
AC 2012-3204: EXPANDING YOUR HORIZONS: THE IMPACT OF A ONE-DAY STEM CONFERENCE ON MIDDLE SCHOOL GIRLS' AND PARENTS' ATTITUDE TOWARD STEM CAREERS

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Diane Johnson graduated from Florida International University with a degree in elementary education and in 1996 earned her master's degree through the Lockheed Martin Scholars Program at University of Central Florida. She is very active within the teaching community as a science trainer, workshop leader, and member of the 2002 & 2011 Orange County, Fla., science curriculum revision team. In the summer of 2008, Johnson put together a group of Orange County teachers and attended the INSPIRE program at Purdue University. Since attending the program, Johnson has become very passionate about bringing more STEM-based curriculum into the classroom and is a proud member of the INSPIRE TiR (Teacher in Residence) team, a research-based program at Purdue University dedicated to improving the quality of STEM curriculum and addressing the downward trends in engineering interest and preparedness. Along with teaching seventh grade science, she is now giving workshops to middle school teachers demonstrating how to incorporate more STEM-based learning into the curriculum. She is also one of the coordinators for Expanding Your Horizons, sponsored by the College of Engineering and Computer Science at University of Central Florida, an annual conference that encourages middle school age girls to realize their potential in science, technology, engineering, and math.

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Leslie Castner graduated from Duke University with a B.S. in computer science. She worked for IBM as a software developer on projects for the FAA and the petroleum industry. She is the Co-coordinator of Expanding Your Horizons at UCF, a one-day STEM conference for middle school girls. Castner has spent countless hours as a volunteer in many capacities, including ten years as a Girl Scout leader (most of them guiding two troops) and several years as a substitute teacher. Her background working with girls combined with her computer science degree gives her great insight into planning an engineering conference for middle school girls.

Expanding Your Horizons: The Impact Of A One-Day STEM Conference On Middle School Girls' and Parents' Attitude Toward STEM Careers

Abstract

This paper is based on a survey of 172 middle school girls and 38 parents who attended a one-day, Expanding Your Horizons (EYH conference) at a large, metropolitan, public university. The purpose of the EYH conference is to encourage girls to consider science, technology, engineering, and mathematics (STEM) careers. Pre-/post questions on the girls' survey showed positive gains after the conference in knowledge of the different STEM fields (57.3% gain), interest in studying STEM (29.5% gain), and confidence in their math skills (14.4% gain). Parents had a positive gain of 34.2% in knowledge of the different STEM fields after the conference, and 65% of parents thought that their daughter was likely to choose a STEM major. In a longitudinal study of EYH participants, Virnoche and Eschenbach¹ found that interest in STEM wanes over time, and one participant reported a diminished sense of self-confidence in her math and science skills. To sustain interest in STEM, multiple interventions that involve parents need to be offered over the high school years. There is also a need for follow up outreach activities that are structured to prepare girls for and retain girls in STEM pathways.

Background

A recent report from the American Society of Engineering Education (ASEE) shows promising results that efforts to attract and retain women into engineering have been successful, but there is still a lot of work to be done. In 2010, 18.1% of engineering bachelor's degrees were awarded to women compared with 17.8% in 2009, up for the first time since 2002². Gibbons² further reports that female undergraduate enrollment in engineering was up for the third consecutive year at 18.6% after a low of 17.5% in 2007. One nationwide program that has been coordinating programs to increase the participation of women in science, technology, engineering, and mathematics (STEM) careers since 1974 is the Expanding Your Horizons (EYH) Network. EYH was first established as an informal network by a group of women scientists and educators who were concerned about low female participation in math courses. According to a recent EYH annual report³, 9,779 middle school girls (92% were in grades 6-8) attended 40 EYH conferences, and EYH won the National Science Board's Public Service Award.

