

AC 2008-913: EMPOWERING GIRLS: MEASURING THE IMPACT OF SCIENCE TECHNOLOGY AND ENGINEERING PREVIEW SUMMER CAMPS (STEPS)

Paul Plotkowski, Grand Valley State University

Dr. Paul D. Plotkowski is the Dean of the Seymour & Esther Padnos College of Engineering and Computing at Grand Valley State University located in Allendale and Grand Rapids, Michigan. Paul has been with the university for 16 years and has been instrumental in the growth of the college and programs for development for women and under-represented populations in engineering. Paul has been extensively published and very involved in accreditation. Paul has been honored as an ASME Fellow, with the ASME Dedicated Service Award, and received the SME Outstanding Young Engineer Award.

Mary Ann Sheline, Grand Valley State University

Mary Ann Sheline is Director of the Regional Math and Science Center at Grand Valley State University and has been involved with K-12 science education for 45 years as an elementary, middle and secondary science teacher, college instructor, and administrator. She has taught biology, chemistry and earth science at a variety of grade levels. She has experience developing curriculum and administering collaborative programs such as the National Science Foundation's Teacher in Industry Program, National Science Olympiad Tournament and is presently Co PI of a Mathematics and Science Partnership Grant. Mrs. Sheline has a BS in Biology from Chatham College, Pittsburgh, Pa., MA in Natural Science from Carnegie Mellon University, Pittsburgh Pa., and Ed.S. in Education Administration from the University of Nebraska at Kearney.

Margo Dill, Grand Valley State University

Margo Dill is a Program Coordinator for the Regional Math and Science Center at the College of Liberal Arts and Sciences, Grand Valley State University. Her work with K-12 education is focused on planning, directing, and facilitating student programming and teacher professional development in science, technology and mathematics. She has eight years of experience with collaborative student programs such as; the Science, Technology and Engineering Preview Summer (STEPS), the Michigan Science Olympiad Region-12 Tournament (MSO), and facilitating teacher professional development for workshops and conferences. Mrs. Dill has a BS in Biology from Grand Valley State University.

Jessica Noble, Grand Valley State University

Jessica M. Noble is the Student Services Coordinator for the Seymour & Esther Padnos College of Engineering and Computing at Grand Valley State University. She earned her B.S. in Industrial Engineering from Kettering University and she is pursuing her Masters degree in Adult and Higher Education at Grand Valley State University. She is the STEPS camp co-director and has been in this role for the past 3 years.

Empowering Girls: Measuring the Impact of Science Technology and Engineering Preview Summer Camps (STEPS)

Abstract

STEPS camps were designed to address the critical shortage of women in science, mathematics, and engineering related careers by providing girls with positive exposure to the exciting opportunities in these fields. Through a variety of workshops, lessons, and hands on activities, the girls gain a better understanding of many science, technology, engineering, and mathematics (STEM) related concepts, culminating with the construction and flight of their own remote controlled aircraft. While influencing long term educational goals is a primary focus of the STEPS camps, the experiences and activities are also designed to promote self esteem, self confidence, and demonstrate the benefits of teamwork and collaboration. Based upon this positive message, Grand Valley State University began offering STEPS camps in the summer of 2002, and the popularity has ensured full capacity participation every year thereafter.

Pre and post assessments measuring content knowledge, self efficacy about success in mathematics and science, and the likelihood of pursuing STEM related fields are used to evaluate the camps yearly. Results indicate that increase in content knowledge among girls in the 2007 program increased from 10.5% to 71% with an average of 41 % from pre-post results. The Dorothy A. Johnson Center for Philanthropy and Nonprofit Leadership Community Research Institute (CRI) at Grand Valley State University is tracking the long term educational choices of girls from the first three years using follow up assessments in 10th and 12th grades, and two years after graduation. Results from the first year are encouraging, with 65% of the participants demonstrating an interest in studying more science, mathematics and technology, and an impressive 50% intending to major in a STEM related field. A limitation of our work is that these students may have pre-selected themselves which may skew our data.

