# Girls Go Beyond Blackboards towards Positive Attitudes about Engineering

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## Abstract

*Beyond Blackboards* is a design-based learning experience in afterschool clubs and summer camps that challenges middle school students to solve real world problems. The program is implemented in a primarily Hispanic, low-income community adjacent to Austin, Texas a city with a strong, technology-based economy, and earned district-wide attention with early success in team-based competitions. *Beyond Blackboards* aims to enhance interest and understanding of engineering, as well as positively influence education and career goals for participants, and ultimately, the entire district. This study examines the effects of *Beyond Blackboards* on girls' (a traditionally underrepresented group in engineering) attitudes surrounding engineering. Specifically, this study investigates (1) primary influences for involvement with engineering, (2) interest and engagement in engineering and design-based learning, and (3) the lasting impact of *Beyond Blackboards* on girls' personal, educational, and engineering progress. Several instruments were used to assess attitudinal changes, including student surveys, teacher interviews, and comparison to national data (*Trends in International Mathematics and Science Study)*. Findings indicate a positive shift in students' interest in engineering as a career, as well as the extent of students' educational expectations. Additionally, female role models, social perceptions, and self-concepts are predominant in shaping girls' experiences with engineering. By working to change engineering attitudes early, *Beyond Blackboards* addresses the current national challenge to improve K-12 education to increase career and college readiness, and to enhance the STEM labor force by eliminating stereotypes and diversifying the field's demographics.


## Introduction

The National Importance of STEM

Developing the STEM workforce is an essential component of the United States' efforts to reform its economy to meet the demands of an increasingly competitive and global market. It is estimated that half of the economic growth in the United States since World War II is a result of technological innovation, including advances in business, healthcare, travel, and entertainment. Still, just 6% of undergraduates in the U.S. are studying engineering, the second lowest percentage among developed nations (NAE, 2006). In order to ensure that the United States remains a leader in technological research, education, industry, and innovation, it is imperative that schools and industries reach a diverse talent pool to foster STEM pursuits (NSB, 2010).

However, STEM demographics are nowhere near a close representation of the U.S. population, with excessively low percentages of women and minorities. The science and engineering labor force is comprised of only 26% women of all races, while White men make up a disproportionate 55% (NSF, 2011). Reasons for this imbalance are not due to lack of ability, as the performance gap between genders in math and science consistently narrows. Instead, the shortage of women is a result of females' negative perceptions of themselves in relation to engineering (AAUW, 2010). This is especially apparent when considering the social relevancy of the field. Many females do not recognize the role of engineering in innovative revolution, let alone everyday life,

and thus do not appreciate the value of participation (NAE, 2008). Working to change this disparity can start early: English (2011**)** states that "middle school has been identified as a crucial period for either encouraging or discouraging students' participation and interest in mathematics and science." Accordingly, *Beyond Blackboards* provides middle school students with an engineering experience aimed to change negative attitudes early on, and expose students to the diversity and relevancy of engineering, reaching to positively impact their future college and career plans.

Overview: *Beyond Blackboards*

*Beyond Blackboards* is a design-based learning experience in afterschool clubs and summer camps that aims to meet the aforementioned national challenge, specifically by providing middle school students with a hands-on engineering experience to enhance students' interests in STEM. To comprehensively develop a culture of engineering education and meet the national challenge, *Beyond Blackboards* employs a three-pronged approach of: (1) engaging students in inquiry-based learning opportunities that encourage practice of key STEM concepts, development of analytical skills, and increased awareness of STEM college and career pathways; (2) professional development and support for teachers to guide students in meaningful engineering design activities and targeted STEM college and career pathway investigation in the context of afterschool Innovation Clubs including robotics activities and summer engineering camps; and (3) informing parents and caregivers of the full range of STEM college and career pathway options so that they may support and encourage their students' pursuit of STEM-related educational and professional goals.

A collaboration between Cave Creek School District (CCSD) in Texas and the engineering school at a nearby university, *Beyond Blackboards* incorporates engineering design method and the National Academy of Engineering (NAE) *21st Century Grand Challenges* to immerse upper elementary and middle school students in design-based learning. During afterschool "Innovation Clubs" throughout the 2010-2011 and 2011-2012 academic year and a summer camp following each year, middle school students worked in teams to design, build, and program robots using LEGO® MINDSTORMS® NXT robotics kits and the NXT-G programming environment. Teams presented the functionality of their final design, and contextualized their project by describing a real world application they researched for their robot that may help to solve one of the 14 NAE *21st Century Grand Challenges*. *Grand Challenges* inspire students to think about open ended questions surrounding society's most pressing issues, such as finding a way to provide access to clean water, and attempt to develop practical and innovative solutions to current engineering focuses. A complete list of the Grand Challenges can be found in Appendix A.

In the fall semester, *Beyond Blackboards* coincides with the FIRST LEGO League (FLL) competition, where middle school teams compete by creating robots that complete "missions" during 2.5 minute trials. Teams also complete research on the year's common mission theme (e.g. clean energy, food supply, biomedical engineering) for a final presentation. For the two years of the program, CCSD has hosted the regional FLL tournament and has had award winning teams across multiple categories of teamwork, research, robotic performance, and design. Of the participating teams from CCSD, one team of all girls advanced to the international competition. In the spring, Innovation Club students create robots to solve Grand Challenges to "Restore and Improve Urban Infrastructure" and "Explore Alternative Energy". During summer camp,

students design and build an underwater robot to solve a relevant problem of their choice, such as searching for debris after natural disasters, or cleaning oceans after an oil spill. Throughout the year, undergraduate and professional mentors work with students to provide technical support, and to act as role models by helping students contextualize engineering in practice.

*Figure 1*. The DTEACh Method

*Beyond Blackboards* uses the Design, Technology, & Engineering for All Children (DTEACh) curriculum, ensuring that students participate in the engineering design process by giving them a chance to do hands exploration of robots and engineering products, discuss specific technical concepts behind their designs, explore the technology and purpose of underwater robotics and use these principles to discover engineering in a constructed setting, create a comprehensive robotic design, and report their final product and research to a group. Figure 1 outlines the DTEACh method cycle described above. Additionally, DTEACh encourages STEM education for all grade levels, supporting students to think creatively and scientifically. Throughout the years of the program, curriculum development has been inspired by the evolving needs of students as global citizens in the 21st century. This new era calls for students to think differently than ever before so that they can effectively learn skills that will help them to be successful lifelong learners. These 21st century skills, such as critical thinking, problem solving, communication, and multiple literacy practices, are key components in our curriculum, and are essential for students in all fields, not exclusively engineering. DTEACh also provides professional development to educate teachers to effectively implement the engineering design process into their classrooms. The teachers attend DTEACh in the summer for extensive professional development about: (1) contextualization of the design problems within the *21st Century Engineering Grand Challenges*; (2) guided self-exploration of engineering concepts using manipulatives; and (3) increased focus on the pedagogy of design-based teaching and learning. Throughout the school year, those teachers participate in continuing professional development to prepare for spring curriculum modules and summer camp. The rationale for the framework and content of the professional development and curriculum is in response to: (1) research that shows females and underrepresented minorities are more attracted to and interested in design challenges that have a relationship to broader impacts on humanity and (2) indications that teachers need more insight into how engineering and design-based learning can be integrated into their teaching.

The target population for *Beyond Blackboards* is each of the three middle schools in the Cave Creek School District. Cave Creek's population is predominantly Hispanic, low income, and low English Language Proficiency. Furthermore, there are limited STEM resources and opportunities for students even though Cave Creek is adjacent to Austin, Texas, a region with a growing technological economy, identified by Forbes magazine (2008) as "recession-proof". Indeed, *Beyond Blackboards* is the first STEM outreach program in the district, providing students with

access to STEM opportunities that they have not previously had the possibility to receive. CCSD is a prime area for this study because it is representative of the current national situation. With a rapidly increasing minority population and a lack of STEM opportunities in economically disadvantaged areas, many Americans are in a poor position to engage in STEM fields. Therefore, the United States' attempts to strengthen its economy through this highly innovative discipline are largely inadequate. Participants in *Beyond Blackboards* are representative of school demographics, with 66% of students identifying as Hispanic, 76% economically disadvantaged, and 7% with limited English proficiency. Even with a concerted effort for equal gender participation, females are underrepresented, making up just 30% of participants, corresponding with the ongoing shortage of women in STEM fields. A full summary of Central Texas enrollment, Cave Creek students, and *Beyond Blackboards* participants is included in Appendix B. Access to economic opportunities is derived from education and technical skills, yet because Cave Creek parents do not have these backgrounds, students are generally not exposed to engineering. Consequently, Cave Creek students are an ideal target population for investigating methods to increase diversity in engineering to improve U.S. competitiveness.

Purpose and Scope

*Beyond Blackboards* focuses on outreach for underprivileged middle school students in a Hispanic community with limited STEM opportunities, and particularly looks for ways for students to understand the importance of engineering in the real world through the *21st Century Grand Challenges*. The program aims to develop an interdisciplinary, inquiry-based engineering program and evaluate effective strategies for developing a culture of engineering education in Central Texas. From the external evaluation, we find that the camps and clubs sponsored by *Beyond Blackboards* have successfully increased participants' interest in engineering, as well as attending a four year university. Still, it is important to look for any visible trends in the success that students have had with the clubs and camp. By understanding the extent of which these students, particularly the girls, have experienced changes in their attitudes and goals related to engineering after being a part of *Beyond Blackboards*, we can potentially apply these advances across campuses.