For close to 30 years (since at least 1982), the College of Engineering and Computer Science (CECS) at the University of Central Florida (UCF), a metropolitan, public university (the second largest university in the nation in terms of student enrollment) has held an annual EYH conference for middle school girls, their parents, and teachers. The percentage of undergraduate women enrolled in CECS is 13.6% (below the national average of 18.6%). This percentage (13.6%) is also below three other public universities in the state in terms of women enrolled in

undergraduate programs in the engineering colleges (University of Florida 22.7%, Florida International University 17.7%, and University of South Florida 16%) and on par with a fourth state university (Florida Atlantic University 13.5%)⁴. Approximately 50% of incoming freshmen into CECS are from high schools in surrounding Central Florida area counties, 32% from counties to the south, and 11% from counties to the north. The remaining 6% of incoming freshmen are primarily from other states, and another 1% from outside the U.S. Sixty-six percent of students who declare an engineering or computer science major transfer in to UCF from one of four feeder community colleges in the area. From these statistics, we can estimate that at best, 50%-70% of middle school girls who participate in our EYH conference will remain in the Central Florida area and potentially be part of our recruitment group for the college. It was therefore important for us to examine further what aspects of our outreach efforts to increase participation of women in STEM were successful and to identify areas for improvement. Our findings and recommendations may be helpful to other engineering colleges who struggle with the same issue.

Theoretical and Conceptual Framework

A study published in the proceedings of the National Academy of Sciences by Hoffman, Gneezy, and List⁵ found no statistically significant difference in math aptitude (in terms of spatial ability) between men and women in the Khasi tribe, a matrilineal society, living in northeast India. A genetically related group living in the same region, the Karbi tribe, a patrilineal society, showed that the men were 36% faster at solving the block puzzles than the women. About one third of the differences in performance could be attributed to differences in education: in the Khasi tribe both genders have the same years of education, and in the Karbi tribe, men have about four more years of education. The results of this study support the theory that men and women may be equally hardwired in terms of math aptitude, and gender gaps are attributable to cultural differences. Yet in the United States, where both girls and boys have the right to equal educational opportunities, and despite many and varied programs to attract women into STEM careers, a wide gender gap persists⁶.

Self-efficacy theory related to children suggests that children who are confident in their ability to perform a task tend to have higher academic aspirations and pursue STEM career paths, though boys are attracted to STEM careers more than girls⁷. Moreover, parents who are involved in their child's scholastic development will also have higher academic aspirations for them. Among college students, STEM career choices were attributed to math self-efficacy (more evident among male students than female students), outcome expectations (a person's belief that their behavior will lead to a certain outcome), and vocational interests⁸. Catsambis⁹ found that the decision to pursue a STEM career is already apparent in the eighth grade, and that while female students are equally capable at math as male students up through the high school years, they do not participate as frequently as their male counterparts in math courses when enrollment in these courses is optional. Female students also tend to take fewer or less rigorous math and science courses because of negative stereotypical ideas or lack of encouragement to pursue

technical careers in typically male-dominated fields^{6,10,11}. Researchers generally agree that female engineering students tend to have lower confidence in their math and science capabilities than their male counterparts, and a confident attitude leads to increases in achievement^{12,13,14,15,16,17}.

Prior Research on the Impact of EYH Conferences

Hochstein, Moses, and Jones¹⁸ evaluated a one-day EYH conference held at the University of Memphis and found that after the conference, 53% of the girls reported that for a successful career taking math was more important than they had thought (57% for science); 46% were “way more interested” in STEM careers; 23% were “as interested as before the conference;” and 28% were “sort of more interested.” Virnoche and Eschenbach¹ conducted a longitudinal evaluation (follow up interviews and small group discussions) with 22 high school girls who had participated in an EYH conference 2-5 years earlier at Humboldt State University. They found that some of the girls had taken math and science courses in high school in preparation for college but had no intentions of choosing a STEM major. Based on their findings, they recommended that EYH conferences could be more effective by: 1) involving teachers and counselors to engage participation of less savvy parents; 2) making workshops “hands-on” (i.e., fun) and “not like school”; 3) including speakers (when possible) with STEM careers who are beautiful, popular, intelligent, and accomplished; 4) asking speakers to explain their career path as part of the workshop activities; 5) showing that there are multiple solutions to a problem (some girls are turned off by one-solution answers if they like to address a problem from multiple perspectives); 6) having multiple interventions over the teenage years to sustain interest as the positive effects of EYH fade over time; and 7) involving role models and parents because they have a lot of influence. In our study of a one-day EYH conference, we extend the findings of these two studies to include evaluations of girls’ confidence in their math abilities and parents’ perspective of the EYH conference (areas identified as important factors in influencing STEM career choice among female students but not addressed in these previous studies).

