# Do Students Believe Girls Belong in Engineering? So What?

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# Do Students Believe Girls Belong in Engineering? So, What? (WIED-Diversity)

In January of 2016, we began a mixed method study at an urban middle school in the Pacific Northwest. The purpose of the work was to study the relationship between mathematics, science, and STEM (as an integrated study) interest in a general school population and in an all-girls after-school program. The observations, focus groups and interviews of the all-girls program are discussed in a different paper. Our interest survey, the quantitative part of our mixed method study discussed here, was developed and validated in a previous study [1]. Our question was can this survey be utilized to determine the following research questions?

- Is believing that girls belong in engineering related to middle school student mathematics, science or STEM interest?
- Does student interest in science, math and STEM vary by grade in school, sex or ethnicity?
- How do the girls in the after-school, all-girls program respond to the STEM interest survey?

Our survey was revised to include the perception question, "Do girls belong in engineering?" The inclusion of the question in the survey was intended to provide some insight into the acceptance of girls in engineering by these middle school students and how believing girls belong in engineering was related to science, math or STEM interest. Since learning, perception, and affects are socio-cultural and situated [2], [3], the survey results suggest the numerous relationships that may exist between believing girls belong in engineering and other STEM interests for both boys and girls that could impact pedagogy and curriculum development. Additionally, the 12 girls from the all-girls after-school program averaged higher interests and different perceptions than the students from the school as a whole.

All the girls who attended the after-school program believed girls belong in engineering compared to approximately 65% of the 6th grade girls, 55% of the 7th grade girls, 42% of the 6th grade boys and 41% of the 7th grade boys. Structured equation modeling revealed endorsement of girls in engineering significantly moderates the effect of gender on earth-space science STEM interest, such that the more an individual believes girls belong in engineering, the more likely girls will report higher interest in earth-science interest. It matters what kids believe in. Perception matters. STEM education could improve the reputation of STEM, especially engineering, as a more approachable and caring profession where girls belong.

**Background**

It is well-known that by middle school interest for mathematics and science is lower for girls than for boys and decreases for all students equally during puberty. Some exceptional work out of Israel indicates school environment may create some balance between sexes and interrupt the puberty influence [4]. Girls and women remain under-represented among students and within the workforce of STEM [5]. Studies suggest interest, rather than ability, is responsible for the overall lack of diversity in advanced degrees or employment in analytical area such as physics, computer sciences, mathematics, mechanical and electrical engineering [6]. This is especially troublesome

since one of these analytical areas, physics, is considered the gateway to engineering [7]. Some say the reason for the persistent lack of females in STEM careers is because the culture of STEM, especially engineering and analytical areas, is a limiting culture devoid of what females seems to prefer, empathy and social caring [8]-[10].

However, measuring constructs such as interest is complex because of the interactive and dynamic nature of constructs with one another, that the constructs are usually self-reported, and that few standardized measurement terms exist [11]. STEM can be considered as one content area or four content areas. We often ask our students to describe STEM. They usually answer by stating the letters S, T, E, and M stand for science, technology, engineering and mathematics, but do not state any concept of what "STEM" means. The term STEM is thought to originate with the United States National Science Foundation (NSF) because the problems of the future were deemed to be complex and required interdisciplinary study. Others think STEM was coined by NASA as SEM with the "T" added because it sounds better.

Because this complexity is pervasive at every stage, most STEM research is focused on one affective construct (such as motivation, attitude, interest, self-efficacy) in a single STEM area [12]-[15]. And consequently, few if any instruments exist to capture STEM as multi-constructs and none in multiple STEM areas [16]. Currently few existing instruments fully capture the breadth and complexity of the STEM disciplines. For example, in 2012, Minner, Ericson, Wu and Martinez [17] reported half of the cognitive assessment tools measured science, 25% measured mathematics, and around 20% measured them together. Developing a more complex assessment tool was the purpose behind the development of this survey [18].

**Conceptual Framework**

The larger mixed methods study has a worldview that is socio-cultural (students learn from each other), framed by the constructs of interest and belongingness, and is seen with a transformative perspective [19]. I chose a transformative perspective because I want to change the way people behave, not just think, toward under-represented STEM bound students, particularly girls in engineering; how policy is written; curriculum is designed and taught in schools; how businesses interview and maintain diversity in their workforce; and how engineering is perceived. The paradigm for this study is interpretivist. Or to say, the intent is to "study 'things' within their context and consider the subjective meanings that people bring to their situation [20]."

As interest develops over time through knowledge, activities, engagement and social support, it can evolve from situational interest to a more committed personal interest [21]. This study seeks to understand interest development, a sense of belongingness and a relationship between the two.

For the survey we postulated the following:

-boys and girls would differ in their belief in whether girls belong in engineering,
-relationships exist between believing girls belong in engineering and math, science and STEM interest,
-student interest in science, math and STEM vary by grade, sex or ethnicity,
-and the girls in the after-school, all-girls program were more interested in math, science and STEM than other students.

**Interest.** The National Research Council identifies interest as a critical factor in predicting future engagement in STEM [22]. Studies focused on girls in STEM indicate girls lack interest, not ability [23]. Interest may have a larger influence than academic achievement on choice of STEM as a career [24], [25]. Fewer and fewer students have been choosing to major in scientific fields at secondary and university levels [26], [27]. In some areas, such as mechanical and electrical engineering, the number of women has declined since the 1960's [28]. Research indicates STEM interest declines with progression in school, with a significant drop by the end of middle school, and greater decline for girls and minorities [29]. Some report girls' and minority interest begin and remain lower than boys [30].