This study examines student surveys and teacher interviews portraying attitudes toward engineering for *Beyond Blackboards* female participants and non-participants, the latter reflecting the effects of *Beyond Blackboards* on the entire CCSD community. Results will be compared to national 8th grade averages from the TIMSS study. Specifically, the question to be addressed is "How does *Beyond Blackboards* impact girls' attitudes toward engineering?"

## Literature Review

The Changing Nature of STEM

It is widely accepted that the United States must enhance its STEM workforce in order to remain an economic leader. However, along with the changing nature of the economy, STEM fields are evolving to demand interdisciplinary ideas, emphasizing the need for individuals who can succeed as global citizens and strong business leaders, who display understanding of ethical principles, and along with the often predominant strengths in mathematics and science, have abilities in analytical skills and creativity. In order to confirm that the U.S. will have such individuals working to generate the ideas that will ultimately build our nation, it is crucial that "a

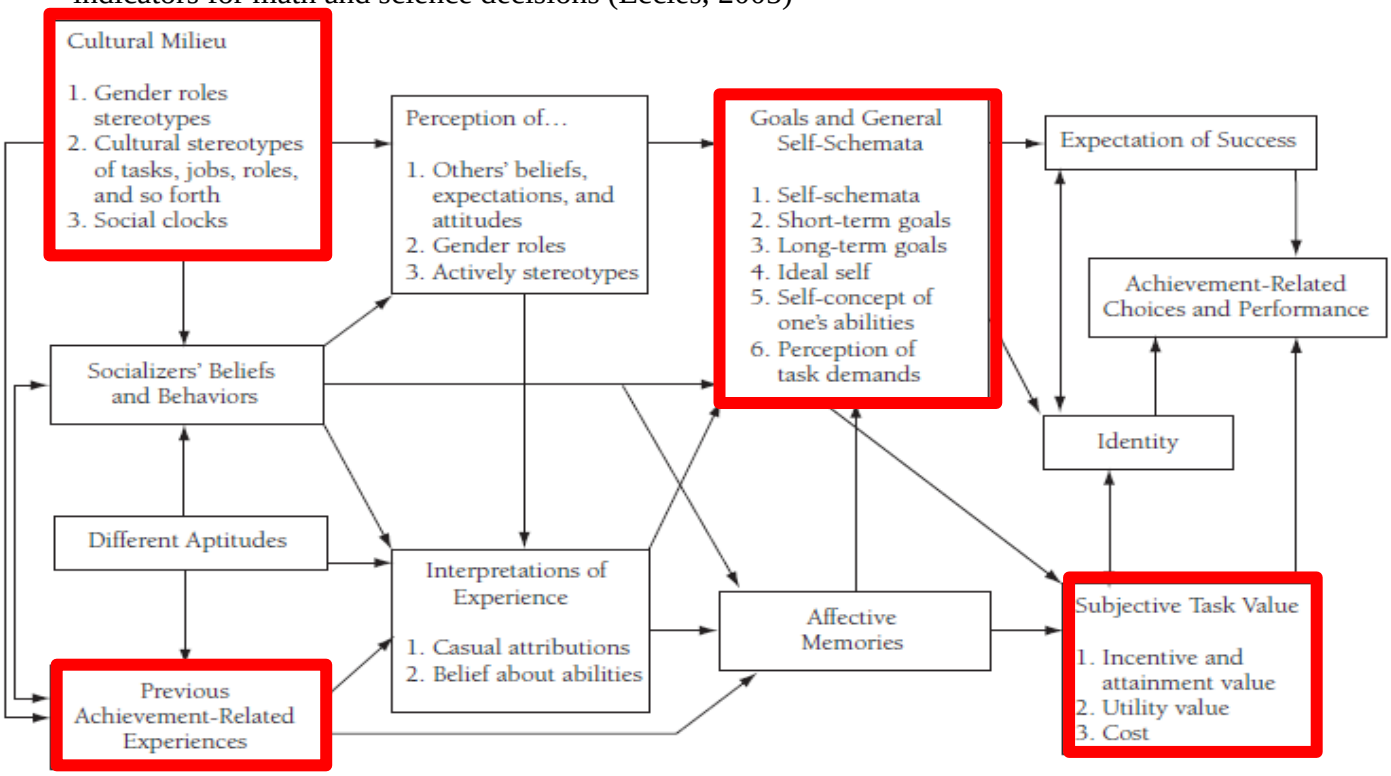
wide net is cast" to reach a diverse talent pool to take part in STEM disciplines. (NSB, 2010; NSB, 2011; Riegle-Crumb et al., 2011; NRC, 2007; NRC, 2009; AAUW, 2010; NAE, 2004).

The Need for Gender Diversity in STEM

While women have become increasingly prominent figures in law, medicine, business, and social science professions over the past fifty years, studies show that the lack of gender diversity remains especially apparent in STEM (Linver & Davis-Kean, 2005). Women are 60% less likely to choose a STEM major than men, leading to women earning only 19% of bachelor's degrees in engineering in 2010 (Riegle-Crumb et al., 2011; NSB, 2010). Ability or biological attributes are not the cause of this severe shortage of women in STEM fields. Female students' grades and test scores are competitive with males', though females are still far less likely to choose mathematics or science courses and careers, even if they enjoy the subjects. Instead, STEM loses women through inaccurate, negative perceptions involving gender roles and engineering, such as the idea that women cannot succeed in engineering, or that it is "just for men" (Farland-Smith, 2009; EWEP, 2005; AAUW, 2010; Kekelis et al., 2005; Jacobs, 2005). These perceptions start early; attitudes toward mathematics begin to differ between genders as early as second grade (Cvencek et all, 2011). Furthermore, early teen years are commonly recognized as the time when girls develop their self-image and begin to take into account gender roles as they consider future career paths (Steinke, 2005; Brophy et all, 2005; Riegle-Crumb, 2011; English, 2011). *Beyond Blackboards* targets middle school students in an attempt to give them positive perceptions of the above factors to take into consideration when they are making education and career choices.

These decisions are defined by multiple influences, including cultural milieu, achievement experiences, and self-perceptions, as outlined by the Eccles Expectancy Value Model, seen in figure 2. Eccles' conceptual framework for decision making is a longitudinal model that is particularly salient in STEM and has been extensively studied over the past few decades. For adolescents, educational and occupational choices regarding mathematics and science are significantly guided by task values (interest, utility, attainment, and cost) and the relation of the choice to one's future goals, which for girls, does not typically include engineering. Mathematics and science achievement is also directly related to students' concepts of their prospects in engineering, and thus their probability of pursuing this field. Consequently, if students think they have the ability to succeed in engineering, it is more likely they will choose that path. Therefore, common stereotypes that 'engineering is for boys' or a lack of understanding of what engineers actually do could result in many young girls turning away from engineering. Adolescents are also influenced by gender roles and social schemas, which is often a strong deterrent from engineering for girls, as they view engineering as a predominantly male field. So, indicators that have the potential to have positive implications for girls to make decisions about engineering are incorrectly perceived as barriers, and many times, girls do not give STEM a chance. *Beyond Blackboards* reaches out to students early with goals to change their perceptions about engineering (Eccles et all, 2005; Watt, 2005).

*Figure 2*. Eccles Expectancy Value Model with emphasis added to reflect most important indicators for math and science decisions (Eccles, 2005)




The arrows in the figure show which indicators influence each other and the direction of influence. The double-headed arrows signify that the indicators influence each other.

<u>Developing Interest and Engagement for Girls in Engineering</u>

Studies show that it is crucial to expose adolescents to engineering so misconceptions do not draw them away from the field. One of the most direct ways to ensure students' understanding of engineering is to improve K-12 education (Riegle-Crumb, 2011; Brophy et all, 2008; NRC, 2007). Many students of both genders have a limited concept of engineering (NAE, 2008), which is directly related to the fact that engineering concepts are not a part of science and mathematics curriculum in most states (Brophy et all, 2008). Design-based learning implemented in schools would be beneficial for all students, as they would gain "problem-solving experiences, tolerance for ambiguity, [and] understanding of systems thinking and technological fluency" (Partnership for 21st Century Skills, 2011).

If students show an interest in engineering, it is important to keep them engaged in the field. It has been repeatedly found that one of the most effective ways to keep girls interested in engineering is to help them study ideas within a real world context, instead of just teaching theoretical and analytical concepts without any practical applications. Girls are engaged when they see how engineering is an essential part of everyday life (NAE, 2008; Hancock, 2010; Kidwell, 2010; Rogers & Portsomore, 2004) and when the material is "challenging, motivational, and interesting" (English, 2011). Design-based learning, such as the DTEACh curriculum used in *Beyond Blackboards* is one such example of meeting these goals.