Methodology

Middle school girls and parents were surveyed at the end of a one-day EYH conference held on the university campus during the Spring 2011 semester. One of the EYH program coordinators (both are co-authors on this paper) is a middle school teacher who is very active in the county and conducts many workshops throughout the year. Through her contacts in K-12, the EYH program was advertised through different venues. For the 2011 EYH conference, pre-event publicity included:

- Direct advertising to schools in five area counties.
- Three posters distributed to each school through the county science curriculum coordinators and fliers emailed to each principal for distribution.
- Emails to principals of 23 private schools in five of the area counties.

- Website hits from parents searching for science enrichment activities.

During the 2011 EYH conference, five “hands-on” workshops were held on the university campus for the girls. These workshops were designed to feature engineering disciplines that are offered at the university. Women engineers from the community worked with engineering students at the university to present a uniform “hands-on” activity that demonstrated principles from chemical engineering and aerospace engineering. They also talked about their career paths as part of leading the workshop. The girls participated in activities that taught the general engineering concepts about communication, and the design process that could be applied to all engineering disciplines. Three “hands-on” workshops were held concurrently for parents and teachers to learn about the different engineering majors available and tips on how to encourage their daughters to pursue a STEM career.

The conference participants totaled 393: 214 middle school girls (6th – 8th grades), 103 parents and teachers, 25 community volunteers, and 51 student volunteers from the university. The girls and their parents were each given a paper survey which included pre-/post-questions, asking them to rate different aspects of the EYH conference. The surveys were distributed in the morning in the backpacks given to the girls. They were reminded to complete them at the end of the day while waiting for the final presentation to begin. They were given to their engineering student guide volunteer upon completion.

Results

One hundred and seventy two girls (80.4% response rate) participated in the student survey. The five workshops received positive ratings (“Loved It” or “Pretty Good” responses) ranging from 80% - 99%. The guest speakers for the 2011 EYH conference included a Miss Florida contestant, a Civil Engineering major at the university. The previous year’s EYH conference (2010) also included as speakers, the reigning Miss Florida and Mrs. Florida title holders, both engineering alumnae. These role models are important because they have the power to dispel misconceptions about engineers as noted in these parent comments from the previous year’s (2010) conference:

I really enjoyed this conference, at this age to expose my daughter to all options is my goal. This was an amazing hands-on way to do it. The cost was very affordable and the encouragement and preconceptions dispelled was wonderful from the Miss/Mrs. Florida ladies!

This conference exceeded my expectations. All preconceptions about engineering are blown away. I hope my daughter came away with the same feelings. The price for the day was affordable (OK it was really cheap.)

I loved the fact that both Miss/Mrs. Florida were engineers and could show our girls that it is possible to be beautiful AND intelligent!

Girls had a 57.3% gain (difference between the percentage of “very high” and “high” responses before and after) in knowledge of the different fields of engineering and the sciences after attending the EYH conference (see Figure 1).