Interest is defined as: (1) a feeling of wanting to learn more about something or to be involved in something or, (2) a quality that attracts your attention and makes you want to learn more about something or to be involved in something [31]. Hidi and Renninger define interest as a multi-dimensional progression of four levels beginning with initial situational, or temporary, interest and moving toward a more lasting, stable and sustained form of persisting or personal interest [21]. A characteristic of personal interest evident in observed behavior or verbal expression is a student's intrinsic readiness to acquire new domain- specific knowledge and to explore an idea or concept about the object of interest meta-cognitively [32]. Taking work home, asking to borrow a book on the subject, or teaching peers are examples of personal interest. We followed the Hidi and Renninger model [21] in our study and analyzed student self-reported interest through written indicators.

**Belongingness.** Engineers from under-represented groups identify a sense of belongingness as important success factors [33]. Recognition and belongingness are closely associated and will be studied together in this study. To belong is defined as "fit (of a person) in a specified place or environment [34]." Maslow's hierarchy of needs lists belonging on its third tier [35]. Humans need to belong, not just to succeed, but to survive. To feel belongingness requires not only the ability to perform the skills required of a member of the community, but also to be recognized by the community as a skilled member [36]-[40]. Being accepted is a difficult task in the highly-gendered (male-dominated and masculine) culture of engineering [37]. Recent research indicates that belonging influences achievement and interest, especially for girls and women [37], [41]-[47] The preference for empathetic work appears to help women maintain their identities, not merely adopt the identities of men [48]-[50].

## Methodology

The reason for conducting a survey was to acquire a broad and general perspective of the perception of the students at a large, urban, ethnically diverse middle school population. The survey results helped design future qualitative and mixed methods studies on interest and belongingness of under-represented populations by these authors and others.

**Participants.** The middle school was chosen because of convenience. One author has a STEM research relationship with the local educational service district and the school. That author was a participant researcher in an all-girls after-school STEM grant at the school. The school is an urban school with grades 6 through 8 whose demographics are primarily low-income (Fig. 1) [51]. The 72 question Likert-scale survey was presented to grades six, seven and eight the last

week of school (217 of the 900 students participated). The responses also included eight of the twelve students from the all-girls after-school STEM program in the larger mixed methods study.

The participants in the after-school grant and in the all-school survey were solicited by the school. Both parent consent and student assent required from all students who participated in the study. Students were informed their participation was voluntary and they could drop out at any time they wished. The survey was conducted during the last week of school in June of 2016, in science class.

| | White | Hispanic | Pacific Islander | Low Income |
|---|---|---|---|---|
| All Students (n=900) | 39.7% | 45.7% | 6.2% | 81.3% |
| Survey (n=217) | 24.9% | 40.6% | 7.4% | unknown |
| After-school (n=12) | 16.7% | 75% | 8.3% | 91.7% |

Figure 1. Middle School Demographics, WA. OSPI, 10/2015.

**Methods Survey.** The survey included a general mathematics, a general science and a science, technology, engineering and mathematics (STEM) component. The STEM component was comprised of four sections: life science, earth-space science, technology-engineering and mathematics puzzle interest questions.
The survey was a five-point Likert scale from disagree a lot to agree a lot. The scale was later changed to provide better visual clarity for presentation graphics to a five-point (-2 to 2) Likert scale from (-2) signifying disagree a lot to (-1) disagree a little, (0) neither agree nor disagree, (1) agree a little, and (2) disagree a lot. Positives, 1 or 2, were combined to signify "positive," and -1 or -2 were combined to signify "negative," when calculating percentages.

The school principal had an opportunity to review the questions and determine best ways to communicate with parents, students, teachers on permissions and how the survey would be conducted with over 900 participants. Although the survey was originally intended for a different but similar in demographics middle school, the principal made no changes to the survey questions. Online access to the survey was requested and provided. Parental consent was obtained through the school and student assent was obtained at the start of survey. Teachers conducted the surveys. These authors did not discuss the survey or the results of the survey with the teachers or the students. The survey results were accessible to the principal at all times and discussed with the principal at numerous occasions.

| Sample Interest Survey Questions | | |
|---|---|---|
| **STEM** | **Science** | **Mathematics** |
| 1. How the human body works and grows.<br>2. How gas and diesel engines work.<br>3. How computers or cell phones work.<br>4. How to grow food and flower.<br>5. How to design new games or toys.<br>6. How to keep my community green.<br>7. How to make different shapes and patterns out of stuff.<br>8. Girls belong in engineering. | 1. Science will be useful in my future.<br>2. I find science difficult.<br>3. I would like to study more science in the future.<br>4. I enjoy learning science.<br>5. I would like to have a job that uses science.<br>6. Science is harder for me that for other kids my age.<br>7. I am just not good at science.<br>8. I see how science relates to my life. | 1. I would like to study more math in the future.<br>2. I enjoy learning math.<br>3. I would like to have a job that uses math.<br>4. Math is boring.<br>5. Math is useful in helping to solve the problems of everyday life.<br>6. My friends think math is cool.<br>7. My math teacher makes me interested.<br>8. I am pretty good at math. |

Figure 2. Sample Interest Survey Questions. A question, such as "How much are you interested in 'how the human body works and grows' offered five choices to from dislike a lot to like a lot," or "How much do you agree 'girls belong in engineering' offered five choices to from disagree a lot to agree a lot.