This paper presents preliminary findings which include the campers' perspectives on women working in STEM fields and their own success and interest in pursuing a STEM career. Our initial results suggest the STEPS camps show promise in addressing this critical national shortage crisis.

A National Dilemma

For the past 50 years, the United States of America has made monumental contributions in science and mathematics achievements, but today, workforce issues are challenging America's manufacturing industry. Employment in traditional manufacturing goods sectors will decline overall by 1.5 million jobs, which is half of the 3 million manufacturing jobs lost in the previous decade (1996-2006).¹ Industries with the largest projected wage and salary employment declines are in the traditional manufacturing sector.

The U.S. Bureau of Labor Statistics predicted total employment is projected to increase by 10 percent by 2016. The projected increase in total employment will add 8.1 million jobs in professional and business services, health care, social assistance and industry sectors showing the largest employment growth. Employment increased 12 percent during the last decade (1996-2006).¹ While global competition and demand are increasing, the pipeline of new science and engineering talent is not growing fast enough to keep up with the retirement of the experienced baby boomer generation. Education and training for these job openings varies, but overall the proportion of occupations requiring a college degree will increase between 2006 and 2016. In fifteen of the thirty fastest growing occupations, a bachelor's degree or higher is the most significant postsecondary education or training required.¹

The Bureau of Labor Statistics estimates that through the next ten years to 2016 manufacturing employers and others will be seeking:²

- 41,000 industrial and manufacturing engineers
- 9,000 mechanical engineers
- 10,000 engineering technicians
- 171,000 metal and plastic production workers.

In 2004, a total of 1,407,900 bachelor's degrees were awarded to women and men. Of that number, women earned 810,817 bachelor's degrees in all fields.³ However, only 227,813 of those degrees were awarded in science and engineering fields. This means that only 28% of degrees awarded to women are in science and engineering when they are earning almost 58% of all bachelor degrees. It is even more discouraging to note that women earned only 25.1% and 20.5% of computer science and engineering degrees, respectively, in 2004.³ In addition, the bachelor's degrees awarded to females in engineering dropped from 15,282 in 2004 to 14,868 in 2005, which signifies a 2.7% decrease.⁴ In this same year, the bachelor's degrees awarded to male engineers increased from 60,721 in 2004 to 61,135 in 2005. With over 30% of the employed scientists and engineers at the age of 50 or older, the current generation will need more males and females interested in science and engineering fields to fill the gap left by retiring baby boomers.⁴

The Current Response

Recognizing this impending shortage of technical talent, Grand Valley State University as well as other institutions and industry leaders have invested in a variety of early awareness programs to expand the pipeline of young men and women interested in the STEM field. These programs include FIRST Robotics, a STEM centered magnet school that is run by the Grand Rapids Area Pre College Engineering Program, and the STEPS program. Each of these programs shows substantial success in expanding the talent pool.

In FIRST (“For Inspiration and Recognition of Science and Technology”) which is a global program, students are exposed to the important concepts of science and engineering through fun and exciting hands on competitions utilizing robots they have

built. The FIRST Program conducted a study of participants in 2005 using FIRST teams in Detroit and New York City. In this study, they found significant differences between participants' and non participants' interests in mathematics, science, and engineering careers. FIRST alumni reported their college majors; 41% chose engineering, compared to only 6% of students who chose engineering nationally. Furthermore, 33% of female FIRST alumni picked engineering as a major, while the national average of female high school seniors who chose engineering was 2%. Also, when the FIRST alumni were compared with students from similar demographics and academic backgrounds, the alumni were nearly twice as likely to major in science or engineering (55% vs. 28%).⁵

In the area, industry and educators collaborate with FIRST, but they also support other programs such as the Grand Rapids Area Pre College Engineering Program (GRAPCEP) at Creston High School. Students enrolled in GRAPCEP experience a curriculum that includes the necessary high school requirements along with a focus in either engineering or biomedical careers. GRAPCEP determined that 56% of its graduates have enrolled in a science, technology, engineering or mathematics related field of study; the national rate of college students enrolled in these fields is 20%.⁶ By exposing students to exciting, hands on opportunities in the mathematics and science fields, these programs have seen a large increase in students interested in pursuing engineering and science careers. GRAPCEP has shown that classes in mathematics, science, and technology in middle school and high school are essential preparation for entering and succeeding in college level courses.