In careers, girls tend to look for areas where they can make a difference. They also seek good working environments and salaries, along with flexible schedules and overall enjoyment of their

work (EWEP, 2009; Steinke, 2005). However, there is dissonance between these traits and how young women view engineering, as they do not understand how engineering can fit in with the above goals, or how it is relevant to everyday life. This is a main factor behind the lack of interest in engineering for female students (Brophy et all, 2005). This limited understanding is emphasized in the "Draw an Engineer Test." When asked to draw an engineer, most students depicted men working with some kind of "building" tools (Knight & Cunningham, 2004). To eliminate these misconstructions, the NAE has been working to create a 'brand' for engineering that provides effective messages and taglines specifically designed to increase awareness of the relevancy of engineering, expectantly encouraging underrepresented groups to stay in the field. In the national report *Changing the Conversation,* evidence is provided that the messages "Engineering is essential to our health, happiness, and safety" and "Engineers make a world of difference" were most effective for girls and Latino/a youth, confirming the idea that girls (and in Cave Creek with ~70% Latino/a) look for careers that they personally relate to and where they can help others (NAE, 2008). Additionally, once individuals learn about the specific challenges engineers address, interest in engineering increases compared to interest in other fields such as medicine or law (Hart Research Associates, 2009). By understanding what words and phrases resonate with women and other minorities, the field of engineering will continue to grow and become more innovative, promoting a higher level of success and leadership nationwide. In an effort to change perceptions, these messages are explicitly expressed throughout the *Beyond Blackboards* program and curriculum.

Even if students are interested in an engineering career, they are frequently unaware of how to prepare for this path. Students may not know what courses to take or the number of years of study needed to prepare for STEM (NAP, 2010; Kekelis et all, 2005). For students in low income areas such as Cave Creek, family and community factors limit the availability of information and resources for success in STEM. When students incorrectly estimate the amount of education for a career (either over or under), they are more likely to experience long term deficits including unemployment and lower educational attainment (Sebates et all, 2011). Through working with teachers, families, and mentors in *Beyond Blackboards,* students learn what will be necessary to have a STEM career.

Predominant Engineering Influences for Girls

Another important factor in ensuring STEM gender diversity is emphasizing positive influences to take part in engineering. Family, the media, and female role models are all substantially strong influences for girls. Similarly, strong social support among peers is important for students to feel accepted in school environments, and contributes to the level of their achievement choices (Jacobs, 2005; EWEP, 2005). Often, family support is focused only on graduation, not career plans. However, girls with parents in STEM careers are often more inspired to follow this path themselves (Kekelis et all, 2005). Women appointed to senior roles in engineering continue to make headlines because this is still a rare occurrence (Wilson, 2007). In addition to the scarce amounts of positive media or societal attention, negative media also commonly takes a forefront, a recent notable example being Harvard's former president Larry Summers, who in 2005 notoriously declared that the reason there are not more women in top STEM positions is because of "issues of intrinsic aptitude" (Jaschik, 2005). Because girls may have a hard time identifying their roles in STEM disciplines due to abundant stereotypes, it is important for them to have access to successful women in the field in order to build the confidence that they too can be

successful in engineering (Mawasha, 2001; Kitzinger et all, 2008). If real role models are not available, television or other media influences can be just as influential. Middle school girls who see female scientists on television are inspired by their confident and intelligent personalities. Though there are not as many strong portrayals of women in engineering as there are in medicine and law, any positive representation of women in STEM can show students that an engineering career is a viable option (Ryan & Steinke, 2010), and exposure to this at an early age can help to eliminate gender stereotypes responsible for the low interest and engagement discussed above. *Beyond Blackboards* specifically includes highlights of role models from traditionally underrepresented groups in STEM in the curriculum and has diverse mentors in the program

## Methods

Survey data was collected for quantitative analysis during the fall and spring semesters of the 2010-2011 academic school year from the three middle schools in the Cave Creek School District. These schools serve approximately 2,200 middle school students, with 1,473 students completing both the fall and spring surveys. Of the 58 participants who took the survey in both fall and spring, 67% of participants were Hispanic, 18% were White, and 14% were Black. 75% of participants were economically disadvantaged, 30% were female and 7% were English Language Learners (ELL). Thus, girls, economically disadvantaged students, and ELLs were underrepresented in the program. Surveys asked students about their school, science and engineering, and educational and career attitudes as well as their educational expectations. The pencil and paper questionnaires were short (approximately 15-20 minutes long), offered in English and Spanish, and completed on scannable answer sheets. Survey results were compared to national trends and statistics for 8$^{th}$ grade students from the *Trends in International Mathematics and Science Study* (TIMSS). Because TIMSS is measured on a Likert scale, percentages for 'Agree a lot' and 'Agree a little' will be combined, along with 'Disagree a lot' and 'Disagree a little'. However, statistical analysis to compare participants to nonparticipants or participants to national data cannot be accurately completed due to the small sample size of *Beyond Blackboards* participants. A comprehensive list of survey questions and TIMSS results along with comparative graphs can be found in Appendix C.

Teacher interviews were conducted for qualitative analysis for eleven teachers (3 male, 8 female) during the 2012 *Beyond Blackboards* underwater robotics summer camp. Interviews were semi-structured, lasted approximately 45 minutes and were tape recorded and then transcribed for further review. To ensure trustworthiness, interviews were coded by two different researchers, and then compared for common themes and trends. Analysis of responses was used to create a more comprehensive understanding of how and why middle school girls engage in design-based learning, such as the DTEACh curriculum implemented in the *Beyond Blackboards* program. Other topics discussed include experiences and perceptions of DTEACh, LEGO® robotics, and the *Beyond Blackboards* program. All interviewees chose to be identified their first name only, and this is how they will subsequently be referred to in the rest of this paper.

## Results

Survey results displayed increased understanding and interest of engineering and engineering careers for *Beyond Blackboards* participants. Teacher interviews reflected on primary influences

(role models, family, school, self-motivation, and media) for girls to take part in engineering, and their notions of other factors that affect girls' perceptions and interest in engineering. Specific topics included confidence, gender roles, connection to real world context, and peer social support. Analysis reflected positive shifts in the way these topics lead to girls' perceptions of engineering, relating back to the Eccles conceptual framework in figure 2 by providing girls with a strong, optimistic base for decisions regarding STEM pathways.

Student Surveys and TIMSS

Student survey responses reflect a high percentage of female participants—87% average between fall and spring semesters—and nonparticipants—80.5% average—that "like learning how things work", which is comparable to the male averages of 92.5% and 84.5%, suggesting an initial interest in engineering ideas. The problem is getting students to understand that their interests are related to engineering. Female participants also reported a high understanding that "Engineers mainly work with other people to solve problems"—87.5% average for fall and spring—this time much higher than the nonparticipants—68.5%—showing that *Beyond Blackboards* plays a role in students' understanding of what engineers do. Females also displayed a large increase in agreeing with the statement "I can make a lot of money as an engineer", with 61% in the fall to 86% in the spring, showing more understanding of engineering careers by the end of the program. However, males remained at a high 89% for both semesters, indicating that boys may have more of an understanding of engineering as a career than females before they take part in *Beyond Blackboards.* Also, female participants had higher understanding than nonparticipants—71.5% average—suggesting that the program does help to educate students about engineering.

*Figure 3*. Many female participants "like learning how things work"

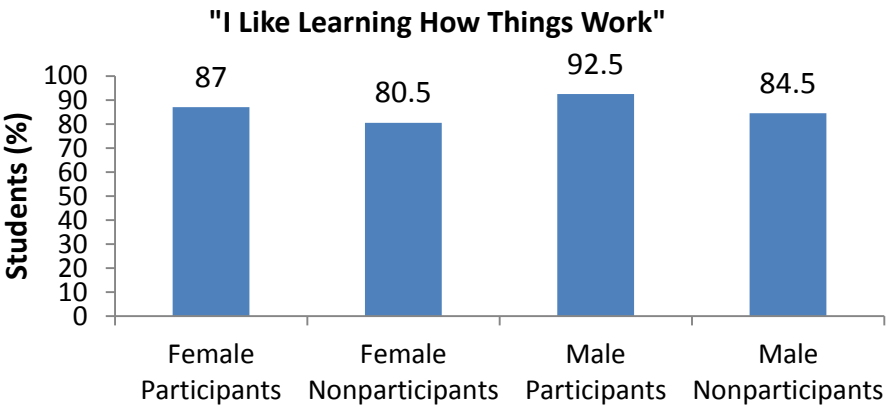



*Figure 4.* Female participants understand engineering strategies more than nonparticipants