A small portion of the survey is illustrated in Fig. 2. General mathematics (black) and science (black) categories included 22 questions, whereas the STEM category included 24 questions. In addition to general mathematics and science, the STEM segment questions cover four areas: life science, earth-space science, technology-engineering and mathematics puzzle interest questions. An example of the questions/categories would be "How computers or cell phones work" is a technology-engineering question. "How to grow food and flowers," represents life-science. The color coding in the STEM questions signify talking point highlights: blue-statistical significant difference between boys and girls, red-surprisingly little difference between girls and boys, black-similar responses between boys and girls, and green-various relationships important to this paper.

**Data Analysis**

Descriptive statistics: mean, standard error, median, mode, standard deviation, sample variance, kurtosis, skewness, range, minimum, maximum, sum, count and confidence level (95.0%) t-tests (comparing boys' and girls' response to specific questions), ANOVAs, and structured equation modeling (SEM) were used to compare mathematics, science and STEM interest constructs and boys versus girls' interest for the 217 participants in the general population. Data was reformatted into pivot tables and analyzed by the descriptive statistics tool in Microsoft Excel and Mplus version 7 for structured equation modeling [52]. Descriptive statistics (percentages and mean scores) were conducted on sex and ethnicity. SEM analysis was limited to sex analysis because of the limited student participation.

**Results**

**Descriptive Statistics.** Of the descriptive statistics, percentages and mean scores are reported here.

The number of students who took the survey decreased from grade six to grade eight from 113, to 60 to 44 (Fig. 3). The eight graders were graduating the day after the survey.

| **Survey Responses Number of Participants** | Boys (101) | Girls (116) | STEM Girls |
|---|---|---|---|
| Grade 6 | 49 | 64 | 6 |
| Grade 7 | 24 | 36 | 2 |
| Grade 8 | 28 | 16 | 0 |

Figure 3. Survey Responses by Sex and Grade

The survey indicated, all 8 of the girls who took the survey and who attended the after-school program believed girls belong in engineering, versus approximately 65% of the 6th grade girls, 55% of the 7th grade girls, and 47% of the 8th grade girls, 42% of the 6th grade boys, 41% of the 7th grade boys, and 25% of the 8th grade boys. The percentage of students who believe girls belong in engineering declined from grade six to grade eight for both boys and girls (Fig. 4). The girls believed girls belong in engineering over 50% more than boys believe. Note all of the girls in the after-school, all-female STEM program believe that girls belong in engineering. The survey responses of 8 girls in the after-school program suggest the program has a positive influence on all categories of girls' mathematics, science and STEM interest.

| **% Believe Girls Belong in Engineering** | Boys % | Girls % | STEM Girls % |
|---|---|---|---|
| Grade 6 | 42% | 65% | 100% |
| Grade 7 | 41% | 55% | 100% |
| Grade 8 | 25% | 47% | n/a |
| All | 37.5% | 60% | 100% |

Figure 4. Percentage by Sex and by Grade Level Who Believe Girls Belong in Engineering.

The percentages were also calculated by ethnicity and sex (Fig. 5). Note that both sexes believed girls belong in engineering but to different degrees, with similar percentages for the Whites (47% male versus 46% female) and Pacific Islanders (33% male versus 40% female) populations. Other (which was a mix of multiracial Asians, Hispanics and students who described themselves as Bosnian, Russian or Ukrainian) was 29% male and 62% female believing girls belonged in engineering. Because the number of African American, Native American, and Asian American students were so few those figures are insignificant. As a group the girls believed they belonged in engineering to a greater extent than boys and the Native American boys very more positive

than the African American boys (75% were positive versus 33%). Contrary to expectations, neither Asian American boys nor girls were overly positive about girls belonging in engineering.

| **Survey Response - % Believe Girls Belong in Engineering by Ethnicity/Sex** | Boys(x/y), where x positive responses/y size of total population by ethnicity | Girls | STEM Girls |
|---|---|---|---|
| African American | (3/9) 33% | (3/3) 100% | (0) 0% |
| Native American | (3/4) 75% | (1/1) 100% | (0) 0% |
| Asian American | (1/4) 25% | (2/4) 50% | (0) 0% |
| Hispanic or Latino/a | (9/27) 33% | (35/61) 57% | (4) 100% |
| Pacific Islander | (2/6) 33% | (4/10) 40% | (1) 100% |
| Other | (6/21) 29% | (8/13) 62% | (1) 100% |
| White | (14/30) 47% | (11/24) 46% | (2) 100% |
| All | 101 | 116 | 8 |

Figure 5. Percentage by Sex and Ethnicity Who Believe Girls Belong in Engineering

When calculated as a mean score by sex and ethnicity (Fig. 6), where -2 is disagree a lot and 2 is agree a lot, the results are similar. Girls believe girls belong in engineering more than boys but differ in degree. In all ethnic groups girls are much more positive about girls belonging in engineering than boys are. In the Pacific Islander and Asian American boys groups the mean scores were negative (0.17 versus -0.25, respectively). African American boys believed girls belonged in engineering but had the width gap between them and African American girls (mean score of 0.22 versus 1.33, respectively). Although a small population, Native American boys were positive and the gaps between them and similarly ethnic girls was small (mean score 0.75 versus 1.00, respectively). The larger populations in the school of Hispanics and Whites both were also positive. White boys and girls perceptions were similar (mean score was 0.57 versus

