engineering profession. Designing and testing for limits to establish factors of safety is an engineering norm (Lottero-Perdue & Parry, 2015). This research uncovered an important message for PK-12 educators; if we want to increase the numbers of engineers in the workforce, we must teach our children of both genders to embrace failure and see it as a healthy part of learning.

Many recent studies have been conducted examining engineering students' fear of failure and most find female students to be significantly more troubled with failing or not doing well in school (Nelson, 2012; Nelson, Newman, McDaniel & Buboltz, 2013; Stuart, 2013). Female students were also found to be more concerned with embarrassment, and having an uncertain future (Nelson, 2012; Nelson et al., 2013). A University of Alabama dissertation research examined "first generation to attend college" students and found no significant difference in fear of failure, procrastination and self-efficacy when compared to their non-first generation peers (Stuart, 2013). However, when the population was sorted by gender, female students from both first generation college attendance and non first generation showed significantly more fear of failure. Ironically, in this same study female students from both groups received higher first semester GPAs than their male counterparts.

2.5 External versus Internal: Examining Environmental Factors

Perceived Stereotypic Threat (PST), fear of failure, and fixed mindset are multifaceted concepts dependent on the individuals' perception and can be intensified by many means. At the core of these variables as they relate to engineering student self-efficacy, is not simply the presence of gender differences but also the importance of the role of the engineering educational environment and curriculum (Beddoes & Borrego, 2011; Sax, 2008; Scutt et al., 2013). We define environment as elements and factors external to the individual. This includes variables like gender composition of the class, students' interactions with the instructor, and curriculum topics and design. By analyzing environment, education researchers can avoid an individual deficit approach, placing 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 fit in and assimilate into existing curricular structures, the message received is that they do not fit.

Buck's qualitative study explored middle school student attitudes towards science curriculum as a cause for the gender gap in science fields of study (2002). Specifically, Buck looked at adolescent girls' ideas and feelings about the structure of science instruction. The study also examined the attitudes of their science teachers. The study revealed that adolescent girls strived to see how science helped them to better understand themselves and their world, but they seldom found such correlation in their science classrooms. To address this, teachers did not attempt to change their science curriculum. Instead teachers interpreted the girls' requests from an assimilative perspective by seeking ways to help the female students "fit" into the existing structure of science education. Buck's findings indicate that some female students are not interested in science because the traditional science curriculum is designed in ways that do not interest them and in compliance with patriarchal norms (2002).

Androcentrism is the practice of attributing things masculine and the male point of view as normative and at the center of ones' view of the world and its culture and history (Shakeshaft, 1984). Women in science have been marginalized, not necessarily due to personal bias by individuals, but rather due to sexism and androcentrism that is culture wide and permeates social, political and economic realms (Harding, 1991, p. 30). The origins and consequences of the bias are unconscious and buried within culture, history and its institutions that people of both genders accept androcentrism as the norm.

Historically, structural obstacles to women's achievement in STEM have emerged, flourished and subsequently declined. In the past "vigorous campaigns" were required for women to gain entry to scientific education, degrees, lab appointments, publications in journals, and scientific prizes (Harding, 1991, p. 30). However, even with most of these obstacles removed, the epistemologies of an *education* in STEM are so androcentric and gender specific, that a many young girls and women do not pursue STEM careers. Bucks findings reported earlier (2002) support Harding's theories.

From the works of Bandura, Harding, Dweck, Mead & Metraux 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, careers and products that are developed within our patriarchal society. 3) Negative stereotypes and gender bias for women in STEM exist, 4) Perceived stereotypic 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 and 2014-15. Our results will examine female (n=220) and male (n=873) high school student responses. Our data represents high school juniors and seniors from 31 diverse Arizona high schools, across 15 school districts, and by 39 instructors. There are noteworthy differences observed in gender distribution, and racial composition in the ENGR 102 High School program (see Table 1 below).

