FREE (Female Recruits Explore Engineering) Project: Different Perspectives on Young Women's Interest in Engineering – How Can We Leverage for a Stronger Crew

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Description

This paper reports on findings from a four-year longitudinal study of a diverse group of high school sophomore girls exploring engineering as a career option. The data suggests that high school is not too late to influence girls to consider engineering as a career path. Drawing upon primarily qualitative data, this paper captures the girls' perspective on engineering as they develop and documents their decision-making process in various activities, personal reflections, a wiki-like website, and cell phone text messages. Altogether, the data paints a picture of the lives of the girls as they try to envision their future selves in engineering, become excited about some of the prospects, and in some cases struggle with difficult challenges that have little to do with engineering itself. The paper opens up a space to ponder ways to leverage these findings to pique and support young women's interest in engineering as a career option and ultimately, build a more diverse engineering workforce.

Introduction

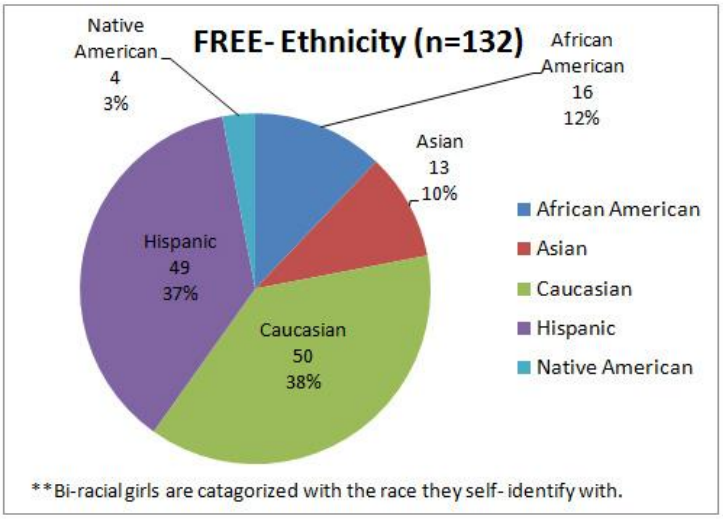
It's a phrase I'll never forget. Our research team was in a high school library kicking off our participatory action research study with a diverse group of high school sophomores. And after being introduced to a variety of engineering fields, one spirited, African American tenth grader exclaims, "I wonder what *style* of engineering will be right for me?!" How refreshing, I reflected. Clearly, there are an abundance of engineering *styles* – a new spin on a traditional concept. I paused and thought, this study – Female Recruits Explore Engineering (FREE) – was going to teach us a lot. Not only, during the course of the study, would we explore engineering where, when and how the girls chose to, but we would learn about it through their eyes and come to know it through their words. It would be fun to learn together!

The FREE study evolved from a dissertation and pilot study entitled "How Young women come to know Engineering" (Bruning 2003), where then-graduate student and college administrator, Monica Bruning sought to revise and update the work Margaret Eisenhart and Dorothy Holland published in *Educated in Romance* (1990). Rather than an ethnographic study of talented college women considering science-related fields in college, the FREE study was a longitudinal

intervention research project targeting high school sophomore girls who knew little about engineering, did not personally know any engineers, and (for the most part) were not already considering engineering as a career option. In 2006, with funding from the National Science Foundation (Collaborative Grant Nos. 624689 and 0624537), one hundred and thirty-two school sophomore girls in three states (CO, IA, and OH) were recruited via high school teachers, administrators and STEM-oriented after school programs. The participatory action research study was led by a diverse and experienced team of researchers: Monica Bruning, pilot study investigator with expertise in adolescent career development, higher education admissions and student affairs, and engineering; Margaret Eisenhart, educational anthropologist, qualitative researcher, and girls and science scholar: and Jill Bystydzienski, sociologist, women's studies expert, and women in science scholar.