0.58, respectively. Note in both percent of positives and mean scores Hispanic boys are positive but a gap of 24% exists in percentage (33% versus 57%, respectively) and over 0.50 in mean score between boys and girls (mean score 0.41 versus 0.93, respectively).

| **Survey Response – Mean Score**<br>**Believe Girls Belong in Engineering**<br>**by Ethnicity/Sex**<br>**-2 to 2, Disagree a lot to agree a lot** | Boys | Girls | STEM Girls |
|---|---|---|---|
| African American | 0.22 | 1.33 | |
| Native American | 0.75 | 1.00 | |
| Asian American | **-0.25** | 1.00 | |
| Hispanic or Latino/a | 0.41 | 0.93 | 2 |
| Pacific Islander | **-0.17** | 0.50 | 2 |
| Other | 0.10 | 0.69 | 2 |
| White | 0.57 | 0.58 | 2 |
| All Mean Score | 0.33 | 0.81 | 2 |

Figure 6. Mean Scores (-2 to 2, disagree a lot to agree a lot) by sex and ethnicity.

Mathematics, science and STEM (as an integrated category) interest, also vary by sex. See Figures 7 and 8. for a list of the top questions (highest interest) by sex. Both sexes are interested in mixing material (expected) but less so on how diseases like cancer work (not expected). Absent is mathematics interest for girls (expected) and space interest for boys (not expected):

**Boys top 6**

1. Mixing materials to see what happens
2. How computers or cell phones work
3. How to design new games and toys
4. How to play Minecraft or similar games
5. What to eat and exercise to stay healthy
6. How diseases like cancer work

**Girls top 6**

1. Mixing materials to see what happens
2. How stars and planet work
3. How earthquakes, volcanoes, and hurricanes happen.
4. What it is like on another planet
5. How computers or cell phones work
6. How disease like cancer work

Figure 7 and Figure 8. Top Six STEM Interest Questions by Sex.

By category, for some of the demographics, the mean scores reflect similar ranges as the responses to the perception question "Do girls belong in engineering." Note that the sample sizes for different ethnic demographics are very small and can only serve as food for thought and future study, not for making claims. For example (Fig. 9), African American students score low, whereas Pacific Islanders and Whites score higher. Note Asian American and Native Americans girls score higher than boys in STEM interest (0.78 girls to -0.10 boys, 0.74 girls to 0.57 boys, respectively) and Pacific Islander boys score highest (0.73) amongst all boys. Unexpectedly, Asian American boys scored lowest of all at -0.10.

| **Eng/STEM Interest Mean Scores** | African American | Native American | Asian American | Hispanic | Pacific Islander | White | Other |
|---|---|---|---|---|---|---|---|
| Boys | 0.10 | 0.57 | **-0.10** | 0.49 | **0.73** | 0.72 | 0.42 |
| Girls | -0.07 | **0.74** | **0.78** | 0.46 | 0.46 | 0.32 | 0.16 |

Figure 9. Mean STEM Interest Scores by Sex and Ethnicity

And then below, White students scoring close to (science as 0.46 versus 0.44 for boys and 0.08 versus 0.05 for girls) or lower than (girls' mathematics interest at 0.30 versus 1.48) Native American was not expected (Fig. 10 and 11). And the low science interest score by Asian American boys at -0.29 was unexpected.

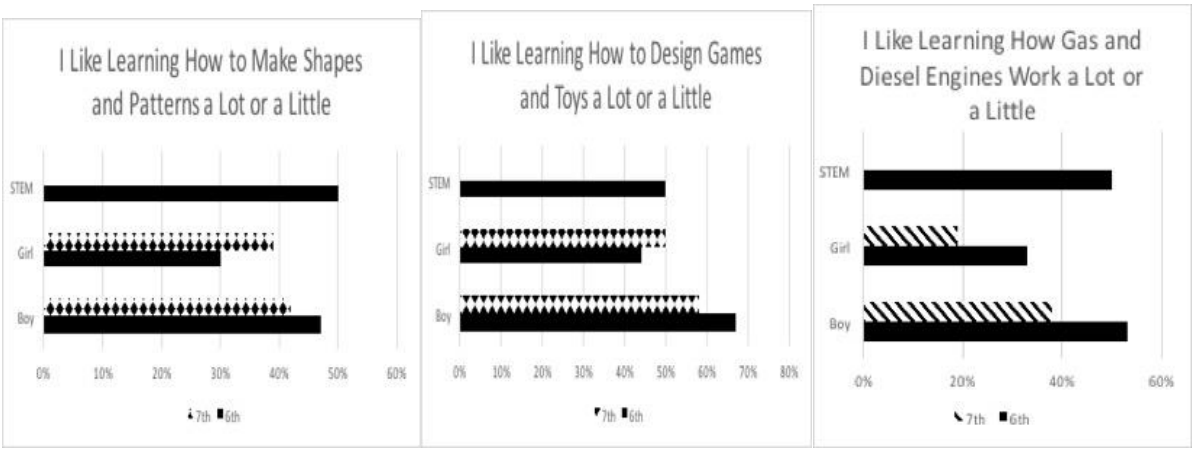
| **Math Interest Mean Score** | African American | Native American | Asian American | Hispanic | Pacific Islander | White | Other |
|---|---|---|---|---|---|---|---|
| Boys | 0.30 | 0.25 | 0.33 | 0.58 | 0.71 | 0.57 | 0.49 |
| Girls | -0.03 | **1.48** | 1.04 | 0.42 | 0.82 | **0.30** | 0.15 |