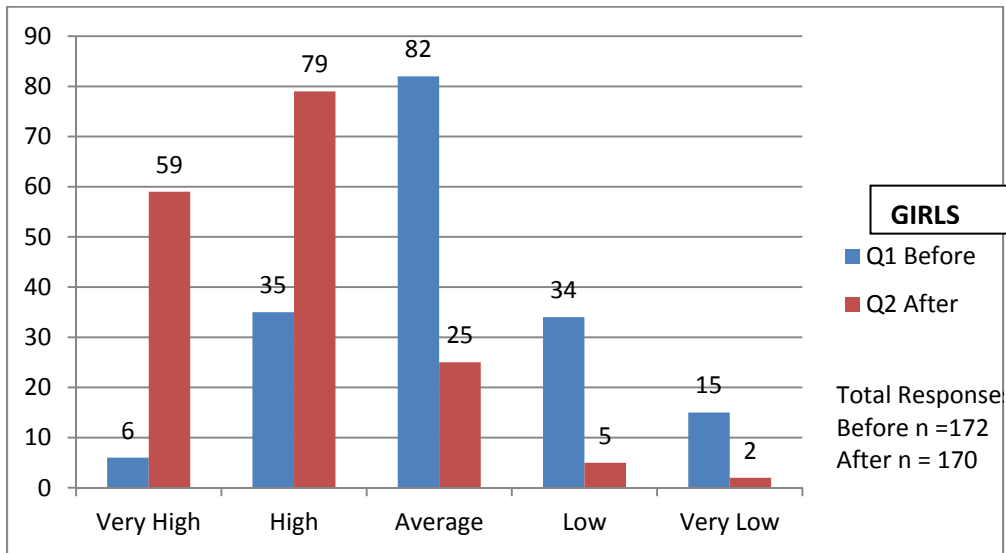


Figure 1. Q1/Q2 How much did you know about the different fields of engineering and the sciences before/after attending this event?

Girls had a 29.5% gain (difference between the percentage of “very high” and “high” responses before and after) in interest in studying engineering or the sciences after attending the EYH conference (see Figure 2). Forty eight percent of the girls had a positive shift in interest in STEM (more interested in STEM); about 32% who were very interested before were just as motivated (i.e., experienced no shift in interest either positive or negative); another 8% who were not very interested before reported no change in interest level; and 7% had a negative shift in interest (less interested in STEM) (see Table 1). These results seem to be generally consistent with those reported by Hochstein, Moses, and Jones⁵, in particular for those who reported the highest gains in interest (i.e., being more interested in STEM). Hochstein, Moses, and Jones⁵ found that that after their EYH conference, 46% of the girls were “way more interested” in STEM careers; 23% were “as interested as before the conference;” and 28% were “sort of more interested .”

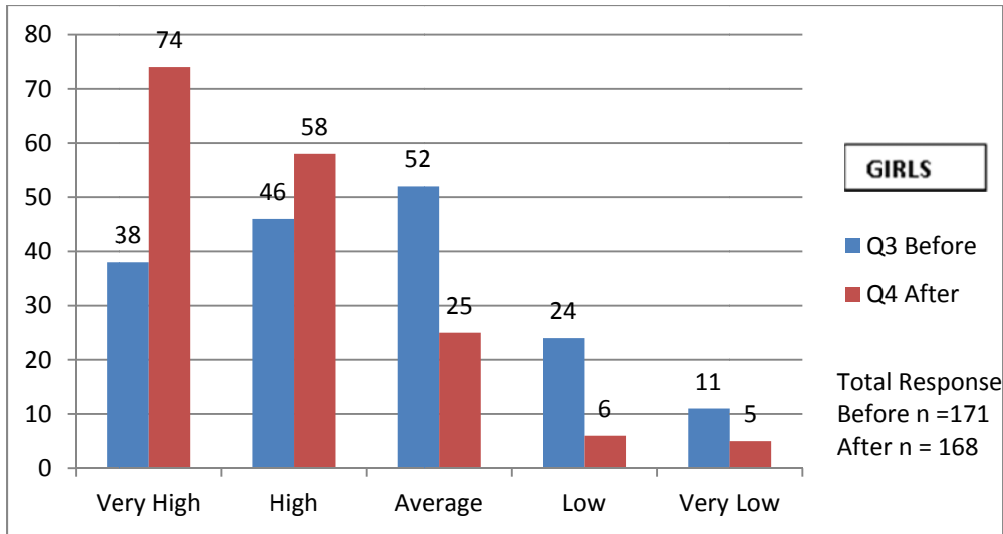


Figure 2. Q3/Q4 How interested were you in studying engineering or the sciences before/after attending this event?

Table 1. Girls’ Attitude Shift in Pursuing STEM after the EYH Conference

Questions 3 & 4	Number of Responses	Percentage
Positive shift in interest (more interested in STEM)	82	48%
No change in interest (very high interest maintained)	55	32%
No change in interest (low to average interest remained the same, not motivated)	14	8%
Negative shift in interest (less interested in STEM)	11	7%
No Response	9	5%
Total	171	100%

Girls had a modest gain of 14.4% (difference between the percentage of “very high” and “high” responses before and after) in confidence in their math skills after attending the EYH conference (see Figure 3). A modest gain was expected as there was very limited math involved, and it was embedded in the activities and very simple.