Table 1. ENGR 102 High School Survey Respondent Demographics by Gender, Race, and Term.					
	ENGR 102 HS Term				
Combined Race Variable for Sample & Student Gender	2011-12	2012-13	2013-14	2014-15	Total
Hispanic/Latino					
Female	18	15	18	16	67
Male	51	46	60	60	217
American Indian/Alaska Native					
Female	1	1	1	1	4
Male	2	2	1	1	6
Asian					
Female	2	6	13	5	26
Male	11	42	15	25	93
Black/African American					
Female	1			1	2
Male	3	5	5	5	18
Native Hawaiian/Pacific Islander					
Female	1			1	2
Male	1	1	3	2	7
White					
Female	20	41	25	32	118
Male	83	166	138	132	519

3.2 Instrument

At the end of each school year, ENGR 102 HS students are asked to fill out an online, 20 question course evaluation. The first four questions provide demographic data and the next 14 questions are built on a five point Likert scale. The remaining two questions are open-ended and allow students to write in their favorite ENGR 102 HS design and build project and comments about their teacher. Most 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. The LAESE instrument was developed with NSF funding as part of the Women in Engineering (AWE) project. Originally, the LAESE questions were included in the course evaluation to allow program directors to informally monitor student efficacy, particularly underrepresented populations. Data collected from these selected self-efficacy questions are the subject of this paper. (See Table 2)

Table 2. Defined Research Questions with Corresponding Survey Questions	
Research Question	**Survey Question**
R1. Is there a statistically significant difference in self-reported self-efficacy between male and female students in the Engineering 102 High School course?	Q11. How confident are you that you can succeed in a university engineering curriculum?
R2. What relationship exists, if any, between gender and a *growth* versus *fixed* mindset?	Q15. Do you think most smart people are just "born that way" or is it something they have to work hard for?
R3. What relationship exists, if any, between gender and a fear of failure?	Q17. How well can you cope with doing poorly (or not as good as you hoped) on a test?

3.3 Analysis
In order to assess the strength of self-efficacy expectations, students were asked to rate how confident they were about succeeding in a university level engineering curriculum on a five-point scale ranging from "not confident at all" to "very confident". For the purpose of measuring mindset (fixed versus growth) the students were asked to indicate whether smart people are inherently "born that way" or if smart people "have to work hard". Finally, to measure the concept of fear of failure, the students were asked to rate how well they can cope with doing poorly on a test using a five-point scale ranging from "not at all" to "very well". Table 2 more concretely aligns our research questions with the corresponding survey questions.

The ENGR 102HS Survey Data from AY 2011-12 to AY 2014-15 were analyzed using STATA (version 14 for Windows) to conduct a comparison of means for our self-efficacy variable using a two-independent sample t-test, assuming differences in variances, as well as a chi-square analysis to determine whether or not there is a significant association between the categorical variables of interest: (1) gender and mindset; (2) gender and fear of failure. Categorical variables were recoded from string to numeric variables; for example, "not confident at all" was recoded to a "1", and "very confident" was recoded to a "5".

4. Results

A two-independent sample t-test was carried out to test whether there is a statistically significant difference in self-reported self-efficacy (how confident students are that they can succeed in a university engineering curriculum) between male and female respondents. The mean "confidence" or self-efficacy score for males was 4.32 ($SD = 0.79$); the mean self-efficacy score for females was 4.1 ($SD = 0.87$). The results of the t-test ($t=3.30, p <0.05$) suggest that the means for male and female respondents are not equal (see Table 3). Thus, a significant difference between the reported level of self-efficacy between males and females was demonstrated: Male students exhibited higher self-efficacy than their female counterparts. We also offer the observation that at the low end of the confidence interval, some women report "not very confident" in their belief that they can succeed in a university engineering curriculum, while men *only* report, "somewhat confident" or "very confident". While these results do not reveal any new or novel findings, they do continue to challenge our understanding and design of "treatments", such as the ENGR 102 High School program, in promoting positive female self-efficacy in engineering.