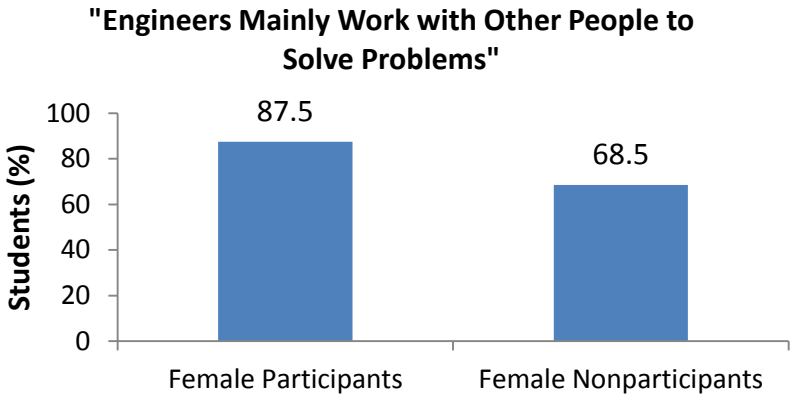
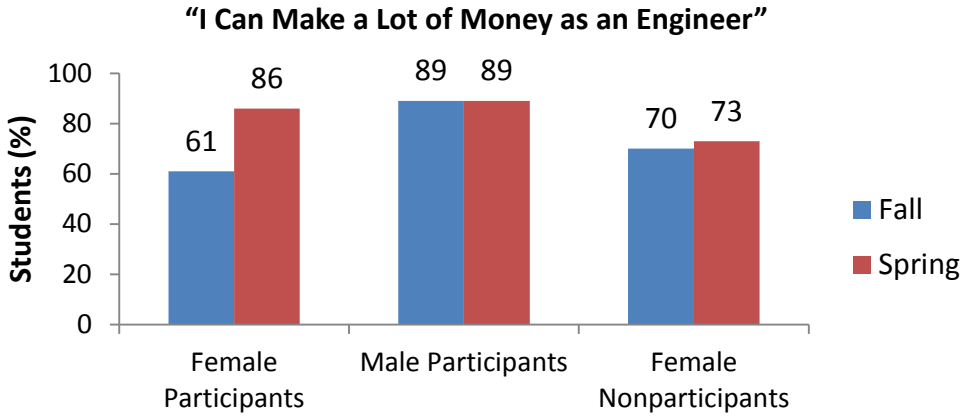
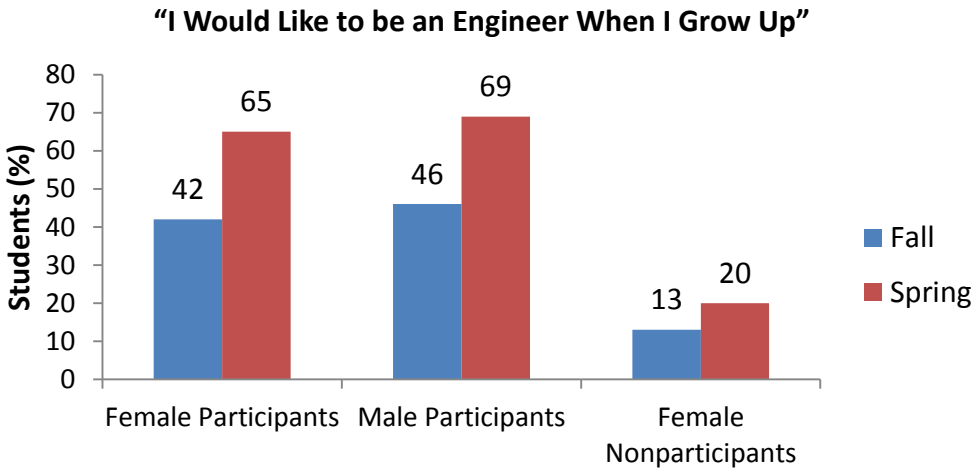


*Figure 5*. Female participants show growth in understanding details of engineering careers




Looking towards the future, the most promising results came from students wanting to be an engineer when they grow up. Female participants displayed an increase from 42% to 65% from fall to spring, while female nonparticipants had much lower numbers at 13% to 20%, again showing that *Beyond Blackboards* is positively influencing girls to take part in engineering. Promisingly, female percentages were very close to males, with 46% to 69% wanting to be an engineer from fall to spring. This reflects that gender stereotypes have less of an impact on program participants.

*Figure 6*. Female participants show higher interest in engineering careers than nonparticipants




Compared to national 8th grade averages from the TIMSS survey, Cave Creek female students had a higher percentage of enjoying math, with a 69.5% average between semesters for CCSD, and 59% average for TIMSS. This was also much higher than male participants at CCSD, with only a 55.5% average. For program participants, more females than males looked forward to math, showing that they may have initial interest in the program and its components, also explaining the higher than national average results. The 69.5% is also higher than the 61%

national average. Female participants and nonparticipants were comparable. Figure 7 outlines these results.

Educational expectations were also compared to TIMSS data. In the spring, 50% of female participants in *Beyond Blackboards* wanted to obtain an advanced degree, which is slightly higher than the 44% national average and nonparticipants. Another 29% (up from 21% in the fall) want a four year degree, which is lower than the 43% national average, though this may come from a higher percentage of CCSD students who do not know how far they want to go in school, though this did decrease from 21% to 14%, most likely because the program exposed them to more career options and how to prepare for them. The high percentage of girls who want to complete a four year or advanced degree can correspond to the promising increase in girls who want to be an engineer when they grow up. Their educational expectations show that they are aware of the path they need to take to become an engineer. Also, in the spring 0% of *Beyond Blackboards* female participants only wanted to finish high school, compared to the 6% national average and 10% nonparticipants, displaying encouraging positive influences from the program.

Teacher Interviews

Teacher interviews focused on five influences that form the attitudes of girls toward engineering, along with four other important factors that shape girls' engagement in and perceptions of engineering. Teacher's perceptions are important to understand, as Lyons (1990) describes in her concept of "nested knowing" or the idea that students and teachers have "nested, interacting epistemological perspectives." Figure 7 summarizes some of the recurring themes from all eleven teachers' interviews. Shifts in girls' engineering attitudes observed by teachers will be related back to decision factors outlined in Eccles' conceptual framework.

*Figure 7*. Main ideas discussed during teacher interviews

Coming into *Beyond Blackboards*, many girls had preconceived ideas about the relationship between engineering and gender, often limiting their level of engagement and interest. Charlene noted that "we've always had girls in the minority", which affects the level of social support girls feel in a generally male dominant environment. Gerwin reflected on perceptions affecting

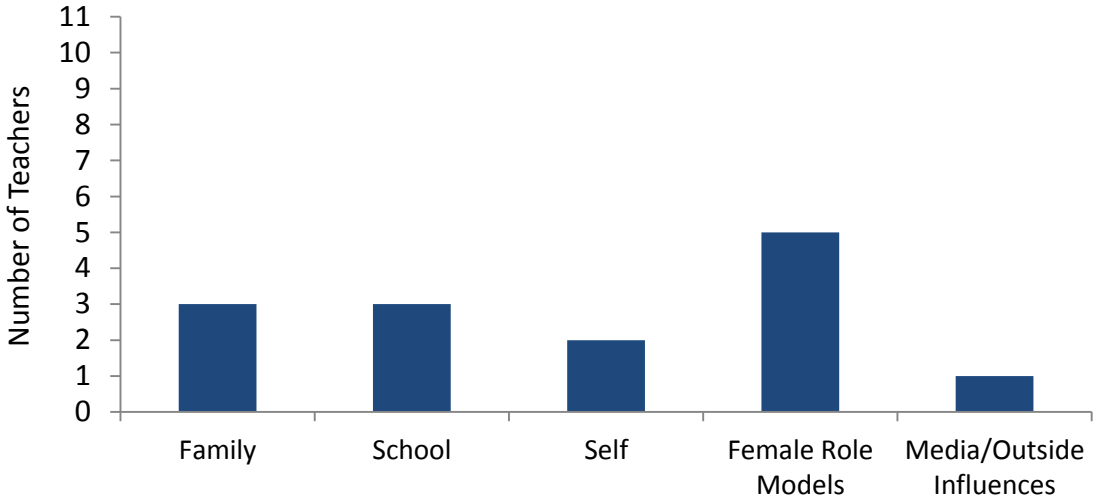
engagement level: "...because there are not a lot of girls that like it [engineering], a lot of girls tend to think it is only for the boys". Similarly, Nabor mentioned that "it [involvement in engineering] does just come down to the girls' self-image and their perspective on their roles in society." Yet, "just because they are a girl, it doesn't mean they have to set limitations for themselves." But these limitations may be all too common for girls in CCSD, who do not have many, if any STEM opportunities. Following Eccles' model, these attitudes are a setback when considering cultural milieu, and if girls remain in this mindset, they would not be inclined to pursue engineering.

Teachers concurred that *Beyond Blackboards* helped to break the boundaries girls perceive because of their gender. When asked what attracts girls to engineering, teachers overwhelmingly emphasized the importance of female role models. Influence and support from family, school, media, and peers is also important, but girls interacting with other successful women in STEM, including teachers and undergraduate and professional industry mentors, encourages them to believe they can be successful as well. "If they don't see an adult that is female [in engineering], they may just think it's more male and more masculine", Analisa said. Tara emphasized this point by saying "Showing them girls in that environment ... they knew that I was into engineering, and I had some experiences where I could share that girls can be smart, girls can do these things". Nabor recognized that female teachers may be able to connect more directly to younger girls: "When they have a woman they can look up to, I think then it relates to them, and they kind of think, okay, well maybe I can achieve something." Girls can strongly connect with female role models, and as Becky mentioned "build relationships with girls who might have some aptitude, proclivity towards some of that (building and programming the robots)".