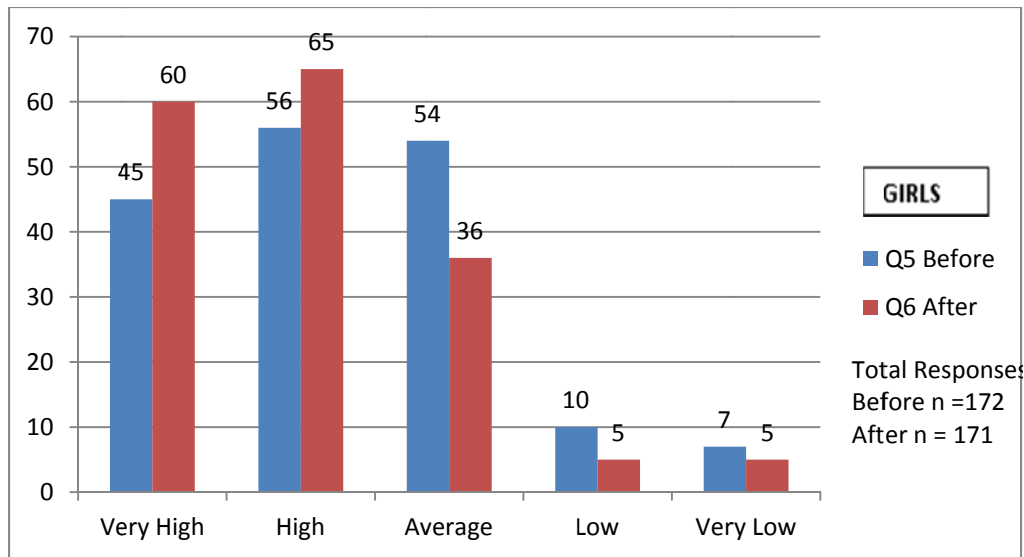


Figure 3. Q5/Q6 How would you rate your confidence in your math skills before/after attending this conference?

Thirty eight parents participated in the survey. Eighty-seven percent of the parents rated the conference as either “Extremely Informative” or “Very Informative.” The three workshops received positive ratings (“Loved It” and “Good”) ranging from 87% - 95%.

Parents had a 34.2% gain (difference between the percentage of “very high” and “high” responses before and after) in knowledge of the different fields of engineering and the sciences after attending the EYH conference (see Figure 4). This gain is lower than the 57.3% gain reported for their daughters on the same set of questions (see Figure 1 above). Sixty-five percent of parents responded that the likelihood of their daughter choosing engineering or the sciences as her major was “Very High” or “High,” and none responded “Very Low” (see Figure 5). Parent comments from the survey seemed to indicate that the conference generated excitement about STEM and may have even influenced some of the girls to identify with a discipline.

It was organized to perfection. Our girls had a wonderful time!

Thank you for a wonderful day! My daughter and her friend enjoyed the experience!

Looks like my daughter wants to be a chemical engineer now!