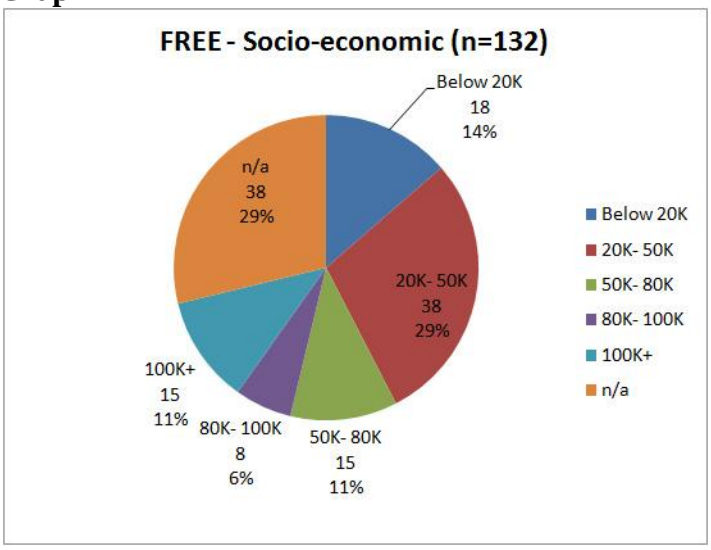
When the FREE study and intervention was launched, all the participants were high achievers in math and science (as measured by their 9th grade record in mathematics and science and their teachers' and counselors' recommendations). As graphs one and two illustrate, most were minorities, many were from working class families, and many were in the first generation of their family to attend school in the U.S. Although the girls were strong students in math and science, and lived in areas with good engineering jobs, fewer than a third were considering engineering as a career possibility and even fewer knew an engineer personally. The design of both the pilot and FREE study utilized participatory action research (PAR) methodology to hear young women's voices as they actively explored engineering as a future career option. The purpose of the study was, first, to support the girls to think seriously about engineering as a career, second, to support their exploration of engineering as a career option, and third, to document the course of their career decision making over time. It is widely known that with few exceptions, academically high-achieving young women do not consider engineering as a career, and many who consider it decide against it. The study aimed to increase the likelihood that talented young women would seriously consider the possibility of engineering as a career.

Graph 1



Demographic for Female Recruits Explore Engineering (FREE) Project participants

Graph 2



Demographic data for Female Recruits Explore Engineering (FREE) Project participants

Interest and Curiosity to Explore Engineering

Our first important discovery was that most of the girls knew little about engineering when FREE began. Engineering was not so much unappealing or uninteresting as it was unknown. 36% of CO girls, 10% of OH girls, and 10% of IA girls knew an engineer when FREE began. 23% of CO girls, 27% of OH girls, and 10% of IA girls were considering engineering as a career option.

One of the first FREE activities was a trip to a Career Fair where the girls met and interacted briefly with representatives of engineering companies and schools. Prior to the trip, we asked the girls to suggest questions they would like to ask the Career Fair representatives. The questions they generated were offered tentatively and focused on very basic aspects of engineering (of any job, really). Some typical questions were:

What do engineers do?
What types of engineering are there?
What do you like about engineering?
What do engineers make [as a salary]?
What courses did you have to take to become an engineer?
Do engineers get to travel much?
How many women work for your company?

After the Fair, it was still clear that their knowledge was thin. Some of the reflections, included comments like

Stephie: *I was told what chemical and mechanical engineering is, however, I cannot recall what they are. I learned that there are different kinds of engineering, like aerospace and more. I also*

learned that in some cases you do not need a lot of background in science and math but other times you need to know a lot in math and science… I would like to know more about the other kinds of engineering and what they do. Also, what kind of profession do engineers can get in to?

Jayde: *I would like to learn more about the types of engineering, and how they affect the lives of people.*

After the career fairs and several FREE meetings where types of engineering were introduced, the girls' knowledge grew. They explored the profession in many ways: via video clips of young women working at Google, Engineers without Borders, and women of color in a variety of engineering roles; a hands-on activity to make a heart valve; a demonstration of how to make a prosthetic device; and online research and in-person interviews with practicing engineers. The girls began to name more kinds of engineering, identify more characteristics, and express more personal interest.