Figure 10. Mean General Mathematics Interest Scores by Sex and Ethnicity

| **Science Interest Mean Score** | African American | Native American | Asian American | Hispanic | Pacific Islander | White | Other |
|---|---|---|---|---|---|---|---|
| Boys | 0.13 | 0.44 | **-0.29** | 0.05 | 0.33 | 0.46 | 0.26 |
| Girls | -0.14 | 0.05 | 0.35 | 0.11 | 0.36 | 0.08 | -0.12 |

Figure 11. Mean General Science Interest Scores by Sex and Ethnicity

Preliminary analysis revealed three categories (Fig. 12, 13 and 14) of significant difference (t-test: two-tailed, unequal variances, $p<0.05$) between sixth grade boys' and girls' interest: Making Shapes and Patterns ($p=0.006$), Learning about Engines ($p=0.011$), and Designing Games ($p=0.002$). Results indicated girls are less interested in these categories than boys. *Note: the t-test was conducted on overall girls versus boys, exclusive of the STEM girls.*




Figures 12, 13, and 14. STEM Interest Questions Exhibiting Significant Interest Difference by Sex and Grade. (% signifies percentage of total positive responses of like a little or like a lot (1 or 2) on the Likert Scale).

**Structured Equation Modeling (SEM).** Our structured equation modeling helps us understand the relationship between student interest and the perception question of "Do girls belong in engineering?"

Utilizing structural equation modeling with maximum likelihood estimation, we found that endorsement of girls in engineering ("Do girls belong in engineering?") significantly predicted interest in life science ($\beta = 0.29$, $SE = 0.11$, $p < 0.01$) and technology ($\beta = .41$, $SE = .09$, $p < .01$), regardless of sex. There were relationships of approaching significance between endorsement and interest in earth-science ($\beta = .19$, $SE = .11$, $p = .07$) and math puzzles ($\beta = .20$, $SE = .10$, $p = .054$). Because relationships were either significant or approaching significant, we assessed the interaction between sex and endorsement.

A significant moderating effect was found, such that at higher levels of endorsement, girls reported more interest in earth-science than boys ($\beta = .52$, $SE = .23$, $p = .02$). No moderating effect was found for life science interest ($\beta = .24$, $SE = .23$, $p = .29$) or technology ($\beta = .27$, $SE = .21$, $p = .19$), and the moderating effect on math puzzle interest was approaching significance ($\beta = .42$, $SE = .22$, $p = .058$). Endorsement was not associated with interest in technology and mathematics, and boys reported significantly higher interest in mathematics compared to girls.

**Discussion**

The research questions were as follows:

- Does student interest vary by grade in school, sex or ethnicity?
- How does an after-school, all-girls program influence girls' STEM interest?
- Is believing that girls belong in engineering related to middle school student mathematics, science or STEM interest?

The descriptive statistics in this study support previous literature that indicates overall STEM interest wanes with progress from grade six to grade eight in middle school (Fig. 3) [18]. Although the sample size is very small, the differences in interest by sex and ethnicity was unexpected in some areas. For example, high interest in STEM by White and Asian boys was expected, but higher interest by Native American and Asian American girls and Pacific Islander boys than White and Asian boys was not (Fig. 9). Asian American boys interest was lowest in STEM and science.

The reason for these results may be influenced by the demographics and the inclusive strategy of the school. The majority of Hispanics in the school might explain the similar scores between those boys and girls that were absent in other populations (Pacific Islander similarities were second). What may be considered a minority in other schools (Hispanics, immigrants and any students of color) is the majority in this school, the survey population and the after-school program. Additionally, this school has other thriving after-school STEM programs including MESA (Mathematics, Engineering, and Science Achievement). Interpreting their sex differences between Native American and Asian American students versus other groups would require a deeper understanding of the school and the participant personal lives than is known by the authors.

Of concern are the overall low interest scores of African American and White students, especially girls and of Asian American boys. The African American population is the minority in this school. Many urban school have a strong Self-Enhancement, Inc. (SEI) program focused on inspiring African American youth. This school might benefit from SEI's after-school programs. The reason for low scores by White students may be somewhat more complex and may be due to their status as minority in the school, having low socio-economic status and the current socio-cultural tension in our country. Anecdotally, the expected growth of the minority population and shrinkage of White male power in our society may impact the interests of our students. The unexpected low scores of Asian American boys in STEM and science is unknown.

The all-girls after-school program seems to have an overall positive influence on female interest. When comparing girls in the STEM after-school program to the sixth-grade girls, the percentage of STEM girls interested in STEM was higher than the general sixth-grade girls in 23 out of 24 STEM categories in the survey. The exception was that 25% of STEM girls, versus 31% of girls and 45% of boys in the general sixth-grade population, were interested in How the Human Body Works.