Why is STEPS Important?

The National Center for Education Statistics at the U.S. Department of Education did a study of student high school transcripts. Their results showed girls who graduated from high school earned, on average, slightly more credits in mathematics and science (7.3) than boys (7.1).⁷ This gender balance is a result of high school graduation requirements that typically include multiple science and mathematics courses. If girls and boys are taking the same high school science courses, why are fewer females interested in pursuing careers in science, technology and engineering? In general, researchers found that girls and women have less confidence in their mathematics abilities than males do, and from early adolescence girls' show less interest in mathematics or science careers. Quite frankly, the report went on to say, "...girls often underestimate their abilities in mathematics and science".⁸

A few of the reasons young women do not seek out these fields are their misperceptions and beliefs. Research has shown that females do not rate themselves very highly in the mathematics and science fields. In 1999, Andre, Whigham, Hendrickson and Chambers discovered that parents perceive boys as more competent in sciences and expected science would be more important to boys. Parents also expected higher performance from boys in science related fields and that careers related to mathematics and science were seen as male dominated.⁹ A study conducted by Steele showed that girls as young as 1st - 4th grade believed that boys were better at mathematics and enjoyed it more than girls.¹⁰ Steele's findings also support Simpkins and Davis-Kean's research, which

concluded that girls are less likely to participate in mathematics activities than boys.¹¹ This suggests improving girls' beliefs about their abilities could alter their choices and performance.

Recognizing this disparity in perception –vs– ability in STEM fields among girls, and the importance of earlier intervention, the Society of Manufacturing Engineers Educational Foundation developed the STEPS program. Organizers concluded the camps had the potential to be an effective intervention in women's misperceptions and beliefs about science, technology, and engineering fields and worked to bring the STEPS camp model to Michigan.¹² In 2002, Grand Valley State University was invited to join them by hosting STEPS camps.

Grand Valley State University has conducted STEPS camps since 2002. Each camp runs for one week and has 40 participants supported by over 100 volunteers and staff members including female Grand Valley State University students who act as camp counselors and a very large number of female volunteer role models. Two camps are conducted in back to back weeks each summer.

Program Components

STEPS is hosted at Grand Valley State University by forming an internal partnership with the Regional Math and Science Center, the School of Engineering, and the Seymour and Esther Padnos College of Engineering and Computing. The STEPS Program was designed to achieve a balance between technical, developmental, and recreational activities. This program is specifically targeted to 7th grade girls. The goals of the camp are to:

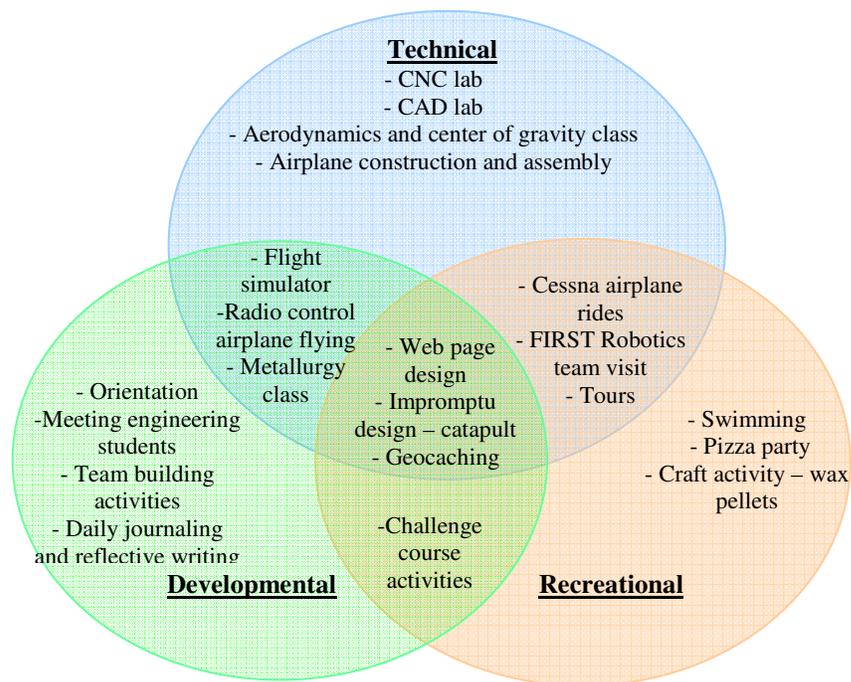
- Positively affect a student's self esteem, confidence, and self efficacy.
- Provide learning experiences that increase content knowledge through lessons and activities.
- Increase their interest in the fields of engineering, science, and technology.
- Learn to work as a team while building their airplane.

Students attending camps learn significant content in physical science, engineering principles, and social and developmental activities. Technical aspects of the camp include CAD and CNC labs, an aerodynamics class, and airplane construction and assembly. Additionally, the scientific concepts underlying flight, aviation, and engineering are taught. Developmental aspects of the camp focus on social interactions, team building, and self reflection skills. These activities include orientation, meetings with engineering college students, cooperative activities, daily journaling, and reflective writing. Recreational activities are an important component to the camp. In our experience, we have determined that these activities support the development of technical and developmental activities while lending themselves to a summer camp atmosphere. The activities include swimming, a pizza party, and craft activities.

Comprehensive camp components provide opportunities that integrate learning for the campers. They share aspects from more than one area. These activities include webpage design, impromptu design (catapults), geocaching, flight simulators, a challenge course, controlling a FIRST robot, flying radio control airplanes, metallurgy class, and tours at a local airport and industries. A highlight of the week is when the campers explore jet engine turbines and interact with female engineers.

The following diagram summarizes the program components.

Diagram # 1. STEPS Program Components



Funding

Donations make it affordable for students from all socioeconomic backgrounds to attend STEPS summer camps. Among the donors and grantees for the 2007 STEPS camps held at Grand Valley State University were:

- Michigan Space Grant Consortium (NASA)
- SME - Society of Manufacturing Engineers Educational Foundation
- The Alcoa Foundation through Howmet Castings, an Alcoa business
- Grand Valley State University

Through the generous support of donors and grants, it is possible to offer the STEPS camps for a \$25.00 registration fee. Without the generosity of donors, the STEPS Camps would not occur.

Assessment

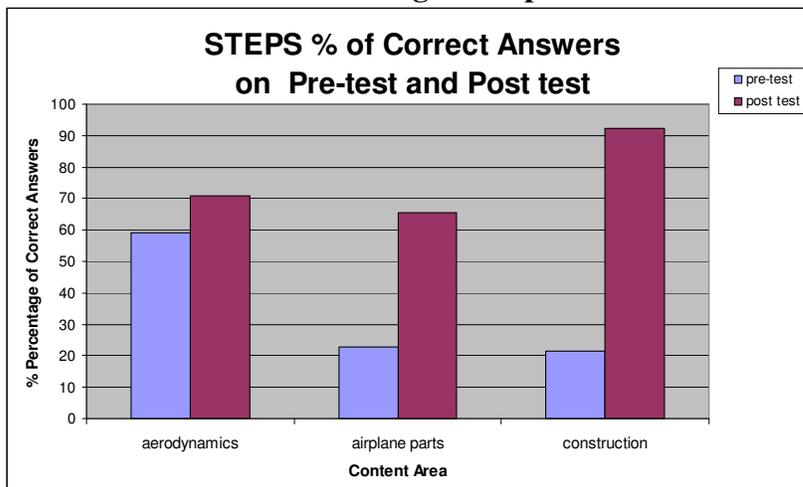
Although assessment has been a critical component of these camps since their inception, camp instructors and leaders developed several new assessment instruments for the 2007 STEPS camps. Instructors from the aerodynamics and construction processes classes created tests and surveys which evaluated student learning experiences. The data we analyzed was drawn from:

- Pre and post quizzes for subject content knowledge
- Daily reflection sheets addressing specific activities
- Pre and post camp surveys
- Post camp parent surveys

Increasing student content knowledge is one of the core elements of the camp. Figure 1 shows the results of the pre content and post content knowledge quizzes. Questions analyzed included information regarding aerodynamics and the center of gravity, airplane parts, construction process plans, and science and engineering vocabulary.

In the summer of 2007, students averaged an increase of 10.5% in their aerodynamics content knowledge. Additionally, students achieved a 42% increase in their airplane parts knowledge. Finally, students achieved a 71% increase on their knowledge of the construction process plans.

Figure # 1
STEPS 2007 Student Percentage of Improvement



The girls were also asked questions about their feelings towards science and engineering, as well as about their abilities. Pre and post camp surveys verified that most students who come to an engineering, science and technology camp have a certain degree of

confidence in their mathematics and science abilities. However, we were pleased that their confidence level about their abilities (on a scale of 1-completely disagree to 10-completely agree) increased from 8.1 to 8.8.

Students were asked if they thought they needed to take more challenging courses in high school to improve their chances of being successful in college mathematics, science, and engineering courses. Their beliefs increased from an average pre test score of 7.1 to an average post test score of 8.1.

They also believed they would be more likely to pursue a mathematics, science, or engineering related career field after camp. This score increased from 6.3 to 7.4. This is particularly important for 7th grade girls who are just beginning to explore career opportunities.

Additional evidence of their growth can also be seen in personal reflections through pre and post camp belief surveys.

Question: What is one thing you learned about engineering today that you didn't know before?

- *I didn't know that engineering has lots of jobs.*
- *Engineers sometimes work by hand as well as with machines.*
- *There are multiple jobs out there for women who want to be engineers.*
- *Engineers design things.*

Question: What did you learn while visiting the jet engine component factory?

- *It looks cool to be an engineer.*
- *That we need way more women engineers.*
- *It takes a lot of people to make the products.*
- *Their process, teamwork and all the work.*
- *Women can engineer as well as men.*
- *Female engineers rock!*

STEPS camp Parent Surveys reflected a few thoughts:

- *Well organized!*
- *Great Program!*
- *My daughter enjoyed being on the Grand Valley State University downtown campus and the YMCA downtown. All impressed her.*
- *This program was very well organized and staffed by caring people and positive role models. There were so many interesting activities packed into a day that our daughter came home every night excited to go back the next day. It made quite an impression on Hannah and gave her ideas about future careers she hadn't thought about. As a side note, we also appreciated the help in reinforcing the fact to her that it's ok to be smart and smart people are cool.*
- *Thanks again for all you do for this program! Nikaysha discovered some interesting things about herself which will be fun to see what she does with them.*

It is amazing to me that spending a week doing the things they do at camp, that the girls can grow so much! Never doubt that you make a difference.

One of the appealing aspects of the STEPS camp is how students are challenged to succeed beyond typical school learning experiences and expectations. This sense of accomplishment for students is what boosts their self confidence and self esteem. The feedback from these assessments and more provide the STEPS staff with pertinent information to make informed decisions about the future of the camp.