Angel: *I would like to learn more about the engineering that had to do with working with technology and creating like shirts with lights and all that other stuff…. I would also like to learn more about the engineering department that worked with the measurements of earthquakes.*

Mikey: *I would like to learn more about mechanical engineering. I also want to know if there is any field in engineering that deals with the medical field.*

They expressed surprise and wonder at the variety and range of engineering activities.

Loni: *I learned that engineering is a great type of career that can help you achieve a lot in life, and that there are all different types of engineering so you can work on one type that you are good at, or one that attracts you.*

Sophie: *One thing that impressed me was that there are so many different people working as engineers with such different personalities, that it showed that no matter what kind of person you are or what your interests are you can become an engineer. Another thing that surprised me was that mostly every person we interviewed said his or her job was fun and that they had a lot of freedom… Some things I didn't know about engineering before the career fair was that there are so many different types of engineering. There are so many branches of engineering that basically for anything you want to do you can be an engineer, even if it isn't directly connected to engineering. Like one of the girls we talked to said she was kind of an engineering lawyer which I thought was kind of crazy because I didn't even know that profession existed.*

They were pleasantly surprised by the amount of teamwork involved in engineering.

Lizbeth: *What I learned that I didn't know before was that every different kind of engineering helps each other out. For example, with aerospace engineering, the projects they made they needed help from the other kinds of engineering.*

Ayan: *The fact that engineers work as a team impressed me because before I assumed it was a more independent job instead.*

They were especially impressed with how much engineering can affect people's lives.

Jayde: *I got a chance to see other fields of work. I had no idea how much engineering affects our everyday life… I learned that engineering can really make peoples everyday life so much easier, and I really want to change people's lives in a positive way.*

They began to think about how they could pursue pre-existing (non-engineering) interests in some kind of engineering field. Loni wanted to know whether there is any connection between psychology and engineering. Others asked about forms of health, forensics, veterinary science, and medical engineering because they were already interested in those areas.

At the same time, however, concerns about engineering also began to surface. One concern was about how much math and science might be needed.

Mya: *The fact that most engineers have to take quite a bit of physics and be in high math bothered me. I don't like physics and I am already in high math and it's not too easy.*

Another concern was how demanding the job can be. Girls worried about long hours, lots of responsibility, lots of stress, and balancing work and family.

Sophie: *I think the only thing that worried me was that everyone said they had to work a lot more hours than I had expected. Typically from at least 10 to 16 hours a day which is twice as much as most other jobs.*

A couple of girls raised questions about the ratio of men to women and its consequences. They wondered whether it was an advantage or a problem to be one of only a few women in engineering. A group of Latino girls theorized that perhaps there was a historical rationale for the imbalance of men to women in engineering.

Remy: *My view of engineering has changed over the past year, based on the number of women involved. The main disadvantage to me is the fact that the field lacks numbers of women. The advantages to becoming an engineer are countless, because of the demand. I think that my generation has many more women who are interested in the field of engineering; the number of women should increase.*

Inez: *Other things I would like to learn about engineering is like why most women do not like engineering. Or why they do everything for men like cars, and stuff like that.*

The results suggest that, as the girls learned more about engineering, their interest in it grew. They expressed a desire to learn more about various fields of engineering, the kind of work that engineers do, and how they might connect some of their pre-existing interests with work in engineering. At the same time, they began to think more about how good one has to be in math and science to do engineering, how much time, pressure, and stress the work entails, and why it is that so few women go into engineering. These concerns are well-taken, but what is striking in the data is how easily and quickly the girls became excited and enthusiastic—more interested—in engineering.

By their junior year (year two of the study), the girls wanted to learn about engineering by doing it. We used pedagogical strategies such as project-based learning, which is a collaborative learning approach that engages learners in authentic open-ended problem-solving activities.