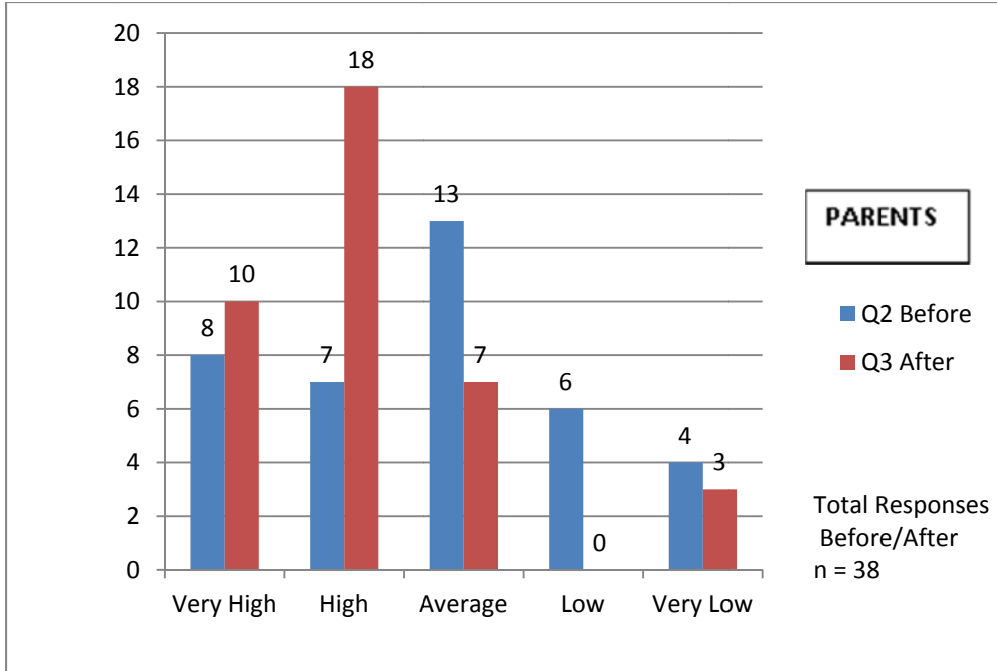


Figure 4. Q2/Q3 How much did you know about the different fields of engineering and the sciences before/after attending this event?

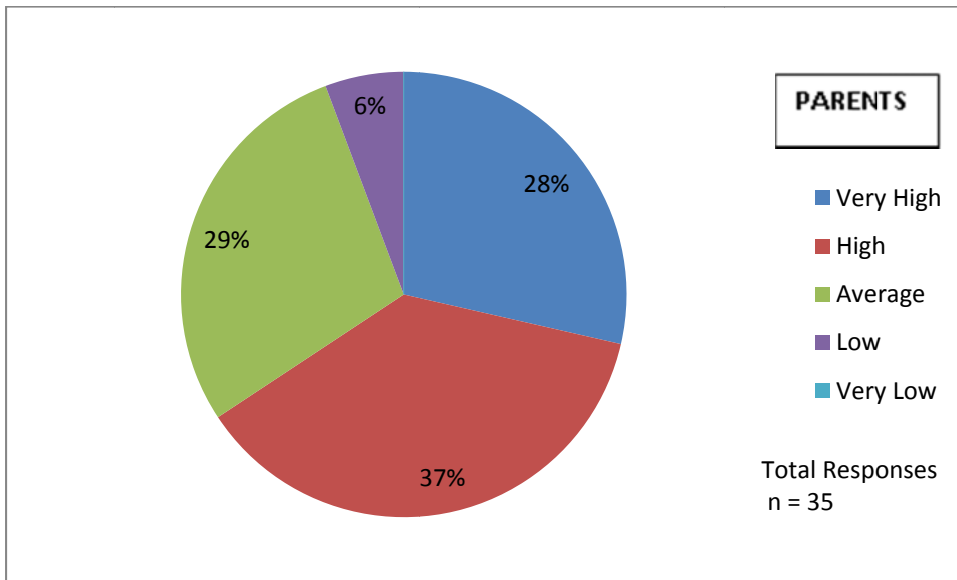


Figure 5. Q4 How likely do you think it is that your daughter will choose engineering or the sciences as her major?

Discussion

As cited previously in this paper, Catsambis⁹ found that the decision to pursue a STEM career is already apparent in the eighth grade. Based on the results of our study and those reported by Hochstein, Moses, and Jones¹⁸, it seems that the EYH conference impacts about 50% of the girls in increasing their interest in STEM, and another 20-30% of girls who are already very interested in STEM before the conference remain as interested after the conference. Sixty five percent of parents at our EYH conference thought it likely that their daughter would chose a STEM major. Our EYH program coordinators received many requests from parents for a similar program for high school students. Data provided by Bruce Furino, Director of Outreach in our college, from the recent 2012 SECME regional competition for the Central Florida area held annually at UCF suggest that the decision to pursue a STEM career may be actually be apparent as early as the elementary grades. Over 300 elementary, middle, and high school students, teachers, parents, volunteers, and industry judges attended the 2012 SECME competition. (SECME was established in 1975 as the Southeastern Consortium for Minorities in Engineering by the Engineering Deans of six Southeastern universities, and it has since expanded its strategic alliance to include other schools, universities, science and technology-based industries, and public and private agencies. The mission of SECME is to increase the pool of historically underrepresented and under-served students in STEM.)