Evaluation

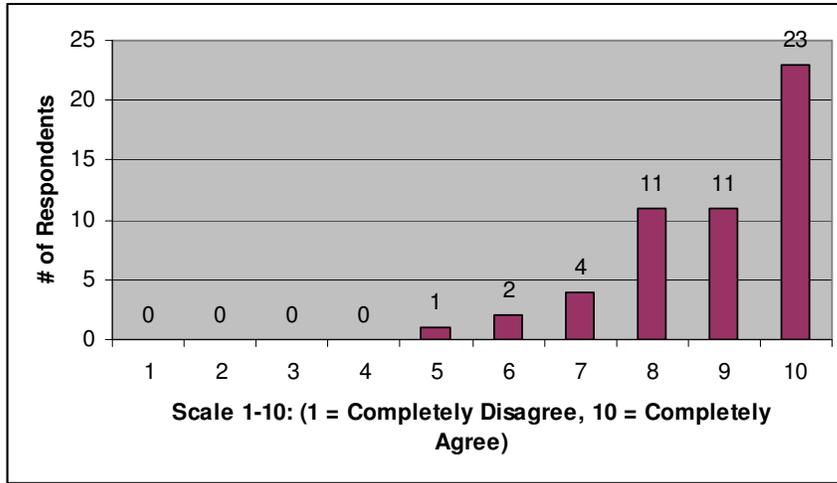
Another method of evaluation used within the STEPS program is the five year longitudinal study. In order to determine if STEPS campers show the same increase in mathematics, science and engineering interest as participants in programs like FIRST and GRAPCEP, it is important to conduct a long term study of the campers. Data is collected at crucial decision making points in the students' high school and college career. The purpose of this long term evaluation, entitled "*STEPS Impact Study*" is to determine if the 7th grade girls' participation in STEPS at Grand Valley State University meets the objectives of increasing young females' interests in engineering and technology as well as motivating them to continue in mathematics and science education. It seeks to determine whether the camp has long term effects on the campers' self confidence, self efficacy and career related decisions.

This new study is being conducted by the Community Research Institute (CRI). This tool enables us to track baseline information and progress of STEPS camp participants from the first three years of Grand Valley State University residential camps (2002-2004). The phone survey questions follow the campers as they enter the 10th and 12th grades, and again two years after high school. This study began May 2007 and concludes May 2012.¹³

The first year of the survey encompassed previous STEPS campers who were in tenth and eleventh grades. It consists of telephone surveys of past campers from 2002, 2003, and 2004. The CRI recruited 25-30 participants from each year of the STEPS camps to participate. After receiving parental and the girls' consent, 52 girls from camp years 2002 and 2003 completed a telephone interview. They received a \$20 Barnes & Noble gift card in appreciation for their responses. In future years, these campers will be surveyed again two years after their expected high school graduation date.

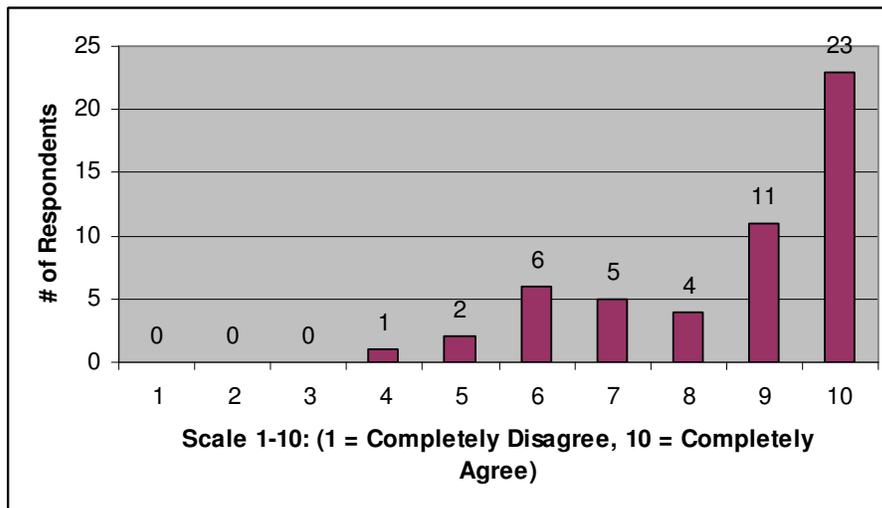
The students were asked to respond to the statement, "I believe I could be successful in a science, mathematics, or engineering career." As shown in Figure # 2 (on a scale of 1-10) the largest majority of the girls believed they could be successful in a science, mathematics, or engineering career. Only one student (2%) was uncertain.