The influential aspect of PAR and project-based learning was the "relevancy" factor. The girls chose projects they were interested in and interest developed naturally. Table 3 lists and categorizes the variety of projects the girls researched. Some girls never settled on *one* project, instead they started and changed to two or three others over the course of the year. Their interests were evolving and there was so much they were interested in that they chose breadth rather than depth in understanding engineering more intimately. By the end of the year, as the projects were completed and presented, the girls' engagement with engineering had taken a new form. In the projects, they began to even take on some of the practices of engineering (research, design, feasibility study, cost and market analysis, prototyping, et al).

Table 3

FREE Engineering Projects		
Build, make, or invent something:		
Laser sunglasses to melt snow Regenerate limbs Powdered water Automatic dog feeder Hover car Translator for different accents Always cold water bottle Implantable telephone Warm bubble Transportable biosphere to be placed on Mars Coma communicator Screen/computer application that transforms speech to sign language Waterproof case for electronics (phone, iPod, etc.) that survives washing	Glow-in-the-dark undergarments Multi-media desk Rolling desk (like a rolling chair) Key/remote finder Thermal clothing (can control temp to make warmer or colder) Head band that changes hair color Harry Potter style picture frame Laser car opener Remote controlled windows and doors Collapsible/foldable cowboy hat Stain resistant seat covers Indestructible American money like Mexican money (doesn't tear or break) Overnight hair growth	Electronic outfit organizer that creates outfits for you (can do multiple searches) Adjustable shoe heel (can go from flats to stilettos in seconds) Chewable flavored pen Key/remote finder Stylish color changing shirt Remote controlled mini fridge that delivers food/drinks Combined aromatherapy and sound therapy (e.g., waves) device Temperature controlled pillow (warm or cool) Quick way of getting rid of (or preventing) morning "bed head" Hair braiding tool
Meet a personal, family, or community need through engineering:		
Hover backpack Lotion that lasts all day Dialysis patient entertainment Dog propelled stroller or bike for kids Remote control cart Playground for handicapped kids Air cleaner/filter/scrubber for the top of smoke/pollution stacks	Wallet for the blind that helps to organize money Money that allows blind people to determine the amount Voice activated/controlled computer Portable ramp for house and travel Hydraulic backpack Self-propelled toothbrush	Air filter for entire school (removes odors from stink bombs, onions, etc.) Lotion that helps cure/alleviate arthritis Pedestrian overpass/bridge or underpass/tunnel on busy streets Alternative to pesticides Turn signals/lights for wheelchairs
Work on a safety issue through engineering:		
Ice grips Really hard/safe motorcycle helmet	Steel toed non-stick shoes for girls Motion sensor for cars	Protective body suit for kids (lightweight and flexible; waterproof, fireproof)
Create a virtual world:		
Weightless virtual world Mars station	Platform for a homecoming float modeled after plate tectonics	Baby translator (translates ooos and coos)

		Create an amusement park Build a mall
Enter a contest in engineering:		
Rube Goldberg		
Start a business around an engineered product:		
Market products from other topic areas Solar powered jewelry	Electronic notebook and pen	A whistle to help find your car in a parking lot (your car whistles back)
Develop a presentation (Road Show, Film Show, Video, Billboard) about engineering:		
Road Show on "boys' think"	Presentation for 9th grade girls about specific field of engineering	