Our SEM analysis suggests that a sense of belonging in engineering is related to higher levels of interest in earth-space science, particularly for girls. This finding may be significant because creating classrooms where boys and girls engage in earth-space science together may influence

boys to improve their belief that girls belong in engineering. Interestingly, this endorsement was related to higher levels of interest in life-science, technology, and math puzzles, on average, regardless of sex. This finding is unusual in that it would logically follow that boys' interests would be less affected by their endorsement of girls in a particular field. In line with this assumption, our results also suggest that boys have higher levels of interest in mathematics and technology, while endorsement does not play a role in this relationship. Why these relationships exist is conjecture. However, one of our researchers suggests boys may be playing a protective role over girls who like mathematics, science and STEM. The reasons for these results are worth further study since they may have an impact on how to create and maintain not only diversity, but inclusivity, maintaining both individuality and a socio-cultural collaborative team [53]. Although most of us respond with an "Of course" when asked, "Do girls belong in engineering?" this study suggests not only "So, what?" but also may not be "Of course." The survey indicated, all 8 of the girls who took the survey and who attended the after-school program believed girls belong in engineering, versus approximately 65% of the 6$^{th}$ grade girls, 55% of the 7$^{th}$ grade girls, and 47% of the 8$^{th}$ grade girls, 42% of the 6$^{th}$ grade boys, 41% of the 7$^{th}$ grade boys, and 25% of the 8$^{th}$ grade boys. Figure 4 illustrates that only 37.5% and 60% of girls believed "Girls belong in engineering.

Figure 5 and 6 reflect the responses to the perception question by ethnicity. Interestingly, boys and girls did not respond alike by ethnicity as they did for the science, mathematics and STEM interest questions. Some of results of the perception questions were unexpected. Although we expected White boys and girls to believe girls belong in engineering, we expected a gap where there was none. We also did not expect a gap between Asian American students, where there was one. Although most ethnic group populations were too small to be significant, the differences between the Hispanic students as the majority at the school are noteworthy. The boys and girls exhibited a gap in both percentage and mean score in their perception of girls' belonging in engineering. Pacific Islanders, who make up the third largest ethnic group at the school, are also worth following. These boys conveyed high math and STEM interest in content yet communicated the largest mean score gap in the girls belong in engineering questions (mean score -0.17 versus 0.50, boys versus girls, respectively), contradicting our SEM supposition. Pursuing further study of cultural impact on perception would be of interest, especially since the STEM girls (primarily Hispanic) scored a mean of 100% and 2.00.

**Limitations**

The survey was considered too lengthy by the students and teachers in this school. Additionally, the survey was conducted the last week of school. Consequently, students, especially graduating 8$^{th}$ graders, may not have been focused on their answers. We were unable to compare responses by grades or by ethnicity because statistical analysis by structured equation modeling requires additional student participation. The number of participants per grade, per ethnicity and in the all-girls after-school STEM program limits generalizations from our data.

Although initially planned, a major limitation of the study was that a pre-survey was not conducted limiting the ability to "compare" the influence of the all-girls after-school program. Additionally, the absence of open-ended questions or follow-up interviews with either all-school students or teachers, limits our insight into student reasoning. For example, do the students know what "engineering" is when asked if girls belong? Interest scores in science were lower than in

other areas. The principal indicated hiring good science instructors was a constant struggle and that the department would be revamped the following year.

The qualitative part of our mixed methods study gives further insights into the girls from the all-girls after-school program answers including their reasons for attending the program, but they also were not given a pre-survey. This program is part of a larger, comprehensive two-hour daily after-school program that provides a free meal and is often chosen by parents as free childcare. This program, however, is the only all-girls STEM program girls voluntarily choose over other programs. Thus, it could be assumed they already are interested in STEM and believe girls belong in engineering before attending.

The relationship of the authors to the students, teachers and general workings of the school was limited. The differences between sexes for different ethnicities may be influences by the demographics of the school or other characteristics or school strategies. For example, Native American boys believed girls belong in engineering, but girls did not. Obtaining permissions was difficult. Part of the challenges is language barriers. However, cultural influences may also have influenced the scores. Students indicating that their "parents" were not interested in "mathematics, science and STEM," may have reflect lack of interest by parents and contributed to the low survey response. What are the social ramifications in a White or an African American versus Hispanics and Pacific Islander socialized engendered culture of women, and women of color acquiring STEM jobs that were traditionally held by men?

**Implications**

The drop of interest by grade and the lower interest by girls versus boys (in many cases) support the background of this study. The variation in mean scores between sexes for different questions and ethnicities is worth studying further at this school and at other school with different socio-economic and ethnic demographics than this school.

Additionally, unexpected differences in interest by ethnicity and sex in other areas suggest changes in curriculum and/or classroom pedagogy (such as inclusive teams working on shared areas of interest: earth-space). Or engaging students in areas some, but not all, may prefer could help improve not only girls' positive perception of STEM and their interest in analytical STEM areas, but, likewise, boys' positive perception of STEM and their interest in life-sciences and the more caring/social improvement areas. The work on inclusive suggests the ideal situation is a balance of independence and teamwork, and individuality and inclusivity [53]. Perhaps, since we believe learning is socio-cultural, if boys attend after-school STEM classes with girls the percentages of boys who think girls belong in engineering could increase.

**References**


[1] J. H. Falk, N. Staus, L. D. Dierking, W. Penuel, J. Wyld, and D. Bailey, 2016. "Understanding youth STEM interest pathways within a single community: The Synergies project," *Int. J. of Science. Educ.*, part B, DOI: 10.108/21548455.2015.1093670.