In addition to role models, Angie noted that girls may be more interested "if they saw more advertising so to speak, like pictures of the girls being successful at the championships, videos that we might show when we are recruiting, showing the girls being involved with it...". These outside sources are another effective method to bring girls into engineering, and to keep them engaged. Family support and influences are another major factor impacting girls' attitudes and interests concerning engineering, and *Beyond Blackboards* has concerted effort to inform parents about STEM opportunities as part of the 3-pronged approach. "We had parents who said, I'm not going to bring them, because this (camp or club) isn't important", Charlene said. This mentality clearly affects the girls' mindsets towards engineering. However, as *Beyond Blackboards* progressed, parents changed their views on engineering, and their daughters. Becky reflected on a parent who said at summer camp that she now "sees her daughter as being someone who is intelligent" and Jeannie included that parents from camp said they "will do everything (for their children) to go into college". So, not only is girls' involvement in engineering more supported, but their educational aspirations are affirmed as well, thus improving multiple facets of their future prospects. Rachel also stated that motivation to become involved in engineering "would have to be something that comes from within" and Gerwin thought that "interest basically comes from your school", but for students who may not have a concept of engineering, or live in an area such as Cave Creek, there may not be realistic prospects of self-motivation if there are no positive resources from the school. This is where the mentors that work with *Beyond Blackboards* can truly make a difference in the girls' lives. All of these influences allow girls to reevaluate gender roles and other "cultural milieu" and their expectations for success, giving

them positive references when making decisions according to the Eccles model. Figure 8 recapitulates how many teachers discussed each of the above influences.

*Figure 8*. Number of teachers who reported various factors influencing females' participation or interest in engineering

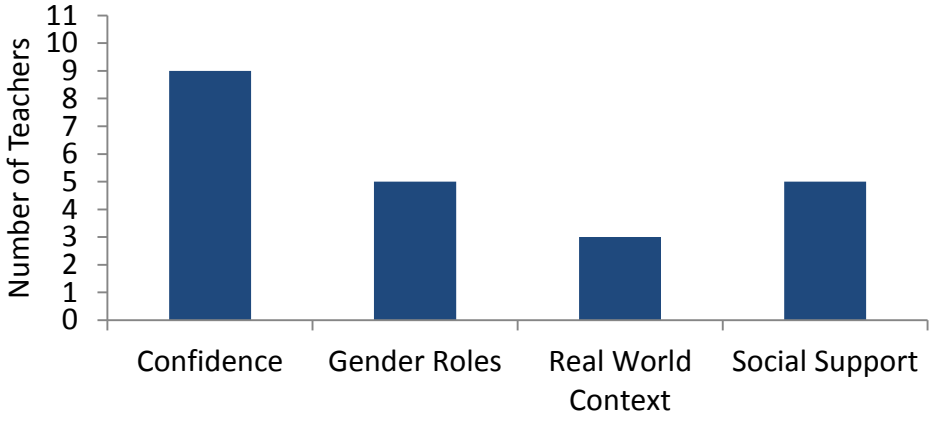



As the girls continued participation in the clubs and camp, teachers noticed an increase in self-confidence, helping girls move away from the stereotypes they may have held before being involved in the program, and being inspired by the influences stated above. When girls start the program, Charlene noticed that "there is a lot of posturing and image issues they are first concerned about, you know, who likes who and how do they look" and Becky observed that "they are more timid at first, and it's a little bit harder for them to feel comfortable to jump in". Because of this initial hesitance, girls tend to seek social support with female peers. Jeannie said, "They [girls] all have something in common because they are the minority here. And so they stick together" and as the program progresses, they "interject ideas, not let the boys take over." Nabor added "Once they started actually building stuff, and programming, and seeing the accomplishments that they were doing, I think they started getting that self-confidence and like, you know, I can do this." According to Analisa, *Beyond Blackboards* also helped to girls who may be shy "come out of their shell" and "meet new friends"; the girls became "not as timid, and were more open to being creative and building and programming. " Tara emphasized that girls actually seeing their accomplishments gave them valuable confidence that allowed them to actively participate "in an arena where boys would outshine the girls all of the time". Teachers in *Beyond Blackboards* work to create classroom environments that are conducive to girls feeling important and included in group work. For example, Gerwin said that even if girls are outnumbered "we still want them to actually you know, say, here I am, and I still can make it... we still want them to coexist in that environment". Girls began to see that "what they had to say was valued (Normando)" in group work, and this confidence that they gain leads them to bring their diverse strengths and personalities into engineering. Again, this increased self-confidence and realization of success positively impacts girls when making decisions regarding engineering, especially regarding the "self-schemata" indicator in Eccles' model.

Teachers also noted the specific aspects of the camp and clubs that appealed directly to girls, and which areas these students thrived in. Girls perform "better than the boys when they are more

self-confident" according to Jeannie, and there are certain ideas that motivate them highly. Teachers said that girls are "thoughtful in their processes, and pretty creative" (Tara), "tend to like the writing part" and "really know when to turn the teamwork on" (Gerwin). Teachers also largely agreed that relating engineering to a real world context kept the girls engaged, and furthered their interest in engineering to a large extent. This allows girls to see the "task value" in engineering outlined by Eccles, along with the relation of engineering to students' goals, again, positively influencing their decisions surrounding engineering. "They enjoyed the idea of thinking about the problem that was there, and what problem they wanted to solve. And it needed to be related to something important to them" (Angie). The *21st Century Grand Challenges* are an excellent source of showing girls how engineering connects to real life and can solve pertinent issues. In addition, girls were very engaged with the design-based learning aspects of the program. As Normando said, it "... really does a great job of keeping their attention and having them feel like they are a part of what's going on in the group". He later added that girls liked that "they are able to get hands-on and really do things". The curriculum of *Beyond Blackboards* allowed students to share many ideas and solve problems in ways they had never thought of before, by applying design-based learning concepts so crucial to engineering. This provided students with "a base of discovery", and let them be comfortable with "not waiting to be spoon fed information, not having an answer (Tara)". Tara, who took a group of girls to the FLL international competition also made note of skills that the girls were learning in addition to engineering practice: "It was way less about the robotics and way more about the connections with themselves". These skills, along with improved self-confidence, are something that is important across all disciplines, not just engineering. Figure 9 summarizes the number of teachers who discussed the above topics that have a direct relationship to female students' involvement.

*Figure 9.* Number of teachers who reported various, common factors affecting females' perceptions or engagement in engineering




The positive effects of *Beyond Blackboards* do not stop at the program's conclusion. For the group of girls who traveled to the international FLL competition, the reach of *Beyond Blackboards* continued. Tara, the teacher who coached and chaperoned them, told of a competition leading to that point:

> ...their programs and stuff still did not do what they liked, but amazingly, they still were excited about it, and still were able to show the judges how they were encouraging each other and getting excited with each other, and I think that was the one where, out of their own mouths came the words, you know, we got into Innovation Club to just try something new, try something different, and we found a family.

The team found a "family" but also success, and after moving on to the international competition, Tara said that "the robots are just a portal to ... other more amazing things that they can get involved with." The idea that the program benefited students beyond strict educational goals was seen by many teachers. Maria told of a student who "was able to see that her passion for engineering was something that she could successfully complete." This student was able to recognize the path she needed to take to be prepared for STEM, and looked back to *Beyond Blackboards* when she saw that her high school did not "have what I need here." Becky commented on the impact that the attitudinal changes could have on the girls' futures by saying "It means that boundaries are broken, and things change, and when women lead, things will look very different in the world, and priorities will shift in a very different direction. And women who break boundaries change the world."

## Discussion

Many girls in Cave Creek School District, along with the rest of the nation, are reluctant to try engineering because of the negative stereotypes they have incurred from a lack of exposure to STEM experiences. Yet *Beyond Blackboards* shows these students that engineering is not just for boys or 'nerds'; it is a profession that solves real world, everyday problems, such as the *21st Century Grand Challenges*. Looking back to the Eccles model, *Beyond Blackboards* helps to expand the way students consider factors that they use to make educational and occupational decisions. Where students may have previously focused heavily on barriers to engineering such as cultural milieu, including gender roles, or achievement in mathematics and science, they now see as inspiration in the form of increased confidence that being a girl does not set limitations, and a valuable experience in success with engineering through the program. *Beyond Blackboards* has also shown students how engineering coincides with their future goals, which was yet another barrier, as students did not understand what engineers do. Girls learned to see value in engineering, and this attributed to the positive shifts in their attitudes about considering engineering as a viable option for their futures. These changes can be greatly accredited to the influence of female role models in the form of female teachers and undergraduate and professional mentors. Students were able to interact with successful females in what they had perceived as a male dominated field, and this helped to give them the necessary confidence to believe that they too could become a woman in STEM.

*Beyond Blackboards* also proved successful for increasing female participants' interest and engagement in engineering. Design-based learning gave students the opportunity to have a more open-ended, hands-on experience, and this resonated with girls more so than a traditional class, which is often designed to "teach to the test", and generally neglects practical applications. Also, the base of the program, which is to solve one of the *21st Century Grand Challenges*, provides students with a context that resonates with their everyday lives. The dramatic increase seen in female participants' interest to become an engineer from fall to spring is strong evidence that

*Beyond Blackboards* effectively shows students that engineering is a diverse and crucial field to the success of the nation, and between the curriculum and the role models, girls learn that they have a strong place in the field. However, because these percentages were much higher for participants than nonparticipants, we know that *Beyond Blackboards* can continue to work on expanding the positive attitudes gained in the clubs and camps to make a difference across the community. Appendix D lists valuable resources for girls of all ages to discover engineering.