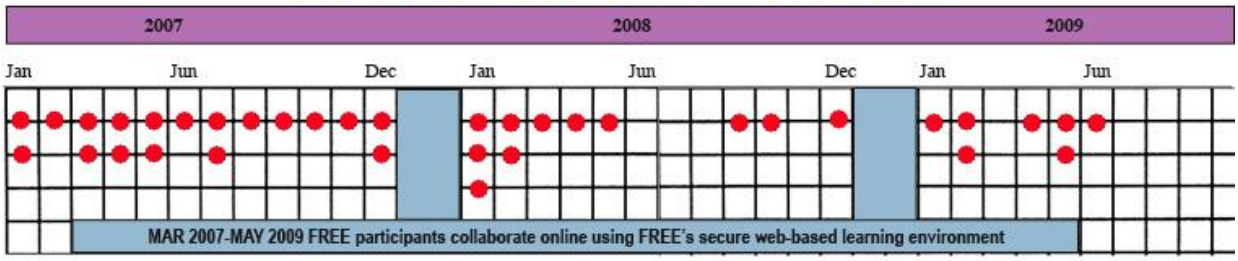
This table captures the variety of engineering projects the FREE girls identified and completed.

FREE Methodology

The FREE research design can be broadly defined as a multi-site qualitative study informed by principles of Participatory Action Research and Case Study Research. The focus of the project was to facilitate young women's explorations of engineering, track the course of their explorations and considerations during high school, identify and map the influences that shaped their sense of the profession, and analyze their views and choices regarding career options in engineering at the conclusion of the study. To accomplish these goals, Table 4 summarizes the activities the girls did as they learned about engineering.

Table 4

FREE Activities Timeline Sample



JAN: First FREE meeting, Career Fairs
FEB: IA Career Fair Debriefing
MAR: Global Marathon, FREE website LIVE
APR: Deliver blackberry, SHPE Shadow Day
MAY: Explore research question with girls, Forensic Lab
JUN: Space Command Lab
JUL: Interview an Engineer, Fisher Controls
AUG: ISU Visit
SEP: Engineering project work begins
OCT-DEC: Project work continues
DEC: Textile Engineering Field Trip

JAN: Career Fairs, Bioengineering Lab Visit, Projects
FEB: SWE Sleepover, PWSE Get Away Weekends, Projects
MAR: Projects
APR: Projeccts
MAY: CELEBRATION - Presentation of projects
JUN:
JUL:
AUG:
SEP: Case Study Kick-Off
OCT: Case Study interviews begin

JAN: Career Fair (IA)
FEB: Case Study Interviews, OSU Visit
MAR:
APR: Case Study Interviews
MAY: Case Study Interviews, Graduations
JUN: School Graaduations

The timeline identifies the activities the FREE girls participated in throughout the three year project.

Additionally, some of the unique features of this 3-year project included:

1. A password-protected online community website that served as a virtual learning space where the girls posted information they found interesting, shared ideas and questions, and reflected on their own and others' posts (learn from and support each other). This supportive online community of like-minded girls as well as research groups functioned like cohort groups.
2. Each girl used a Blackberry® as a research and communication tool. This innovative data collection tool allowed the researchers to collect in-the-moment data and facilitated interaction among the girls and with the researchers over the course of the intervention.
3. In year two of the study, the girls embarked on a year-long engineering-related project based on their own interests. A list of their projects is provided in Table 3.
4. One year of case studies with 24 girls allowed the research team to explore influences and decision-making in depth.

Fieldnotes, interview responses, website postings, and Blackberry messages were analyzed using a coding scheme developed from the research questions (a priori codes) and a preliminary review of two months of the accumulated data from each of the 3 states (in situ codes). The coding scheme was applied to the data in ATLAS.ti, a software program for qualitative data analysis. The website and Blackberry data (>100,000 messages) required special treatment. To handle these data, E-Data Viewer, a new software is under development by one of the researchers to process the messages in their original e-format, thread them together into conversations, and code them.