[2] L. Vygotskiĭ, and A. Kozulin, 1986. *Thought and Language* (Translation newly rev. and edited / by Alex Kozulin. ed.). MIT Press, Cambridge, Mass.

[3] J.S. Stets, 2006. "Identity theory." In P. J. Burke, (Ed.), *Contemporary Social Psychological Theories.* Stanford University Press, Stanford, CA.

[4] D. Vedder-Weiss, and D. Fortus, "Opening up pathways: Engagement in STEM across the primary-secondary school transition," *J. of Res. in Science Educ.*, vol. 48, no. 2, pp.199-216, 2011.

[5] C. Corbett, and C. Hill, 2015. *Solving the Equation. The Variables of Women's Success in Engineering and Computing.* American Association of University Women, Washington, DC.

[6] Y. Ma, "Sex differences in the path leading to a STEM baccalaureate," *Social Science Quarterly*, vol. 92, no.5, pp.1169-1190, 2011.

[7] B.C. Cunningham, J. Ralph, and K.M. Hoyer, 2015. *Stats in Brief: Sex Differences in Science, Technology, Engineering, Mathematics (STEM) Interest, Credits Earned, and NAEP Performance in the 12th Grade.* U.S. Department of Education, NCES2015-075, National Center for Education Statistics, Washington, D.C.

[8] A.I. Schäfer, "A new approach to increasing diversity in engineering at the example of women in engineering," *European J. of Eng. Educ.*, vol. 31, no.6, pp.661- 71, 2006.

[9] A. Godwin, and G. Potvin. "Fostering female belongingness in engineering through the lens of critical engineering agency," *Int. J. Eng. Educ.*, vol. 31, no. 4, pp. 938-952, 2015.

[10] B. Capobianco, and J.H. Yu, "Using the construct of care to frame engineering as a caring profession toward promoting young girls' participation," *J. Women and Minorities in Science and Eng.*, vol. 20, pp. 21- 33, 2014.

[11] P.K. Murphy, and P.A. Alexander, "A motivated exploration of motivation terminology." *Contemporary Educ. Psychology,* vol. 25, pp. 3-53, 2000.

[12] A.C. Frenzel, T. Goetz, R. Pekrun, and H.M. Watt, "Development of mathematics interest in adolescence: Influences of sex, family and school context," *J. of Research on Adolescence,* vol. 20, pp. 507-537, 2010.

[13] P. Haussler, and L. Hoffman, "An intervention study to enhance girls' interest, self- concept, and achievement in physics classes," *J. of Research in Science Teaching*, vol. 39, pp. 870-888, 2002.

[14] L.B. Krogh, and P.V. Thomsen, "Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom," *Int. J. of Sci. Educ.*, vol. 27, no. 3, 2015.

[15] K. Salta, and C. Tzougraki, "Attitudes toward chemistry among 11th grade students in high schools in Greece," *Sci. Educ.*, vol. 88, pp.535-547, 2014. doi:10.1002/sce.10134

[16] J. Walther, S. Miller, and N. Sochacka, "A model of empathy in engineering as a core skill, practice orientation, and professional way of being," *J. of Eng. Educ.* [serial online], vol.106, no.1, pp.123-148, 2017. Available from: Academic Search Complete, Ipswich, MA. Accessed February 12, 2017.

[17] D. Minner, E. Erickson, S. Wu, and A. Martinez, 2012. *Compendium of Research Instruments for STEM Education. Part 2: Measuring Students' Content Knowledge, Reasoning Skills, and Psychological Attributes.* Abt Associates, Cambridge, MA.