## Summary

Though girls in Cave Creek have more challenges than the average student because of their low socio-economic status, their attitudes were very comparable to national averages defined by TIMSS, most notably in educational expectations. This display of resilience shows that students in CCSD are becoming aware of the opportunities that lie even within close proximity to them, and are working towards a path that will allow them to grow out of the confines set by their current social status. *Beyond Blackboards* is an important factor for girls to not only learn about engineering, but to learn other valuable skills that they can apply to whatever path they may choose. As their teachers responded, girls gained confidence in their abilities and their prospects to succeed, and these stronger self-concepts will stay with the girls at an age where they are heavily influenced by their surroundings. As for the many girls who were inspired to become an engineer, if these new attitudes are maintained, they will be a part of the essential effort to diversify the STEM workforce and strengthen a field that has the capacity to change the world. With contextualization and community development around facing the *21st Century Grand Challenges*, there are more possibilities for real world, design-based learning that attracts, retains, and in this case, improves STEM education for traditionally underrepresented groups in engineering. As more school districts and universities engage in these *21st Century Grand Challenges* we anticipate seeing positive trends of females and other traditionally underrepresented groups engaged and successful in engineering design-based experiences.

## References

American Association of University Women. (2010). *Why So Few?: Women in Science, Technology, Engineering and Mathematics.* Washington, DC: AAUW.

Brophy, S., Klein, S., Portsmore, M., & Rogers, C.. (2008). Advancing Engineering Education in P-12 Classrooms. *Journal of Engineering Education, 97*(3), 369-387. Retrieved July 31, 2012, from Research Library. (Document ID: 1552332281).

Cockrell School of Engineering. (2012). DTEACh Method. In DTEACh: Design, Technology and Engineering for All Children. Retrieved August 7, 2012, from http://dteach.engr.utexas.edu/.

Cunningham, C., Knight, M. (2004). *Draw an Engineer Test (DAET): Development of a Tool to Investigate Students' Ideas about Engineers and Engineering.* Retrieved from http://gk12.poly.edu/amps-cbri/pdf/Draw%20an%20Engineer%20Test%20(DAET)%20-%20Development%20of%20a%20Tool%20to%20Investigate%20Students%E2%80%99%20Ideas%20about%20Engineers%20and%20Engineering.pdf.

Cvencek, D., Meltzoff, A. N. and Greenwald, A. G. (2011), "Math–Gender Stereotypes in

Elementary School Children." *Child Development*, 82 : 766–779.
Eccles, Jacquelynne S. (2005)."Studying gender and ethnic differences in participation in math, physical science, and information technology." New Directions for Child and Adolescent Development 2005(110): 7-14. http://hdl.handle.net/2027.42/39129
English, L. (2011-01-01). Perceived Gender Differences in STEM Learning in the Middle School. The International journal of engineering education, 27(2), 389-398.
EWEP. (2005). *Extraordinary Women Engineers Final Report*. Retrieved from http://www.eweek.org/site/news/Eweek/EWE_Needs_Asses.pdf.
Farland-Smith, D. (2009). Exploring middle school girl's science identities: examining attitudes and perceptions of scientists when working "Side-by-Side" with Scientists. *School Science and Mathematics*, *109*(7), 415+. Retrieved from http://go.galegroup.com.proxy.lib.umich.edu/ps/i.do?id=GALE%7CA213079328&v=2.1&u=lom_umichanna&it=r&p=ITOF&sw=w.
Hancock, T. (2010-01-01). PALs: Fostering Student Engagement and Interactive Learning. Journal of higher education outreach and engagement. 14(4), 37-60.
Hart Research Associates. (2009). *Americans' Attitudes toward Engineering and Engineering Challenges—National Survey Results.* Washington D.C.: Hart Research Associates.
Jacobs, J. E. (2005-01-01). Twenty-five years of research on gender and ethnic differences in math and science career choices: what have we learned?. New directions for child and adolescent development, 110, 85-94.
Kekelis, L.S., Ancheta, R.W., Heber, E. (2005). Hurdles in the Pipeline: Girls and Technology Careers. *Frontiers: A Journal of Women Studies. 26* (1), 99-109.
Kidwell, C.. (2010, March). The impact of STUDENT ENGAGEMENT on learning. *Leadership, 39*(4), 28-31. Retrieved July 31, 2012, from Research Library. (Document ID: 1985933201).
Kitzinger, J. Haran, J.Chimba, M. & Boyce, T. (2008). *Role Models in the Media: An Exploration of the Views and Experiences of Women in Science, Engineering and Technology.* Retrieved from http://schools.caerdydd.ac.uk/jomec/resources/Kitzinger_Report_1.pdf
Linver, M. R. & Davis-Kean, P. E. (2005), The slippery slope: What predicts math grades in middle and high school?. New Directions for Child and Adolescent Development, 2005: 49–64. doi: 10.1002/cd.149
Lyons, Nona. (1990). Dilemmas of Knowing: Ethical and Epistemological Dimensions of Teachers' Work and Development. *Harvard Educational Review, 60*(2), 159. Retrieved August 8, 2012, from Research Library. (Document ID: 1659824).
Mawasha, P. R. (2001-01-01). Girls Entering Technology, Science, Math and Research Training (GET SMART): A Model for Preparing Girls in Science and Engineering Disciplines. Journal of women and minorities in science and engineering, 7(1), 49-57.
National Academy of Engineering. (2004). *Engineer of 2020.* Retrieved from http://site.ebrary.com.proxy.lib.umich.edu/lib/umich//docDetail.action?docID=10057020.
National Academy of Engineering. (2008). *Changing the Conversation: Messages for Improving Public Understanding of Engineering*. Washington, DC: The National Academies Press.
National Academy of Engineering. (2012). Grand Challenges. In Grand Challenges for Engineering. Retrieved August 7, 2012, from http://www.engineeringchallenges.org/.
National Research Council (2007). *Rising Above the Gathering Storm: Energizing and*

*Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press.

National Research Council (2009). *Engineering in K-12 Education Understanding the Status and Improving the Prospectus*. Washington, DC: The National Academies Press.

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital*. Retrieved from http://search.proquest.com.proxy.lib.umich.edu/docview/750311391?accountid=14667

Partnership for 21st Century Skills (2011). *Framework for 21st Century Learning*. Retrieved from http://www.p21.org/storage/documents/1.__p21_framework_2-pager.pdf

Riegle-Crumb, C., Moore, C. and Ramos-Wada, A. (2011), Who wants to have a career in science or math? exploring adolescents' future aspirations by gender and race/ethnicity. Sci. Ed., 95: 458–476. doi: 10.1002/sce.20431

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education : Innovations and Research, 5*(3), 17-28. Retrieved from http://search.proquest.com.proxy.lib.umich.edu/docview/222795467?accountid=14667

Ryan, L., & Steinke, J. (2010). I Want to be Like. *Science Scope, 34*(1), 44-49.

Sabates, R., Harris, A., & Staff, J. (2011). Ambition Gone Awry: The Long-Term Socioeconomic Consequences of Misaligned and Uncertain Ambitions in Adolescence. *Social Science Quarterly, 92*(4): 959-977.

Steinke, J. (2005-01-01). Cultural representations of gender and science: Portrayals of female scientists and engineers in popular films. *Journal of science communication*, 27(1), 27-63.

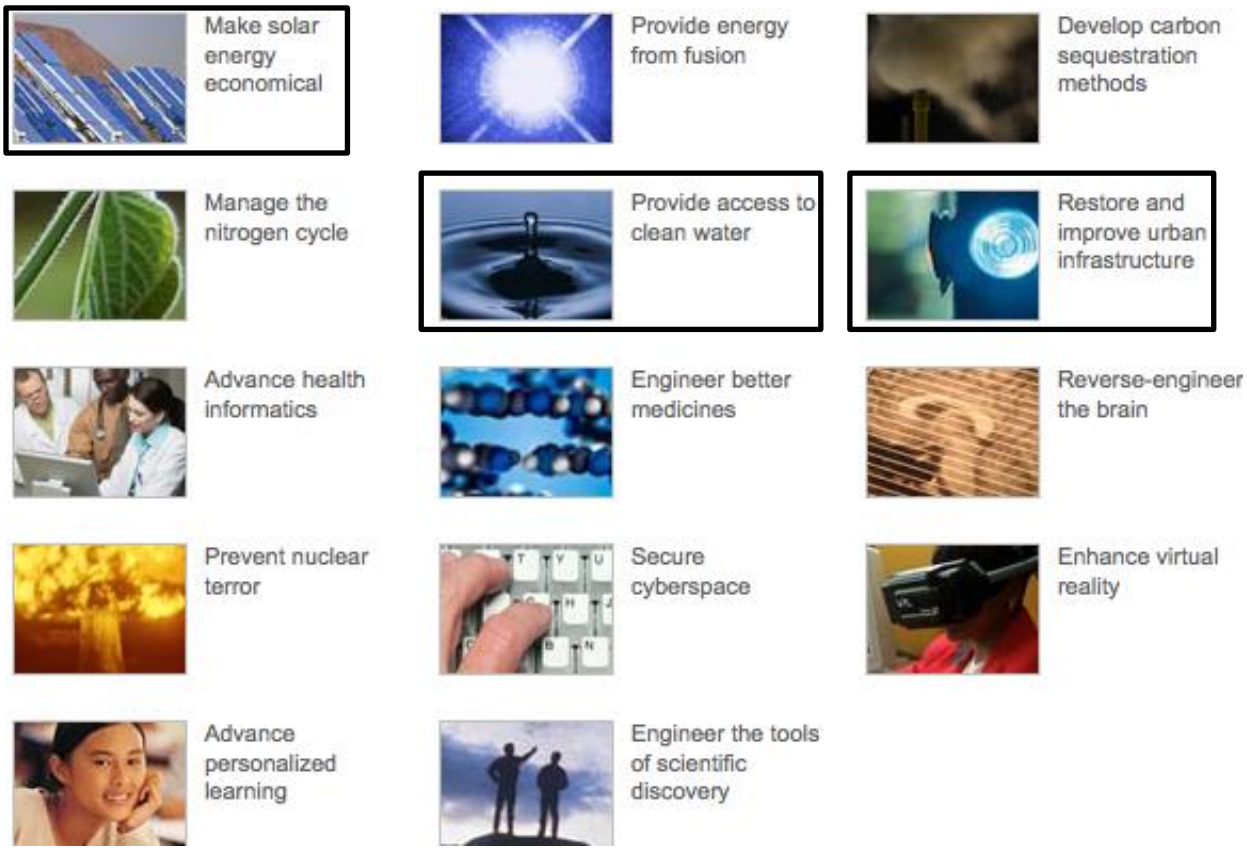
Watt, H. Exploring Adolescent Motivations for Pursuing Maths-Related Careers. Australian journal of educational & developmental psychology. 2005-01-01;5:107-116.