Table 3. Two-sample t test with unequal variances for analysis of self-efficacy: How confident are you that you can succeed in a university engineering curriculum?							
Group	n	Mean	Std.	95% Confidence Interval		t	p
Male	862	4.31	0.79	4.26	4.37	3.3	0.0011
Female	220	4.1	0.87	3.98	4.22		

A chi-square test was carried out to test whether or not there is a relationship between our independent variables, *mindset* –whether smart people are "born that way" (fixed mindset) or "have to work hard" (growth mindset) and *fear of failure* –how well an individual can cope with doing poorly on an exam—and our dependent variable, *gender*. The results of the chi-square test for *fear of failure* ($x^2 =9.36, p>0.05$) suggests that there is no statistically significant relationship between gender and how well a student can cope with doing poorly on a test. However, even though a significant relationship between gender and failure may not exist in the present study, the contingency table (see Table 4) reveals some interesting group differences. We find that while male respondents are over-reporting responses of "somewhat" and "very well" in their ability to cope, women are under-reporting in the categories of "somewhat" and "very well" by 10% and 15%, respectively, and over-reporting in the categories of "not at all" and "not very well". These observed differences reflect existing findings in the fear of failure literature.

Table 4. Chi-Square Analysis of Fear of Failure Test: How well can you cope with doing poorly on a test?						
		Column				
Row		Not at all	Not very well	Neutral	Somewhat	Very Well
Male	Obs	25	138	194	295	210
	Exp	30.3	145.9	196.2	287.9	201.7
	Column %	2.90%	16.00%	22.50%	34.20%	24.40%
	Res	-5.302	-7.926	-2.163	7.135	8.255
	Std. Res	-0.963	-0.656	-0.154	0.421	0.581
	Adj. Res	-2.178	-1.599	-0.39	1.145	1.475
Female	Obs	13	45	52	66	43
	Exp	7.7	37.1	49.8	73.1	51.3
	Column %	5.90%	20.50%	23.70%	30.10%	19.60%
	Res	5.302	7.926	2.163	-7.135	-8.255
	Std. Res	1.911	1.302	0.306	-0.834	-1.153
	Adj. Res	2.178	1.599	0.39	-1.145	-1.475
	Note: $x^2 = 9.36$; Pr = 0.053					

The results for the chi-square test for *mindset* ($x^2 =1.82, p>0.05$) suggest that there is no statistically significant relationship between gender and whether a student thinks smart people are "born that way" (fixed mindset) or "have to work hard" (growth mindset). From these results we cannot say definitively that mindset and gender are linked. What we can draw from the contingency table, however, is that female respondents over-report in our measure of a “growth mindset” and under-report (by 13%) in our measure of “fixed mindset”. This is an encouraging finding that may reveal positive environmental factors in the ENGR 102 High School program that are combating PST and other factors at the root of a “fixed mindset”.

Table 5. Chi-Square Analysis of Mindset Test: Do you think most smart people are just "born that way," or is it something they have to work hard for?			
		Column	
Row		Born that Way	Work Hard
Male	Obs	242	617
	Exp	234.1	624.9
	Column %	28.20%	71.80%
	Res	7.944	-7.944
	Std. Res	0.519	-0.318
	Adj. Res	1.348	-1.348
Female	Obs	52	168
	Exp	59.9	160.1
	Column %	23.60%	76.40%
	Res	-7.944	7.944
	Std. Res	-1.026	0.628
	Adj. Res	-1.348	1.348
	Note: $x^2 = 1.82$; Pr = 0.178		

5. Discussion and Recommendations

Here we revisit the three research questions and discuss the findings from the literature review and data analysis.

1. Is there a relationship between self-reported self-efficacy and gender with ENGR 102 HS students?
2. Is there a relationship between self-reported fear of failure and gender with ENGR 102 HS students?
3. Is there a relationship between mindset and gender with ENGR 102 HS students?