[18] J.H. Falk, N. Staus, L.D. Dierking, P. William, J. Wyld, and D. Bailey, "Understanding youth STEM interest pathways within a single community: The Synergies project," *Int. J. of Sci. Educ.,* vol. 6, no. 4, pp. 1-16, 2016.
[19] J.W. Creswell, 2014. *Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.),* SAGE Publications, Inc., Thousand Oaks, CA.
[20] P. Clough, and C. Nutbrown, 2012. *A Student's Guide to Methodology,* SAGE Publications, Inc., Thousand Oaks, CA.
[21] S. Hidi, and K.A. Renninger, "The four-phase model of interest development," *Educ. Psychologist,* vol. 41, pp. 111-127, 2006.
[22] *National Research Council, Rising Above the Gathering Storm; National Center on*Education and the Economy. 2007. Tough Choices, Tough Times. Government Printing Office. Washington, DC, 2006.
[23] B.C. Cunningham, and K.M. Hoyer, 2015. *Stats in Brief: Sex Differences in Science, Technology, Engineering, Mathematics (STEM) Interest, Credits Earned, and NAEP Performance in the 12th Grade.* U.S. Department of Education, NCES2015-075, National Center for Education Statistics, Washington, DC.
[24] C.P. Benbow, "Identifying and nurturing future innovators in science, technology, engineering, and mathematics: A review of readings from the study of mathematically precocious youth," *Peabody J. of Educ.,* vol. 87, pp. 16-25, 2012.
[25] A.V. Maltese, and R.H. Tai, "Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students," *Sci. Educ.,* vol. 95, pp. 877-907, 2011.
[26] R. George, "A cross-domain analysis of changing students' attitudes toward science and attitudes about the utility of science," *Int. J. of Sci. Educ.,* vol. 28, pp. 571-589, 2006.
[27] J.F. Osborne, F. Simon, and S. Collins, "Attitudes towards science: A review of the literature and its implications," *Int. J. of Sci. Educ., vol*. 25, pp. 1049-1079, 2003.
[28] R. Varma, "Why so few women enroll in computing? Sex and ethnic differences in students' perception," *Computer Sci. Educ.,* vol. 20, pp. 301-316, 2010.
[29] J. DeWitt, J. Osborne, L. Archer, J. Dillon, B. Willis, and B. Wong, "Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable," *Int. J. of Sci. Educ.,* vol. 35, pp. 1037-1063, 2011.
[30] A.C. Frenzel, T. Goetz, R. Pekrun, and H.M. Watt, "Development of mathematics interest in adolescence: Influences of sex, family and school context," *J. of Res. on Adolescence,* vol. 20, pp. 507-537, 2010.
[31] *Merriam-Webster Online Dictionary.* Retrieved 2016 from http://www.merriamwebster.com
[32] A. Krapp, and M. Prenzel, "Research on interest in science: Theories, methods and findings," *Int. J. of Sci. Educ.,* vol. 33, no.1, pp. 27-50, 2011.
[33] M. Ayre, J. Mills, and J. Gill, "Yes, I do belong: The women who stay in engineering," *Eng. Studies,* vol. 5, pp. 216-232, 2013.
[34] *Oxford Online Dictionary.* Retrieved 2016 from http://www.oxforddictionaries.com
[35] A.H. Maslow, "A theory of human motivation," *Psychological Review,* vol. 50, no.4, pp. 370- 396, 1943.
[36] J. Boaler, and J.G. Greeno, 2000. "Identity, agency and knowing in mathematics worlds," Boaler J. (Ed.), *Multiple Perspectives on Mathematics Teaching and Learning.* Ablex Publishing, Westport, CT. pp. 171-200.

[37] K. Buse, and E. Pierce, "Why they stay: The ideal selves of persistent women engineers," *Academy of Management Careers Division Presentation,* Montreal, Canada, 2010.
[38] P.J. Burke, "Sex identity, sex, and school performance," *Social Psychology Quarterly,* pp. 159-169, 1989.
[39] J.P. Gee, "Identity as an analytic lens for research in education," *Review of Res. in Educ.,* vol. 25, pp. 99-125, 2000.
[40] R.W. Lent, S.D. Brown, and K.C. Larkin, "Relation of self-efficacy expectations to academic achievement and persistence," *J. of Counseling Psychology,* vol. 31, no. 3, pp. 356-362, 1984.
[41] L. Archer, J. DeWitt, J. Osborne, J. Dillon, B. Willis, B. Wong, "Not girly, not sexy, not glamorous; Primary school girls' and parents' constructions of science aspirations," *Pedagogy, Culture & Society,* vol. 21, no. 1, pp.171-194, 2013.
[42] K. Buse, "Why they stay: Individual factors predicting career commitment for women engineers," *Paper presented at the First International Conference on Engaged Management Scholarship,* Cleveland, OH, 2011.
[43] K. Buse, D. Bilimoria, and S. Perelli, "Why they stay: Women persisting in US engineering careers," *Career Development Int.,* vol. 18, no. 2, pp. 139-154, 2013.
[44] J.M. Bystydzienski, M. Eisenhart, and M. Bruning, "High school is not too late: Developing girls' interest and engagement in engineering careers," *The Career Development Quarterly,* vol. 63, pp. 88-95, 2015.
[45] L. Saavedra, A.M. Araujo, M. do Ceu Taveira, and C.C. Cieira, "Dilemmas of girls and women in engineering: A study in Portugal," *Educational Review,* vol. 66, no. 3, pp. 330-344, 2014.
[46] J.R. Shapiro, and A.M. Williams, "The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields," *Sex Roles,* vol. 66, pp.175-183, 2012.
[47] S.V. Rosser, "The sex gap in patenting: Is technology transfer a feminist issue?" *NWSA Journal,* vol. 21, no. 2, pp. 65-84, 2009.
[48] J.M. Bystydzienski, and A. Brown, "I just want to help people: Young women's sexed engagement with engineering," *Feminist Formations,* vol. 24, no.3, pp. 1-12, 2012.
[49] B.C. Cunningham, J. Ralph, and K.M. Hoyer, 2015. *Stats in Brief: Sex Differences in Science, Technology, Engineering, Mathematics (STEM) Interest, Credits Earned, and NAEP Performance in the 12th Grade.* U.S. Department of Education, NCES2015-075, National Center for Education Statistics Washington, DC.
[50] D. Voyer, and S.D.Voyer, "Sex differences in scholastic achievement: A meta-analysis," *Psychological Bulletin,* vol. 140, no. 4, pp. 1174. 2014.
[51] *OSPI (Office of the Superintendent of Public Instruction).* Retrieved 2015 from http://www.k12.wa.us
[52] L.K. Muthén, and B.O. Muthén, 1998-2015. *Mplus User's Guide (7th ed.).* Muthén & Muthén, Los Angeles, CA.
[53] M.B. Brewer, "The social self on being the same and different at the same time," *Personality and Social Psychology Bulletin,* vol. 17, pp. 475-482, 1991.