Discussion

Table 5: Girls' Trajectories of Interest in Engineering as a Possible Career

	A. Start Spr 07	B. Consider'g Eng at Start	C. Retained Aug08	**D.** Consider'g Eng Aug08	E. Stay in Eng	F. Stay in NEng	G. Switch Eng→ NEng	H. Switch NEng→ Eng
CO	69	16 (23%)	38(65%)	15 (39%)	6(16%)	19(50%)	4 (11%)	9 (24%)
IA	46	13 (28%)	21 (29% & 56%)*	10 (48%)	7 (33%)	1 (5%)	2 (9.5%)	5 (24%)
OH	20	2 (10%)	15 (75%)	12 (60%)	2(10%)	3(15%)	2(10%)	10(50%)
	131	31 (24%)	74 (56%)	37 (50%)	15 (20%)	23 (31%)	8 (11%)	24 (32%)

Girls' interest in engineering as a career option from sophomore through fall of senior year in high school

*One site in IA was an urban district serving 4 schools. Retention in this multi-school site was 29%. Retention in single school sites was 56%.

Perhaps the most significant outcome from this study is that 65% of girls who started in the program continued for two years and some for even longer. Table 5 provides the numbers and percentages of girls who started in Spring 2007 (A), who were considering engineering at the start (B), who were still in FREE in August 2008 (C), who were considering engineering in August 2008 (D), who were considering engineering at both the beginning and end of the program (E), who did not consider engineering at either the beginning or the end (F), who switched away from considering engineering (G), and who switched to engineering (H) over the course of the program.

Of those who stayed in the study, nearly 50% were still considering engineering in their senior year, including 32% who were not considering it at the beginning of the study. In addition (not shown in Table 5), approximately 50% of those who stayed said they were more interested in engineering at the end of the program than they had been at the beginning.

High School is Not too Late to Influence

As the figures in column C of table 5 suggest, the FREE intervention was wildly successful in piquing the interest of academically-able, high school girls to consider engineering as a career choice. The majors at the time of enrollment in college and the narrative data, which is beyond the scope of this paper, however, are a bit more sobering. Thirteen girls enrolled in engineering programs (plus 21 who majored in science, math, or technical fields) at their perspective colleges. For some girls from middle and upper-middle income families, choosing engineering was an easy and natural choice. For most first generation college-bound girls, however, making the decision to choose engineering was easily compromised by other (non-program) factors.

We concur with prevailing thought that the primary factors which influence a young woman's post-secondary aspirations and subsequently, the college planning process include one's educational background and achievement, personal experiences, values, and parental influences (Burger et al. 2007; Eccles 1994; Eisenhart & Finkel 1998; Margolis et al. 2008; Margolis & Fisher 2003). What we encountered in the field, was the reality that talented, but, marginalized minority and low socio-economic girls, could not, on their own, learn about, connect with, nor gain access to high tech career pathways due to their lack of social and cultural capital and institutional ignorance and barriers that have passively inhibited access for the under-represented and under-served for decades. However, what we did not fully anticipate is the unusual nature of support the girls needed and the impact our minimal support (once a month meeting and sporadic online interaction) had on these girls.

The evidence is compelling; the educational playing field is leveling – girls are capable and potentially interested in pursuing career fields like engineering. And like the literature in science education reform suggests -- girls need the time, space, tools, and support to become aware of topics that interest them, and in contexts that intrigue them (Eisenhart & Finkel 1998). For girls to learn (pre-screening), become engaged (in-depth exploration), and choose a non-traditional career path like engineering, it is imperative to engage them in activities they find meaningful, provide support that is sustainable, and information that is timely. Carol Burger and colleagues in *Reconfiguring the Firewall – Recruiting Women to Information Technology across Cultures and Continents* (2007) conclude that "the one biggest challenges facing educators who want to

promote women's interest in STEM fields is to develop a portfolio of developmentally appropriate strategies that engage young women in thoughtful reflection about career options that are good matches for their values, skills, and interests" (p. 17). We, the FREE research team, concur, and add the importance of scalable, sustainable, developmental, and meaningful support, because girls are not under-represented, they are under-supported in engineering communities.

Questions for audience

1. How could a FREE-type intervention be scale-up to expose more girls to possibilities in engineering and support their exploration?
2. How could the engineering ranks and professional societies be mobilized to support local girls during pivotal career development stages?
3. What kind of partnerships are possible to scale-up FREE intervention and mobilize adult influencers (teachers, role models, others)?

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