Figure # 2. Survey of past STEPS campers (10th & 11th grade)
Statement: *I believe I could be successful in a science, mathematics, or engineering career.*¹³



The students were also asked to respond to the statement, “I have an interest in studying more science, mathematics, or engineering in the future,” This graph shows similar results as were obtained in Figure # 2.

Figure #3. Survey of past STEPS campers (10th & 11th grade)
Statement: *I have an interest in studying more science, mathematics, or engineering in the future.*¹³

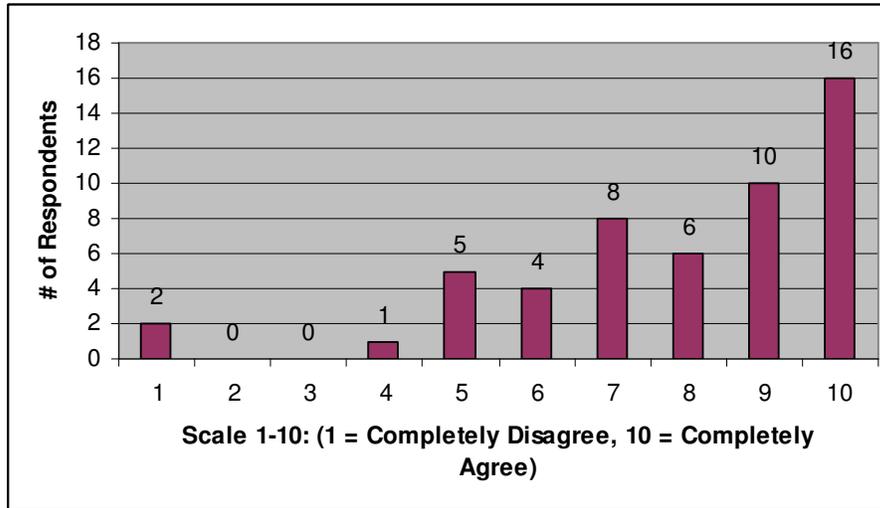


When asked the statement, “I think I will major in a science, mathematics, or engineering related field,” the majority of girls agreed (44) but (8) girls were either uncertain or stated they will not. Results are shown in Figure # 4.

Figure # 4

Survey of past STEPS campers (10th & 11th grade)

Statement: *I think I will major in a science, mathematics, or engineering related field.*¹³



For comparison we looked at female enrollment in bachelor degrees in 2004 as reported by the National Science Foundation. Only 14.8% (1,221,219) of female students intended to major in a science, mathematics, or engineering related field.³ We found 50% of the female STEPS students thought they would major in a science, mathematics, or engineering related fields.

When asked if their interests in mathematics, science, and technology related careers changed or have changed over the past few years, some of our students described how STEPS has already changed their lives:

“Before the camp, (I) had no thoughts/interest in engineering/science/mathematics careers, camp opened doors.”

“(I have) become more interested in specific aspects of engineering as a result of various camps, including STEPS.”

In addition, the students were asked to look back on their experience at STEPS and determine if they thought it had any influence on their interest in school or career. The students said:

“Yes, in a variety of ways. Without the camp, there would have been a lack of information about engineering, especially in relation to computers. (I) learned to

build planes during camp (and) because (of that I'm) interested in learn(ing) about aerodynamics.”

“Yes, made (me) think about engineering more as a plausible career goal rather than being just a fun camp.”