Wilson, R. (2007). Women engineers: Where are the role models? *Electronics Weekly*, (2293), 33-33. Retrieved from http://search.proquest.com.proxy.lib.umich.edu/docview/206314062?accountid=14667

Women engineers trace tech gender gap to childhood. (2012). *Bennington Banner*, pp. n/a. Retrieved from http://search.proquest.com.proxy.lib.umich.edu/docview/1018276294?accountid=14667.

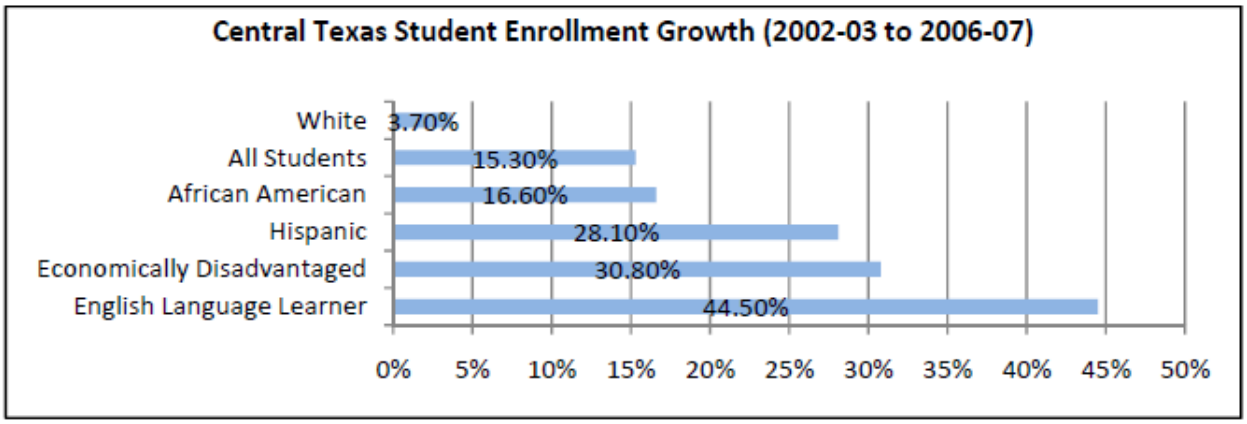
Zumbrun, J. (2008) *America's Recession-Proof Cities*. Retrieved from http://www.forbes.com/2008/04/29/cities-recession-places-forbeslife-cx_jz_0429realestate.html.

**Appendix A: The 14 National Academy of Engineering 21st Century Grand Challenges**




(Emphasis added to show focuses of *Beyond Blackboards* Innovation Clubs)

## Appendix B: Cave Creek Demographics




*Texas Education Agency data show trends in student enrollment in Central Texas Schools.*

### Cave Creek Middle School Demographic Information

| | Cave Creek Middle Schools | Beyond Blackboard Participants |
|---|---|---|
| Number of Students | 2,220 | 80 |
| % Black | 12 | 14 |
| % Hispanic | 81 | 66 |
| % White | 5 | 18 |
| % Economically Disadvantaged | 87 | 76 |
| % Limited English Proficiency | 32 | 7 |
| % Female | 49 | 30 |

SOURCE: Texas Education Agency reports and *Beyond Blackboards* data

**Appendix C: Full Student Survey Responses for 2010-2011 School Year and *Trends in International Mathematics and Science Study* Results**

| | Surveyed Students | | Surveyed Students | | | | | | Ever Participated (58 students) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fall | | | Spring | | | Fall | | | Spring | |
| | *Fall* | *Spring* | *Male* | *Female* | | *Male* | *Female* | | *Male* | *Female* | | *Male* | *Female* |
| Number of Students (not in percent) | 1,940 | 1,854 | 945 | 968 | | 707 | 750 | | 39 | 19 | | 39 | 19 |
| **School Attitudes** | | | | | | | | | | | | | |
| I like school | 74 | 74 | 69 | 80 | * | 73 | 78 | ~ | 90 | 79 | | 69 | 93 |
| I think students try their best | 71 | 57 | 67 | 74 | * | 55 | 61 | ~ | 67 | 74 | | 39 | 50 |
| **Science and Engineering Attitudes** | | | | | | | | | | | | | |
| I look forward to math class | 68 | 60 | 69 | 66 | | 62 | 59 | | 66 | 74 | | 45 | 65 |
| I like learning how things work | 86 | 79 | 87 | 84 | * | 82 | 77 | * | 88 | 95 | | 97 | 79 |
| Engineers mainly work with other people to solve problems | 74 | 65 | 74 | 74 | | 67 | 63 | | 75 | 89 | | 83 | 86 |
| The most popular students in this school do well in math and science | 27 | 28 | 30 | 25 | ~ | 33 | 23 | * | 21 | 17 | | 35 | 21 |
| **Educational and Career Attitudes** | | | | | | | | | | | | | |
| I can make a lot of money as an engineer | 76 | 77 | 82 | 70 | * | 83 | 73 | * | 89 | 61 | * | 89 | 86 |
| I would like to be a scientist when I grow up | 24 | 27 | 28 | 21 | * | 30 | 27 | * | 37 | 69 | | 41 | 50 |
| I would like to be an engineer when I grow up | 27 | 33 | 41 | 13 | * | 46 | 20 | * | 46 | 42 | | 69 | 65 |
| **Educational Expectations** | | | | | * | | | * | | | | | |
| Finish high school | 14 | 12 | 14 | 14 | | 15 | 10 | | 13 | 5 | | 10 | 0 |
| Complete a two year degree | 9 | 8 | 11 | 8 | | 9 | 8 | | 5 | 5 | | 10 | 7 |
| Complete a four year degree | 27 | 29 | 32 | 23 | | 32 | 26 | | 18 | 21 | | 42 | 29 |
| Complete an advanced degree | 34 | 37 | 27 | 41 | | 30 | 44 | | 46 | 48 | | 34 | 50 |
| Do not know | 15 | 13 | 15 | 15 | | 14 | 11 | | 18 | 21 | | 3 | 14 |

SOURCE: Evaluating Beyond Blackboards, Middle School Student Survey, 2010-2011

* significant differences between gender at the .01 level

~ significant differences between gender at the .05 level

**National Center for Education Statistics (NCES)**
**Institute of Education Sciences (IES)**
**Trends in International Mathematics and Science Study (TIMSS)**
**This report was generated using the TIMSS International Data Explorer. http://nces.ed.gov/surveys/timss/idetimss/**

**Report 1: Table**

Percentages for mathematics, grade 8 by year, Sex of student [ITSEX], jurisdiction and Nat\how far in sch you expect [USBSGQ7]: 2007

| | | | Finish high school | | Finish vocational certificate after hs | | Finish community or junior college | | Finish bachelor's degree | | Beyond a bachelor's degree | | I do not know | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Sex of student** | **Jurisdiction** | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error |
| 2007 | Girl | United States | 6 | (0.4) | 1 | (0.1) | 7 | (0.5) | 36 | (0.9) | 44 | (1.0) | 7 | (0.5) |
| | Boy | United States | 8 | (0.6) | 2 | (0.3) | 7 | (0.6) | 33 | (0.9) | 39 | (1.0) | 10 | (0.5) |

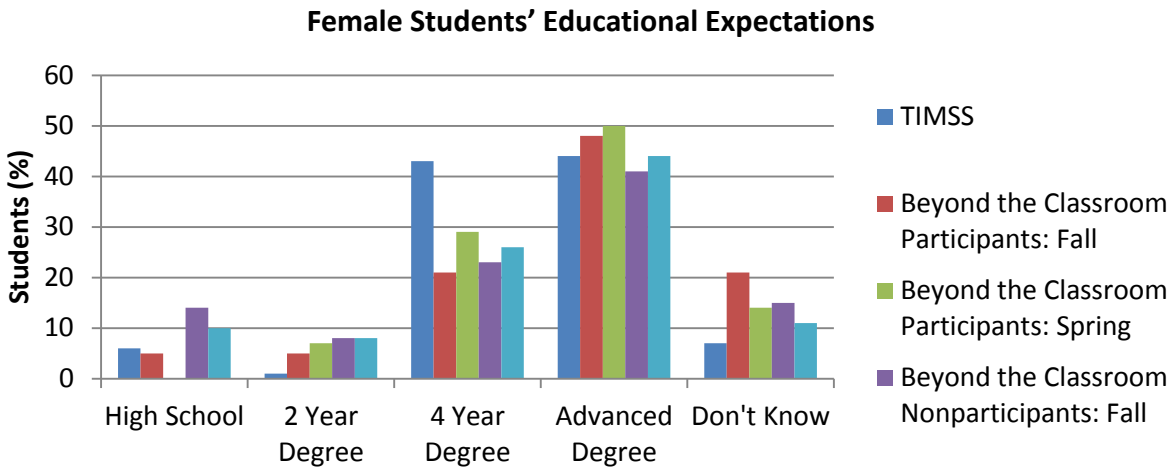
NOTE: Population coverage and/or participation rates for 4th graders in Kazakhstan, Latvia, the Netherlands, Lithuania, United States, Denmark, Scotland, Georgia and 8th graders in Hong Kong, England, Lithuania, United States, Serbia, Scotland, Israel, and Georgia deviated from international standards, as described in the TIMSS 2007 United States report (NCES 2009-001). Detail may not sum to totals because of rounding. Some apparent differences between estimates may not be statistically significant.
SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2007.