Survey results of elementary school students (Grades 3-5) who attended the 2012 SECME competition at UCF showed that in response to the question, “What do you want to be when you grow up?”, engineer was the most frequently cited answer; followed by artist (act, paint, dance, etc.); teacher, cop/guard/army and doctor/veterinarian tied for third place; and in fourth place, scientist, entrepreneur, and sport-related professions. Thirty eight percent reported that they were more enthusiastic about the thought of someday becoming an engineer, 14% thought it a possibility, and 48% were not interested. What was interesting to see in the responses was that some elementary students identified the particular field of engineering they were interested in, e.g., civil engineering, electrical engineering, software engineering, aeronautical engineering. This survey was based on data from 37 of the 75 elementary school students (49% response rate) who participated in the SECME competition (data were not available by gender).

Conclusion

Lack of a comprehensive plan to attract and retain women into the STEM disciplines seems to be an issue among engineering colleges. The findings of a recent survey (*Bayer Facts of Science Education XV* survey) conducted by the Bayer Corporation¹⁹ for their national, award-winning program, “Making Science Make Sense,” revealed that 82% of 413 STEM department chairs from the nation’s top 200 research universities thought that while American women entering college are the best prepared to succeed academically, they graduate at a lower rate than men. Only 33% reported that their colleges had a comprehensive STEM diversity plan with recruitment and retention initiatives; 64% had informal, department-level, diversity recruitment

programs; and 43% diversity retention programs. To successfully prepare girls for and retain them in STEM career pathways, there should be a structured, formal progression of multiple types of interventions.

Research studies suggest perception of math self-efficacy among female engineering students is one predictor of the decision to pursue a STEM career pathway^{12,13,14,15,16,17}. What we have learned from our study and previous studies cited in this paper is that multiple, confidence-building interventions targeted to girls need to be offered over the elementary, middle, and high school years (and through the college years) to sustain interest in STEM. The (one-day) EYH conference is successful as a recruitment activity to stimulate interest in STEM, but it may not be as effective in retaining girls in STEM pathways as interest wanes over time¹. Not only does interest tend to erode over time, but also self-confidence in math and science skills, as reported by one participant in a longitudinal study (follow up interviews and small discussion groups of 22 prior EYH conference participants) conducted by Virnoche and Eschenbach¹. Though this participant was quite capable in the math and sciences, it was her perception of her abilities that she was not “good enough” to be a doctor or scientist (when comparing herself with her high school peers who completed assignments faster than she did) that eventually turned her off from pursuing a STEM career.

The specific types of pre-collegiate outreach activities that have been found to be more effective at fostering confidence in STEM skills for future engineering students was published in a study by Fantz, Siller, and DeMiranda²⁰. They suggested that pre-collegiate activities patterned after engineering hobby camps/workshops or pre-engineering classes were better at fostering self-efficacy in engineering students than multi-day engineering programs, school-related extra-curricular engineering programs, one-day engineering workshops/field trips, or working in engineering environments. In our study, girls reported a modest gain of 14.4% in confidence in their math skills after attending the EYH conference (see Figure 3). A modest gain was expected as there was very limited math involved, and it was embedded in the activities and very simple. The focus of the EYH conference was offering fun, “hands-on” activities rather than rigorous, analytical activities. These findings may have curricular implications for the K-12 curriculum. In her study, Catsambis⁹ also found that female students (though equally capable) tend not to enroll in optional math courses during the high school years with the same frequency as their male counterparts. Future research could examine the impact various types of recruitment and confidence-building outreach activities during the elementary and middle school years on girls’ choice of optional math enrollment in the high school years. The research could be extended to investigate the influence of similar types of outreach activities in the high school years and girls’ decision to choose STEM as their college major.

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