Results from the literature review compared to the data analysis on ENGR 102 HS student responses revealed discrepancies. It was expected that female students in the ENGR 102 HS course would exhibit significantly less self-efficacy than male students when asked the question: *How confident are you that you can succeed in a university engineering curriculum?* This outcome shows a relationship and supports the reports from the literature on self-efficacy. However, when the same students were asked about how well they cope with doing poorly on a test to examine fear of failure, there was no statistically significant difference between genders.

This outcome does not agree with the literature on fear of failure. This discrepancy could be due to several factors, including the reality that only one survey question was posed regarding failure, and true measures of fear of failure require more comprehensive research studies.

Prior to analysis, the literature was unclear how mindset might be affected by gender. It is interesting to learn that ENGR 102 HS male and female students exhibit a fixed mindset at a similar rate. The result demonstrated no relationship between mindset and gender. Looking deeper at this phenomenon it is recommended that research be conducted to explore how PST and gender bias might cause female students to be more adversely affected by a fixed mindset than male students. If this was the case, it would account for the lower self-efficacy recorded in the study group, even though no relationship was found between mindset and gender. Below we list some additional recommendations for future research and practice.

5.1 Recommendations for practice

If Carol Dweck's cognitive social theory, fixed versus growth mindset is applied, treatments can be devised to help engineering students of both genders. Young people can be taught that the brain is like a muscle that needs to exercised and that, "you can be as smart as you want to be" (Dweck, 2010). Educators in the PK-12 system could; 1) emphasize challenge, not only success, 2) grade for student growth, 3) and give students a sense of improvement and progress in all work that they do. All students can benefit from a growth mindset, and young women with a growth mindset will be better able to cope with PST (Mangels et al., 2012).

5.2 Recommendations for research

There may be a relationship between female students' self-reported self-efficacy and the ratio of female students enrolled in the class. This fits into the stereotype-threat framework and may provide more evidence to our argument that environmental factors in school settings impact students' understanding of their own self-efficacy. Future researchers might consider including the proportion of female students in each class as a covariate in a multivariate linear model.

Additional qualitative studies might examine how students interact with the curriculum, one another, and the instructors. This would help researchers, university administrators, and educators to understand elements that could drive differences in self-efficacy. By examining subjective data, researchers can develop additional measures and analytics that can be incorporated into future surveys. These data can help researchers infer more statistically significant conclusions regarding classroom environment and student interaction.

6. Conclusion

It seems possible that some of the treatments being applied to improve the self-efficacy of female engineering students could be, in fact, negatively impacting the physiological state of young women considering engineering for an undergraduate major. Programs that single out female students by providing special remediation, or pander to gender with pink robot components and media materials might have the opposite of the desired affect. Much of the prior research and designed treatments "…cast women in a deficit roll… and view them as 'other' " (Godfrey, 2003, p.13).

As gender equality in STEM fields becomes a more universal value in American society, research on gender equity in the PK-12 classroom becomes more and more relevant to conversations around curriculum development, outreach, and classroom climate. The results of this limited-scope study demonstrate that male and female students may have slightly varying dispositions, and that the underrepresentation of women has less to do with individual mindset and performance and more to do with environmental factors in the classroom, school, and society. Although it is easy to look outward at "society" or "culture," true environmental shift happens on both micro- and macro-levels. The similarities in mindset and fear of failure, combined with differences in self-reported self-efficacy, are telling of a classroom climate that disproportionately impacts self-efficacy.

Instructors teaching high school level engineering courses, as well as university administrators setting program goals, developing curriculum, and training instructors, may use these conclusions to more intentionally direct their pedagogical goals and learning outcomes. ENGR 102 HS, one form of high school level engineering education, has long focused on broadening the curriculum to meet the needs of a diverse student population. Topics for hands-on projects steer away from the stereotypical and instead try to frame engineering work as creative, social, artful, and a service to the community. These preliminary results suggest that directly addressing an intentional curriculum structure and pedagogical style may be a necessary next step in achieving higher levels of enrollment and self-efficacy for female students.

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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