These are preliminary results from our first year of long term study. Due to funding constraints, we are unable to gather a random sample as a control group at this time. In future years we will consider this option to further support our conclusions.

Expected Impact

The STEPS camp experience provides many opportunities that are difficult to achieve in the typical school setting. Girls in particular are not encouraged to use high tech equipment or build with customized manufacturing jigs and tools. The goal is to not only provide students with an advanced understanding of the physical science concepts that underlie aeronautics and flight, but also help them develop a positive attitude about careers in engineering, mathematics, science, and technology. Students need more exposure to everyday workplace skills such as team building, ability to form partnerships, cooperation with one another, and problem solving. All these skills are emphasized during the STEPS camps.

As this is the first year for the STEPS longitudinal study, we are not able to draw any firm conclusions about our data. We hope as the study continues, the data will demonstrate that STEPS assists students in preparing for college in a number of ways. First, by targeting girls going into the 7th grade, our intent is to influence their course selections and elective subjects in middle and high school. If they know they are interested in STEM topics, then they can plan to take the appropriate preparatory courses as they transition to high school. STEPS seeks to influence their career choices. By exposing campers to the opportunities in science, technology, and engineering, and encouraging them to take the appropriate high school courses, they will be better equipped to make informed decisions regarding their college and career paths.

References:

1. US Department of Labor, Bureau of Labor Statistics, (2007), NEWS, Employment Projections: 2006-16. Retrieved December 11, 2007 from <http://www.bls.gov/emp/>
2. US Department of Labor, Bureau of Labor Statistics (2007), National Employment Matrix (2006-2016). Retrieved January 10, 2008 from <http://www.bls.gov/emp/empoccl.htm>
3. National Science Foundation. (2006). *Women, minorities, and persons with disabilities in science and engineering*. Retrieved November 16, 2007 and February 20, 2008, from <http://www.nsf.gov/statistics/wmpd/>.
4. National Science Foundation, *Undergraduate enrollment in engineering programs by sex, race/ethnicity, and citizenship*, Table B-9. (1995-2005, NSF.gov).
5. For Inspiration and Recognition of Science and Technology. (April 2005). *More than robots: An evaluation of the FIRST robotics competition participant and institutional impacts*.

Retrieved November 16, 2007, from http://www.usfirst.org/uploadedFiles/Who/Impact/Brandeis_Studies/FRC_eval_execsum.pdf

6. *Grand Rapids Area Pre-College Engineering Program Quick Facts*. (n.d.). Retrieved November 11, 2007, from <http://services.davenport.edu/grapcep/Web/Program/quick%20fact.htm>.
7. Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., Brown, J. Lyons, M., Averett, C., and Kastberg, D. (2007). *The nation's report card: America's high school graduates* (NCES 2007-467). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.
8. Halpern, D., Aronson, J., Reimer, N., Simpkins, S., Star, J., Wentzel, K., *Encouraging Girls in Math and Science, ICS Practice Guide*, National Center for Education Research, Institute of Education Sciences, U.S. Department of Education, September, 2007.
9. Andre, T., Whigham, M., Hendrickson, A., and Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching*, 36, 719-747.
10. Steele, J. (2003). Children's gender stereotypes about math: The role of stereotype stratification. *Journal of Applied Social Psychology*, 33(12), 2587-2606.
11. Simpkins, S. D. and Davis-Kean, P. E. (2005). The intersection between self-concept and values: Links between beliefs and choices in high school. *New Directions for Child and Adolescent Development*, 110, 31-47.
12. Society of Manufacturing Engineers Educational Foundation, STEPS Academy Grants. Retrieved January 2, 2008 from; http://www.sme.org/cgi-bin/smeefhtml.pl/?foundation/grants/youth_program_grants.htm .
13. Gajewski, M (2007). [STEPS camper responses to interest in math and science topics as reported by the Community Research Institute]. Unpublished raw data.