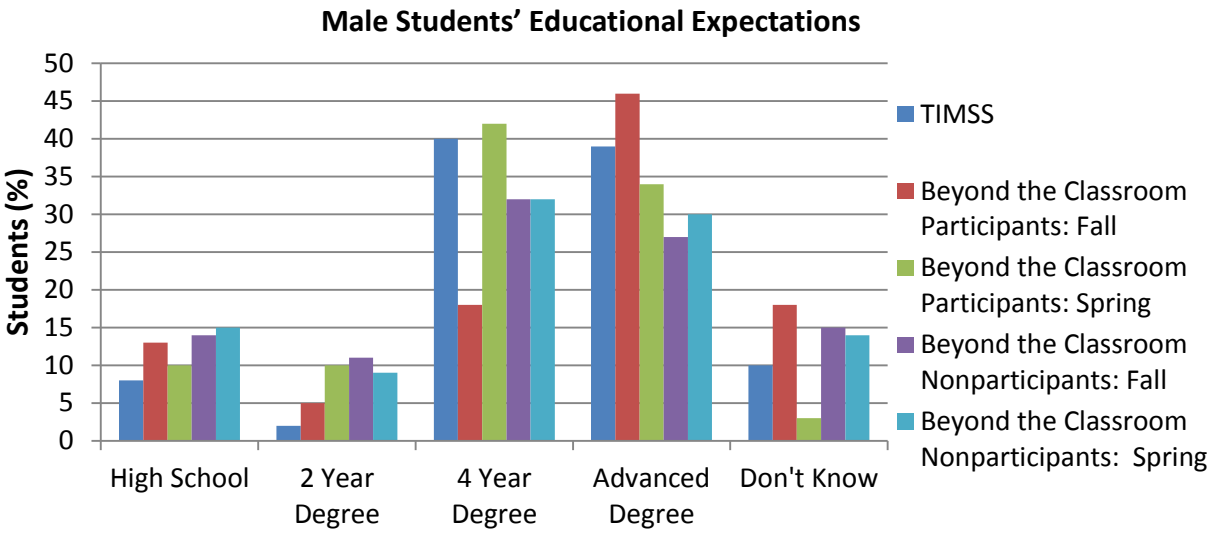
**Report 2: Table**

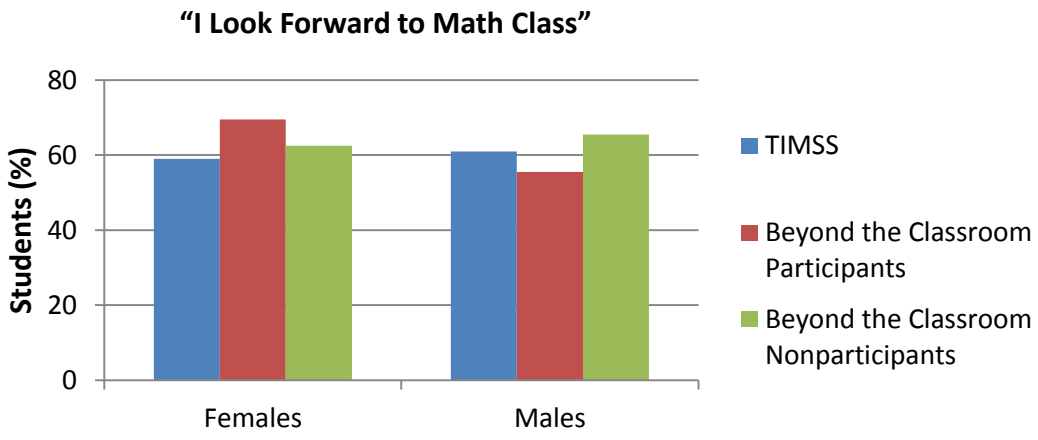
Percentages for mathematics, grade 8 by year, jurisdiction, Sex of student [ITSEX] and Mat\agree\i enjoy learning mathematics [BS4MAENJ]: 2007

| | | | Agree a lot | | Agree a little | | Disagree a little | | Disagree a lot | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Jurisdiction** | **Sex of student** | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error | Percentage | Standard Error |
| 2007 | United States | Girl | 22 | (0.9) | 37 | (0.9) | 23 | (0.9) | 18 | (0.8) |
| | | Boy | 21 | (0.8) | 40 | (1.0) | 21 | (0.7) | 18 | (0.8) |

NOTE: Population coverage and/or participation rates for 4th graders in Kazakhstan, Latvia, the Netherlands, Lithuania, United States, Denmark, Scotland, Georgia and 8th graders in Hong Kong, England, Lithuania, United States, Serbia, Scotland, Israel, and Georgia deviated from international standards, as described in the TIMSS 2007 United States report (NCES 2009-001). Detail may not sum to totals because of rounding. Some apparent differences between estimates may not be statistically significant.
SOURCE: International Association for the Evaluation of Educational Achievement, Trends in International Mathematics and Science Study (TIMSS), 2007.


Female Students' Educational Expectations
Students (%)
60
50
40
30
20
10
0
High School
2 Year Degree
4 Year Degree
Advanced Degree
Don't Know
TIMSS
Beyond the Classroom Participants: Fall
Beyond the Classroom Participants: Spring
Beyond the Classroom Nonparticipants: Fall


Male Students' Educational Expectations
Students (%)
50
45
40
35
30
25
20
15
10
5
0
High School
2 Year Degree
4 Year Degree
Advanced Degree
Don't Know
TIMSS
Beyond the Classroom Participants: Fall
Beyond the Classroom Participants: Spring
Beyond the Classroom Nonparticipants: Fall
Beyond the Classroom Nonparticipants: Spring


"I Look Forward to Math Class"
Students (%)
80
60
40
20
0
Females
Males
TIMSS
Beyond the Classroom Participants
Beyond the Classroom Nonparticipants

## Appendix D: Additional Sources for Female Students Interested in Engineering

In the first twenty results of a Google image search for "engineer", only two women are represented. The remaining images depict White men in hardhats, corresponding and contributing to society's overall misinterpretations of engineering. The following resources are designed to eliminate the stereotypes surrounding STEM disciplines, and educate middle and high school students about the diverse and exciting field of engineering.

| Discover Engineering! | | |
|---|---|---|
| | **This is What a Scientist Looks Like:**<br>"Challenge the stereotypical perception of a scientist" by exploring pictures of diverse individuals practicing many fields of science. | http://lookslikescience.tumblr.com/ |
| | **Engineering, Go For It!:**<br>The American Society for Engineering Education allows you to read about engineering, learn how to prepare for the field, and meet engineering students. | http://www.egfi-k12.org/ |
| | **Imagine Engineering:**<br>Girl Scouts describes engineering and provides advice for girls and parents/guardians. | http://www.girlscouts.org/imagineengineering/default.asp |
| | **Exploratorium** :<br>The Museum of Science, Art and Human Perception displays science applications in new ways. | http://www.exploratorium.edu/index.php |
| | **25 Women in STEM You Should Know About**:<br>Read about 25 successful women working in STEM. | http://edudemic.com/2012/06/25-women-in-stem-you-should-know-about/m |
| | **A Sightseer's Guide to Engineering**:<br>Explore how various applications of engineering are applied across the United States. | http://www.engineeringsights.org/search.asp |
| | **TryEngineering**:<br>Learn about the different kinds of engineering, ask real engineers and students' questions, find universities, play games, and discover engineering in the news. | http://www.tryengineering.org/home.php |
| | **Brain Cake**:<br>Find an engineering mentor that matches your specific interests. | http://www.braincake.org/default.aspx |
| | **Girls in STEM: A New Generation of Women and Science:**<br>Watch girls from around the nation present their science projects in the White House. | http://www.youtube.com/watch?v=Q_11rwb4vEc |
| | **Engineer Your Life/Engineer Girl**:<br>A general engineering guide for high school and middle school girls. | http://www.engineeryourlife.org/ |

*"I do not mind that you are a girl, but the main thing is that you yourself do not mind. There is no reason for it."*
- Einstein's Advice to a Little Girl Who Wants to Be a Scientist.